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D2.7

Updated course material on smart solutions for the interconnection of transportation networks

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DOCUMENT CONTROL SHEET

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Author(s)	Eftihia Nathanail, Ioannis Karakikes, Giannis Adamos, Lambros Mitropoulos (UTH)		
Co-author(s)	-		
Responsible Organisation	UTH		
WP Leader	UTH		
Project Officer	Agnes Hegyvarine Nagy		

ALLIANCE Beneficiaries	
TRANSPORT AND TELECOMMUNICATION INSTITUTE – TTI	Latvia
PANEPISTIMIO THESSALIAS – UTH	Greece
FRAUNHOFER GESELLSCHAFT ZUR FORDERUNG DER ANGEWANDTEN FORSCHUNG EV – Fraunhofer	Germany

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LIST OF ABBREVIATIONS

Abbreviation	Description
EC	European Commission
EU	European Union
MSc	Master of Science
STIP	Sustainable Transport Interchange Program
STSE’s	Short-Term Staff Exchanges
TTI	The Transport and Telecommunication Institute
UTH	University of Thessaly
WP	Work Package

Abstract

This deliverable includes the second version of the ALLIANCE course material on smart solutions for the interconnection of transportation networks as presented firstly in deliverable D2.3. The material has been updated after the 1st summer school “Sustainable Transport Interchanges Program” in Riga, Latvia and is expected to be updated again, after the realization of the 2nd summer school.

1 Introduction

1.1 Background

ALLIANCE aims at developing advanced research and higher education institution in the field of smart interconnecting sustainable transport networks in Latvia, by linking the Transport and Telecommunication Institute – TTI with two internationally recognized research entities – University of Thessaly – UTH, Greece and Fraunhofer Institute for Factory Operation and Automation – Fraunhofer, Germany. Close collaboration of TTI with UTH and Fraunhofer will enable the achievement of the goals through the following activities:

- Organization of young researchers' seminars.
- Organization of workshops.
- Organization of summer schools for trainers and young researchers.
- Development of educational programme for graduate and post-graduate students.
- Development of training programme for trainers and practitioners.
- Provision of grants for participation as authors of peer reviewed publications in conferences.
- Facilitation of Short-Term Staff Exchanges (STSE's) with the aim of international collaboration, mainly publications.
- Establishment of a guidance strategy for preparing scientific publications.
- Creation of an educational forum as on-line tool for distance learning and knowledge sharing.

The overall methodology of the project is built around the analysis of the needs of Latvia and the surrounding region of the Baltic sea (Lithuania, Estonia, Poland) on knowledge gain about intermodal transport networks and the development of the tools to attain this knowledge, providing at the same time excellence and innovation capacity. The analysis to be conducted during the first stages of the project relies on the overarching relations among policy makers, industry and education/research.

Structured around three main pillars: 1) Organizational/governance, 2) operational/services, and 3) Service quality/customer satisfaction, ALLIANCE will deliver a coherent educational/training program, addressed to enhancing the knowledge of current and future researchers and professionals offering their services in Latvia and the wider region. The expected impacts on the overall research and innovation potential of TTI and Latvian research community will be of high importance and TTI will benefit from ALLIANCE by:

- Improving its knowledge in methodologies for preparing, writing and publishing scientific papers.
- Strengthening its research capacity.
- Establishing international research teams in specific areas of interest.
- Generating new innovative ideas for future research work through the project's activities.
- Setting up the fundamentals for the young generation of researchers.
- Being integrated in a number of existing international transport research networks.
- Being incorporated in the European research system of transport and logistics.

In addition, the cooperation of TTI with UTH and Fraunhofer will induce benefits into several domains of everyday life at regional, national and international scope. New bases will be established concerning knowledge transfer procedures, education and interdepartmental collaboration amongst research institutes. The innovative organizational framework, which will be structured for this purpose during the project, is expected to constitute a best practice application with tangible and well estimated progress results, which will be disseminated and communicated through social events to the research community and to the respective business sector as well. Lastly, an important benefit will be the configuration of an integrated framework pertaining to the knowledge transfer techniques and the generic upgrading of the educational system with use of networking, staff exchange, webinars and other knowledge transfer methods and techniques based on a well-structured and well-tried schedule.

1.2 Deliverable scope and structure

This document is the sixth deliverable of WP2 (Work Package 2) and its scope is to provide the second version of the ALLIANCE course material on smart solutions for the interconnection of transportation networks. The first version of the ALLIANCE course material was presented in deliverable 2.3 (ALLIANCE, 2016a).

Following the introductory chapter, the subsequent sections of this deliverable include: Chapter 2 presents an updated overview of the “Sustainable Transport Interchange Program – STIP”, and Chapter 3 the final version of the courses’ metadata and the final version of the material developed for the program.

2 Sustainable Transport Interchange Program

2.1 Overview

The Transport and Telecommunication Institute – TTI with two internationally recognized research entities – University of Thessaly – UTH, Greece and Fraunhofer Institute for Factory Operation and Automation – Fraunhofer, Germany develop an advanced research and higher education program in the field of smart interconnecting sustainable transport networks in Latvia. The program, entitled "Sustainable Transport Interchange Program – STIP", captures the needs of interconnecting transportation networks and the current and emerging research, educational and training requirements in Latvia and the region.

STIP aims to strengthen the scientific and technological capacity of Latvia and build the grounds for a common understanding of the basic principles that affect sustainable intermodality. While this program is developed for graduate students who attend either program at TTI "Transport Economics and Management" and "Transport and Logistics" it may be attended by other PhD students who did not graduate from these master programs.

The educational objectives of the program are (ALLIANCE, 2016b):

- For graduates to develop essential skills on transportation intermodality and establish the engineering profile that is needed to address issues in society, environment, and economy.
- For graduates to advance their careers to a higher position of responsibility by acquiring professional judgement and critical thinking of every day transport related problems.
- For PhD students to become familiar with methods and tools that are prerequisites to fulfil their program and have not covered in previous earned degrees or are required in the development of their thesis.

2.2 STIP courses

The two-level gap analysis, conducted previously in WP2 and documented in Deliverable D2.1 (ALLIANCE, 2016b), converted practice related requirements for passenger and freight interchanges (Gap analysis I) into educational gaps and requirements for passenger and freight transport interchanges (Gap analysis II). The requirements per thematic area, i.e. governance, smart solutions and decision-making, were linked with an educational area. Twenty educational areas were determined, based on the Gap analysis II requirements, and the existing research, educational and training programs offered at research and educational institutes at European level (ALLIANCE, 2016c):

1. Building business models for passenger transport interchanges
2. Development and implementation of sustainability and transport policies in the EU region
3. Development and implementation of freight transport policies in the EU region
4. Public Private Partnerships in transport: Theory and schemes
5. Building business models for freight transport interchanges
6. Sustainable passenger transportation planning
7. Sustainable freight transportation planning

8. Operation and management of urban public transport systems
9. Operation and management of urban freight transport systems
10. Multimodal transport optimization for passenger transport (General and case studies)
11. Multimodal transport optimization for freight transport (General and case studies)
12. Information systems for passenger intermodal terminals
13. Integrated ticketing and time table coordination
14. Design and safety principles of transport terminal infrastructure
15. Passenger terminal design
16. Urban freight terminals design
17. Information technologies for intermodal freight transport
18. Smart transhipment and alternative transport fuels
19. Risk assessment analysis, behavioral modeling, social cost benefit analysis and multi-stakeholder multi-criteria assessment
20. Innovative data collection methods to support decision making.

The above 20 educational areas were then combined, based on their content (where applicable) to shape 12 courses for passenger and freight transportation interchanges. These 12 courses are going to be used for training and education in Latvia, and they are grouped in the 3 thematic areas as shown in Table 2.1. An additional tutorial course, entitled “Research methodology and teamwork setup” has been added in the curriculum of STIP, while course 12 is separated into two parts.

Table 2.1: STIP courses

Code	Thematic area	Course
C0	-	Research methodology and teamwork setup
C1	Governance	The European policy on intermodal transport
C2		Building business models for intermodal transport interchanges
C3		Sustainable development and transportation planning
C4		Operation and management of intermodal transport systems
C5		Optimization of intermodal transport systems
C6	Smart solutions	Intelligent services for passenger transportation
C7		Smart information technologies in freight transport logistics
C8		Design of passenger transport interchanges
C9		Design of freight transport interchanges
C10		Smart equipment for freight transhipment
C11	Decision making	Decision making methodologies
C12a		Data collection methods: Surveys
C12b		Data collection methods: Historical and observed data

These 13 courses formulate the core curriculum of STIP. Following the requirements for the Latvia and the region two curricula are going to be further developed (ALLIANCE, 2016b):

1. Educational and training program to be implemented during the life cycle of the project. This program will be addressed to students attending Master's and PhD courses in one of the two programs offered at TTI, on "Transport Economics and Management" and "Transport and Logistics".
2. Long-life-educational (LLE) program, addressed to University graduates who practice their profession in the transport industry, thus work for an authority, SME, or other organization (Trans-logistics Educational forum).

Course material is further divided into three parts: a) Core, b) Freight transportation (1st Summer School), and c) Public transport systems: from research to decision making (2nd Summer School), as shown in Table 2.2, and planned to be covered over two Summer Schools. Core courses are covered over both Summer Schools, while content for "Freight" and "Passenger" courses is modified to cover freight and passenger interchanges, respectively.

Table 2.2 Core, Freight and Passenger STIP courses

Course	Core	Freight	Passenger
C0. Research methodology and teamwork setup	X		
C1. The European policy on intermodal transport	X		
C2. Building business models for intermodal transport interchanges	X		
C3. Sustainable development and transportation planning		X	X
C4. Operation and management of intermodal transport systems		X	X
C5. Optimization of intermodal transport systems	X		
C6. Intelligent services for passenger transportation			X
C7. Smart information technologies in freight transport logistics		X	
C8. Design of passenger transport interchanges			X
C9. Design of freight transport interchanges		X	
C10. Smart equipment for freight transhipment		X	
C11. Decision making methodologies	X		
C12a. Data collection methods: Surveys		X	X
C12b. Data collection methods: Historical and observed data		X	X

3 Course material development

3.1 Metadata

The responsible lecturer has prepared the course metadata, which include the following information:

- Analytic description, e.g. title, thematic area, responsible institute, lecturer, aim, learning outcomes, prerequisites, language, hours, key words, syllabus, bibliography, teaching methods, evaluation methods, license, number of topics
- Lecture content
- A short description of how each teaching method will be applied.

The updated version of the metadata of the 13 courses is analytically presented from Table 3.1 to Table 3.18. Courses C3, C4, C12a and C12b metadata files are given in two versions namely 2017 and 2018, according to the two versions of the course lecture, either with focus on freight transportation or passenger transportation.

Table 3.1: Course C0

Course: C0	
Title	**Research methodology and teamwork setup**
Thematic area	NA
Responsible Institutes	Transport and Telecommunication Institute - TTI, Latvia University of Thessaly - UTH, Greece
Lecturers	Prof. Irina Yatskiv (Jackiva) (TTI) Prof. Eftihia Nathanail (UTH)
Aim	• Present techniques of conducting literature review • Guide how to use databases, search engines and electronic libraries • Explain how to write a scientific report • Explain how to prepare and present research work • Organize teams for conducting the summer school project.
Learning outcomes	
On successful completion of the course, students will: attain knowledge on how • to work with databases, search engines and electronic libraries to retrieve information about a topic • to prepare a research paper,literature review, monograph, dissertation and poster be able to • plan a programme of research • conduct state-of-the-art in research direction • document methodology and results • work as a team member • communicate with colleagues about their research	
Prerequisites (if any)	
-	
Language	English
Hours	1
Key words	Research, paper, presentation, literature review, dissertation, report, citation, references, ethics, team
Syllabus	Course material will be presented to facilitate students' conceptual understanding of scientific work which is necessary part of master or PhD thesis, and to help them choosing their research topic, as well as to improve their presentation skills. In the course students acquire basic principles of analysis and overview of scientific publications which are necessary for the development of thesis. The student will be become familiar with scholarly resources in particular fields of science and technology and be able to critically analyze and evaluate sources sufficient to develop an annotated bibliography and literature review for their chosen topic. **Course topics:**

	- Research Methodology 1. Research process: definition, phases, methods 2. Scientific document types • Review Paper • Thesis • Technical Report • Case Study • Scientific Article • Scientific Proposal 3. Guidelines for good research work 4. Disseminating your research 5. Citations and references 6. Research ethics - Teamwork setup	
Bibliography	• The Writing Lab & The OWL at Purdue and Purdue University (1995-2011) • A Guide for Writing Research Papers Based on Modern Language Association, documentation prepared by the Humanities Department as part of The Guide to Grammar and Writing and the Arthur C. Banks Jr. Library Capital Community College Hartford, Connecticut. • Bates College, How to Write a Paper in Scientific Journal Style and Format, http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWgeneral.html • Alan Stevens, “Preparing the scientific paper, or: Confessions of a Journal Editor”. • Kate L. Turabian, “A Manual for Writers of Research Papers, Theses, and Dissertations”, Seventh Edition. • Richard Pears and Graham Shields, (2005), “Cite them right: the essential guide to referencing and plagiarism”. Pear Tree Books, Newcastle upon Tyne, http:www.citethmright.co.uk. • Elsevier. Publishing Ethics Resource Kit (PERK). Available at: http://www.elsevier.com/wps/find/editorshome.editors/Introduction.Accessed: June 11, 2012 • Gustavii, B. (2008). How to Write and Illustrate a Scientific Paper. Second Edition. Cambridge: Cambridge University Press. 178 p. • Jonker J. Pennink, B. (2010). The Essence of Research Methodology. A Concise Guide for Master and PhD Students in Management Science. Berlin. Heidelberg: Springer–Verlag. 250 p. • The University of Wisconsin-Madison Writing Center, 2007: The Writer’s Handbook: Scientific Reports. Internet: <http://www.wisc.edu/writing/Handbook/ScienceReport.html> • Comrie, A.C., 2007: Scientific Report Writing. Internet: <http://www.geog.arizona.edu/~comrie/geog230/report.htm>. • Latham, J. R. (2014). Research design canvas: A framework for designing and aligning the “DNA” of your research study (Version 2.0 ed.). Colorado Springs, Colorado: Organization Design Studio™ Ltd. • Nancarrow, S., Booth, A., Ariss, S., Smith, T., Enderby, P. and Roots, A. (2017). Ten principles of good interdisciplinary team work.Internet: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3662612	
Teaching methods	Lecture	x

	Demonstration	
	Hands on/games	
	Exercises	
	Visits at facilities	
	Other (describe): Case studies	
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	6	

Lecture content	
1	Research process: definition, phases, methods
2	Scientific document types
3	Guidelines for good research work
4	Disseminating your research
5	Citations and references
6	Research ethics
7	Teamwork setup
8	Suggested literature

Table 3.2: Course C1

Course: C1	
Title	**The European policy on intermodal transportation**
Thematic area	Governance
Responsible Institute	University of Thessaly, Greece
Lecturer	Dr. Giannis Adamos
Aim	• Present and analyse the basic concepts on intermodality • Identify stakeholders that play an important role in intermodal transport • Identify trends, challenges and emerging schemes that will influence the shaping of future European Transport Policy • Review the European legislation and policies in terms of transport modes (road, rail, waterborne, air), transport system environment, intermodality and financing • Review, analyse and assess the planning and financing schemes developed in the representative European countries addressing intermodal transport.
Learning outcomes	
• Provide an understanding of the basic concepts on intermodality • Possess an understanding of the complexity of decision-making processes, mainly addressed by the involvement of several entities and the conflict of interests of the involved stakeholders • Acquire knowledge of the European Union's policies and legislation on intermodality • Ensure that students are capable of investigating and identifying key drivers that provide coherence in the regulatory framework, and the planning and financing schemes affecting intermodality within decision-making.	
Prerequisites (if any)	
-	
Language	English
Hours	2
Key words	Interchanges, stakeholders, EU policies, legislation, institutional frameworks, planning schemes, financing schemes
Syllabus	This course introduces the basic concepts that are met in intermodal transport, such as intermodality, co-modality, passenger urban interchanges, freight urban interchanges, long-short distance interconnection, urban/interurban interconnection, sustainable transport. The main focus of the course is to present the European policies and legislation on intermodality, to identify the degree of flexibility provided by EU legal instruments, to illustrate how this flexibility is adopted by representative European countries, e.g. Italy, Norway, Czech Republic and Greece, and to investigate the role that other regulatory actors may have. Also, it analyses the complexity of the decision-making processes followed in intermodal transport, mainly affected by the involvement of different entities in all stages and the absence of a strict hierarchical flow chart of responsibilities, resulting to complicated procedures. **Course topics:**

	• Background • Basic concepts • Future trends and emerging schemes in European Transport Policy • Transportation in an era of change • Obstacles and problems • Decision-making framework • Stakeholders and interrelations • European institutional framework • EU policies and strategies • Regulatory frameworks • Indicative legislation • Planning and financing schemes • Case studies • Suggested literature • List of indicative legislation
Bibliography	• Adamos, G., Tsami, M. & Nathanail, E., 2015. “Urban interchanges: Moving towards a seamless transportation solution”. 5th International Conference on Environmental Management, Engineering, Planning and Economics (CEMEPE) and SECOTOX Conference. Mykonos Island, Greece, June 14-18, 2015. • Adamos, G. & Nathanail, E., 2013. “Recommendations on the development and implementation of a coherent decision making process in the short-long transport interconnection”. 13th World Conference on Transport Research, Rio de Janeiro, Brazil, July 15-18, 2013. • Adamos, G., Nathanail, E. & Zacharaki, E., 2012. “Developing a Decision-Making Framework for collaborative practices in long-short distance transport interconnection”. Procedia – Social and Behavioral Sciences, Volume 48, 2012, Pages 2849-2859. • CLOSER, 2011. CLOSER Deliverable D4.1. Analysis of the decision-making framework. CLOSER Project. • CLOSER, 2012. CLOSER Deliverable D4.2. Policy Advisory Group recommendations. CLOSER Project. • European Commission, 2001. White Paper " European transport policy for 2010: Time to decide (CEC, 2001). • European Commission, 2004. Towards passenger intermodality in the European Union. Brussels. • European Commission, 2006. Keep Europe Moving. Sustainable mobility for our continent. Mid-term review of the European Commission’s 2001 transport White Paper. ISBN 92-79-02312-8. Luxemburg: Office for Official Publications of the European Communities, 2006. • European Commission, 2007. “GREEN PAPER - Towards a new culture for urban mobility”, Brussels, 25.9.2007 COM (2007) 551 final. • European Commission, 2009. A sustainable future for transport — Towards an integrated, technology-led and user-friendly system Luxembourg: Publications Office of the European Union 2009 — 26 pp. — 21 x 29.7 cm ISBN 978-92-79-13114-1.

- European Commission, 2011. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. White Paper of the European Commission. COM (2011) 144 final.
- Eurostat (population and social conditions), Statistics in Focus No 72/2008; and European Commission, ‘Demography report 2008: Meeting social needs in an ageing society’. SEC(2008) 2911.
- Nathanail E. & Adamos, G. 2013. “Planning and financing schemes linked to the decision-making for the interconnection of long-short distance transport”. Transport and Telecommunication. Volume 14, Issue 1, Pages 20–28, ISSN (Online) 1407-6179, ISSN (Print) 1407-6160, DOI: 10.2478/ttj-2013-000, February 2013.
- United Nations Population Division (2009), ‘World population prospects — The 2008 revision’.

List of Indicative legislation

- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions of 25 June 2008: “Single European Sky II: towards more sustainable and better performing aviation”.
- Communication from the Commission of 28 February 2013: EU Space industrial policy: Releasing the potential for economic growth in the space sector.
- Council Regulation (EC) No 12/98 of 11 December 1997, laying down the conditions under which non-resident carriers may operate national road passenger transport services within a Member State.
- Council Regulation (EEC) No 684.92 of 16 March 1992 on common rules for the internal carriage of passengers by coach.
- Council Directive 95/64/EC of 8 December 1995 on statistical returns in respect of carriage of goods and passengers by sea.
- Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system.
- Council Regulation (EC) No 2236/95 of 18 September 1995 laying down general rules for the granting of Community financial aid in the field of trans-European networks.
- Decision No 1692/96/EC of the European Parliament and of the Council of 23 July 1996 on Community guidelines for the development of the trans-European transport network.
- Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on safety on the Community´s railways and amending Council Directive 95/18/EC on the licensing of railway undertakings.
- Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification.
- Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 “Establishing a single European railway”.
- Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of intelligent transport systems in the field of road transport and for interfaces with other modes of transport.
- Regulation (EC) No 551/2004 of the European Parliament and of the Council of 10 March 2004 on the organisation and use of the airspace in the single European sky.

	• Regulation (EC) No 552/2004 of the European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network. • Regulation (EC) No 550/2004 of the European Parliament and of the Council of 10 March 2004 on the provision of air navigation services in the single European sky.	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	
	Exercises	
	Visits at facilities	
	Other (describe): Case studies	x
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	15	

Lecture content	
Background	
1	Background
Trends in EU policy on intermodality	
2	Basic concepts
3	Future trends and emerging schemes in European Transport Policy
4	Transportation in an era of change
5	Obstacles and problems
6	Decision-making framework
7	Stakeholders and interrelations
EU legal and institutional frameworks	
8	European institutional framework
9	EU policies and strategies
10	Regulatory frameworks
11	Indicative legislation
Planning and financing schemes	

12	Planning and financing schemes at national level
13	Planning and financing schemes at regional/local level
14	Financing schemes
Guidance to further knowledge acquisition	
15	Case studies
16	Suggested literature
17	List of indicative legislation
Case studies	
Title	**The European policy on intermodal transport**
Thematic area	Governance
Responsible Institute	University of Thessaly
Lecturer	Dr. Giannis Adamos
Respective topic for method	All
Method description	In this course, a number of case studies is used as part of the teaching methods. The case studies are clustered into ports, airports, bus terminals, railways and freight terminals. Each case study is presented in terms of organizational, planning and financing schemes.

Table 3.3: Course C2

Course: C2	
Title	Building business models for intermodal transport interchanges
Thematic area	Governance
Responsible Institute	Fraunhofer Institute for Factory Operation and Automation IFF, Otto-von-Guericke-University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Aim	• Get introduced to business models and the development thereof • Get enabled to analyze the options for and limitations to logistics implementation concepts concerning intermodal transport aspects • Develop a thorough understanding of the physical and monetary aspects and processes of material flow technology in intermodal transport networks • Get enabled to evaluate business models for intermodal transport
Learning outcomes	
• Acquire basic knowledge of intermodal transport interchanges and business models • Acquire knowledge about the processual importance of intermodal transport interchanges in efficient supply chains • Develop skills for logistical evaluations required for the selection of intermodal transport concepts and to assess economic conditions of service and functionality • Enable the analysis and definition of complex intermodal transport networks	
Prerequisites (if any)	
-	
Language	English
Hours	2
Key words	Logistics, business models, intermodal interchanges, modal split, transport modes
Syllabus	This course is composed of two parts, a lecture style introduction to the topic of business models in intermodal transport, in particular intermodal interchanges and an exercise section. The lecture includes the topics of creation and analysis of business models, an introduction to intermodal transport chains, possible transport mode interchanges and their relevant business models and the fundamental principles of technological means and infrastructure in logistics. Further it gives a summary of recent research findings and current applications of intermodal transport. The exercise section is divided into three parts itself. The first part is the assessment of intermodal transport modes, to understand their specific advantages and disadvantages from a technological, economic, and ecological point of view. The second part of the exercise section involves an exemplary shipment, which is to be realized by intermodal transport. The aspects of sustainability and costs are evaluated and a business model for the participants' preferred variant is to be developed. The last exercise section is concerned with the evaluation of a business model using the bm canvas. The objectives of the exercise are deepening the understanding of application fields of intermodal transport, assessing intermodal transport modes on their technological and monetary soundness (which is facilitated by the discussion of possibilities and

	their pros and cons) and gaining practical knowledge on the analysis of business models. The first exercise section is done individually, while the second and third are intended to be done in small groups. The course will conclude with a presentation of the developed business models and preferred intermodal transport solutions for the discussed case. This is followed by a short summary of the workshop, and an evaluation of intermodal interchanges based on a critical discussion.	
Bibliography	• Brinkmann, B. (2005): Seehäfen, Planung und Entwurf, Springer, Berlin. • Fielt, E. (2011): Business Model Definition. Business Service Management, Smart Services CRC Pty Ltd., Vol. 3. • Gleissner, H., Femerling, J. C. (2013): Logistics: Basics - Exercises - Case Studies, Springer, Cham. • Osterwalder, A., Pigneur, Y. (2010): Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, Wiley & Sons, Hoboken, NJ. • Pfohl, H.C. (2010): Logistiksysteme, Betriebswirtschaftliche Grundlagen, Springer, Cham. • Rodrigue, J.-P., Slack, B., Comtois, C. (2013): Transportation Modes, Modal Competition and Modal Shift, In: The Geography of Transport Systems, 3rd ed., New York: Routledge. • Trapp, M. (2014): Realizing Business Model Innovation - A Strategic Approach for Business Unit Managers, Springer Fachmedien, Wiesbaden.	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	
	Exercises	x
	Visits at facilities	
	Other (describe) …summary and critical discussion…………………….	x
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	3	
Lecture content		
1	Business models	
2	Stakeholder´s governance models	

3	Intermodal transport
4	Modes of transport
5	Exercise 1 (Selection and assessment of transport modes)
5	Interchange zones
6	Safety and Security
7	Sustainable interchanges
8	Ownership structures
9	Exercises 2 & 3 (evaluation of transport modes & evaluation of business model)
10	Suggested literature

Exercise	
Title	Intermodal interchange applications
Thematic area	Governance: Selection and assessment of transport modes
Responsible Institute	Otto-von-Guericke-University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Respective topic tor method	3, 4, 5
Method description	Assessment of current application fields of intermodal transport modes to allow for a deepening of the understanding of application fields. The participants select and reason their own preferred intermodal transport mode based on economic, ecological and technological aspects. The results are to be discussed in class.

Exercise 2	
Title	Evaluation of transport modes for intermodal interchanges
Thematic area	Governance: Evaluation of transport modes
Responsible Institute	Otto-von-Guericke University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Respective topic for method	3
Method description	Evaluation and comparison of different transport modes for intermodal transport. The participants will put their newly gained knowledge about the transport modes to work to calculate the transport chain and develop a pro and cons overview of the transport modes for different application fields applying different evaluation criteria (costs, emissions, time). The findings are to be discussed controversially in class.

Exercise 3	
Title	Evaluation of transport modes for intermodal interchanges
Thematic area	Governance: Evaluation of business model

Responsible Institute	Otto-von-Guericke University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Respective topic for method	3
Method description	Evaluation of intermodal transport business models. Transfer of previously calculated transport chain and included transport modes and integrated interchange zones into a business model. Application of business model canvas for description and evaluation of the business model. Participants will practically describe the business model and evaluate it based on the 9 building blocks. The applied method and the resulting findings are to be discussed controversially in class.
Other	
Title	Conclusion of the workshop
Thematic area	Governance: Evaluation of intermodal interchanges, critical discussion, and summary of the workshop
Responsible Institute	Otto-von-Guericke University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Respective topic for method	All
Method description	Concluding the main topics and findings are recapitulated. A critical discussion, of advantages and disadvantages of different transport modes and interchange possibilities is initiated to conclude the lecture.
Additional literature	
Title	Additional Literature on intermodal transport
Thematic area	Governance
Responsible Institute	Otto-von-Guericke University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Instructions	
- *Comtois, C. and B.P.Y. Loo (2015): Sustainable Railway Futures: Issues and Challenges, Transport and Mobility Series, London: Ashgate.* - *Crainic, T. G., Kim, K. H. (2007): Intermodal Transportation, In: Transportation Amsterdam, Elsevier North-Holland, pp. 467-537.* - *Dess, G.G., McNamara, G., Eisner, A.B. (2015): Strategic Management: Creating Competitive Advantages, 8th ed., Mcgraw-Hill Education.* - *Dudek, G., Stadtler, H. (2005): Negotiation-based collaborative planning between supply chain partners. European Journal of Operational Research, 163, pp 668–687.* - *Lun, Y.H., Lai, K.H., Cheng, E. (2010): shipping and logistics management, Springer publishing.* - *Piotrowicz, W., Cuthbertson, R. (2015): Supply chain design and management for emerging markets: learning from countries and regions, Springer International Publishing.* - *Puettmann, C. (2010): Collaborative Planning in Intermodal Freight Transportation, Gabler Verlag.*	

Table 3.4: Course C3 (2017)

Course: C3 (2017)	
Title	**Sustainable development and transportation planning**
Thematic area	Governance
Responsible Institute	University of Thessaly, Greece
Lecturers	Dr. Lambros Mitropoulos Prof. Eftihia Nathanail
Aim	The course aims to provide an understanding of transportation planning at a National, regional and local context through outlining transport strategies, policies and smarter choices for increasing sustainability. Methods and approaches for analysing intermodal transport and sustainable transport interchanges are presented, such as scenarios, forecasting, environmental impact and safety analysis and strategic environmental assessment. The course will provide knowledge on planning and operations of intermodal transport systems and their analysis and evaluation through various measures of performance.
Learning outcomes	
• Implement the basic concepts of transportation modelling, scenario development and forecasting • Identify the challenges and elements for creating sustainable transport systems • Develop relevant policy measures, strategies and select smart solutions to address transport oriented problems • Account for sustainability indicators, implement indicators to different transport systems and compare scenarios with present transport systems • Identify different stakeholder groups and factors influencing transport development • Embed environmental impact and safety assessment approach of transport interchanges	
Prerequisites (if any)	
-	
Language	English
Hours	2
Keywords	Sustainable assessment, freight modelling, forecasting, indicators
Syllabus	This course will focus on integrated development plans with reference to sustainable development and the environment. During the entire course attention is paid to a sustainable development of the transport interchanges for freight in the European Union. First the course will present essential transportation forecasting methodologies that are used at EU level and the importance of forecasting towards estimating transport impacts and successfully delivering transport plans. The components which affect traveling and transportation system performance will be identified. The sustainability principles will be covered. Sustainability Urban Logistics Plans will be analysed. Indicators being estimated by impact assessment of transportation interchanges will be discussed and explained. Students will get exposed to software packages dealing with transportation planning and impact assessment. **Course topics:**

	• Background • Sustainable transport • Smart solutions in sustainable transportation planning • Sustainable urban development and mobility plans • Transportation planning principles • Modelling freight transport • Transport impacts • Environmental impact assessment • Safety impact assessment
Bibliography	• Anylogic (2017). https://www.anylogic.com/ • Banister D. (2002). Transport planning (Transport, Development and Sustainability Series). Second edition. Routledge. • Beckx C, Arentze T, Int Panis L, Janssens D, Vankerkom J, Wets G (2009). An integrated activity-based modelling framework to assess vehicle emissions: approach and application. Environment and Planning B: Planning and Design. 36 (6): 1086–1102. doi:10.1068/b35044. • Cascetta E. (2009). Transportation system analysis: models and applications. 2nd edition. Springer. • Denos C. Gazis. (2002). Traffic theory, Kluwer Academic Publishers. • EUROSTAT, “Methodologies used in surveys of road freight transport in Member States, EFTA and Candidate Countries”, EUROSTAT manuals and guidelines, 2014. • Handbook of Transport Modelling, Handbooks in Transport, Volume 1, Edited by David A. Hensher and Kenneth J. Button, Pergamon, an Imprint of Elsevier Science, 2005. • Hensher D.A., Button K.J. (2000). Handbook of transport modelling, Pergamon. • Lincoln MPO. (2006). Travel demand model. Loma and associates. http://www.princeton.edu/~alaink/Orf467F12/LincolnTravelDemandModel.pdf • Meyer M., Miller E. (2000). Urban transportation planning, 2nd Edition, McGraw-Hill Series in Transportation. • Model validation, Final report revised for TransCAD 4.8. (2008). Alliance Transportation Group, Inc. CARTS TRAVEL DEMAND MODEL IMPROVEMENT PROGRAM (PHASE II) (S) METROPLAN. LITTLE ROCK ARKANSAS. • Moshe E. Ben-Akiva, Steven R. Lerman. (1985). Discrete choice analysis: Theory and application to travel demand. The MIT Press. • Oppenheim, N. (1995). Urban travel demand modeling, from individual choices to general equilibrium, J. Wiley & Sons. • Richardson E.A, and A. Meyburg. (1995). Survey methods for transport planning. Eucalyptus Press. • Stopher P. and M.Lee-Gosselin. (1997). Understanding travel behaviour in an era of change. Pergamon. • Trip generation manual. (2014). 9th edition, Institute of Transportation Engineers ITE. • Weidner T.J., Donnelly R., Freedman J., Abraham J.E., Hunt J.D. (2007). A summary of the oregon TLUMIP model microsimulation modules. Presented at

	the 86th Annual Meeting of the Transportation Research Board, Washington D.C. • Willumsen L. (2014). Better traffic and revenue forecasting. Maida Vale Press.	
Teaching methods	Lectures	x
	Demonstrations	
	Hands on/gaming	
	Exercises	
	Visits at facilities	
	Other (please describe):	
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	9	

Lecture content	
1	Sustainable transport
2	Smart solutions in sustainable transportation planning
3	Sustainable urban development and mobility plans
4	Transportation planning principles
5	Modelling freight transport
6	Transport impacts
7	Environmental impact assessment
8	Safety impact assessment
9	Suggested literature

Table 3.5: Course C3 (2018)

Course: C3 (2018)	
Title	**Sustainable development and transportation planning**
Thematic area	**Governance**
Aim	The course aims to provide an understanding of transportation planning at a National, regional and local context through outlining transport strategies, policies and smarter choices for increasing sustainability. Methods and approaches for analysing intermodal transport and sustainable transport interchanges are presented, such as scenarios, forecasting, environmental impact and safety analysis and strategic environmental assessment. The course will provide knowledge on planning and operations of intermodal transport systems and their analysis and evaluation through various measures of performance.
Learning outcomes	
• Implement the basic concepts of transportation modelling, scenario development and forecasting • Identify the challenges and elements for creating sustainable transport systems • Develop relevant policy measures, strategies and select smart solutions to address transport oriented problems • Account for sustainability indicators, implement indicators to different transport systems and compare scenarios with present transport systems • Identify different stakeholder groups and factors influencing transport development • Embed environmental impact and safety assessment approach of transport interchanges	
Prerequisites (if any)	
-	
Language	English
Hours	2
Responsible personnel/institute	University of Thessaly
Lecturers	Dr. Lambros Mitropoulos Prof. Eftihia Nathanail
Syllabus	This course will focus on integrated development plans with reference to sustainable development and the environment. During the entire course attention is paid to a sustainable development of the transport interchanges for freight in the European Union. First the course will present essential transportation forecasting methodologies that are used at EU level and the importance of forecasting towards estimating transport impacts and successfully delivering transport plans. The components which affect traveling and transportation system performance will be identified. The sustainability principles will be covered. Sustainability Urban Mobility Plans will be analysed. Indicators being estimated by impact assessment of transportation interchanges will be discussed and explained. Students will get exposed to software packages dealing with transportation planning and impact assessment. **Course topics:**

	• Sustainable transport • Smart solutions in sustainable transportation planning • Sustainable urban development and mobility plans • Transportation planning principles • Transportation planning models • Transport impacts • Environmental impact assessment • Safety impact assessment	
Bibliography	• Banister D. (2002). Transport Planning (Transport, Development and Sustainability Series). Second edition. Routledge. • Beckx C, Arentze T, Int Panis L, Janssens D, Vankerkom J, Wets G (2009). "An integrated activity-based modelling framework to assess vehicle emissions: approach and application". Environment and Planning B: Planning and Design. 36 (6): 1086–1102. doi:10.1068/b35044. • Cascetta (2009). Transportation System Analysis: models and applications. 2nd edition. Springer. • Denos C. Gazis, (2002). Traffic Theory, Kluwer Academic Publishers. • Hensher D.A., Button K.J., Handbook of Transport Modelling, Pergamon, 2000. • Lincoln MPO, Travel demand model, (2006). Loma and associates. http://www.princeton.edu/~alaink/Orf467F12/LincolnTravelDemandModel.pdf • Meyer M. and E.Miller (2000). Urban Transportation Planning 2nd Edition, McGraw-Hill Series in Transportation. • Model validation, Final report revised for TransCAD 4.8, (2008). Alliance Transportation Group, Inc. CARTS TRAVEL DEMAND MODEL IMPROVEMENT PROGRAM (PHASE II) (S) METROPOLITAN. LITTLE ROCK ARKANSAS • Moshe E. Ben-Akiva, Steven R. Lerman (1985). Discrete Choice Analysis: Theory and Application to Travel Demand, The MIT Press. • Oppenheim, N. Urban Travel Demand Modeling, From Individual Choices to General Equilibrium, J. Wiley & Sons, 1995. • Ortuzar, J. D. and L. G. Willumsen, Modelling Transport, (2011). J. Wiley & Sons. • Richardson, E. Ampt, and A. Meyburg (1995). Survey Methods for Transport Planning, Eucalyptus Press. • Stopher P. and M.Lee-Gosselin, (1997). Understanding travel behaviour in an era of change, Pergamon. • Trip generation manual, (2014). 9th edition, Institute of Transportation Engineers ITE. • Weidner, T.J., Donnelly, R., Freedman, J., Abraham, J.E., and J.D. Hunt (2007). A Summary of the Oregon TLUMIP Model Microsimulation Modules, presented at the 86th Annual Meeting of the Transportation Research Board, Washington D.C. • Willumsen, L. (2014). Better Traffic and Revenue Forecasting. Maida Vale Press.	
Teaching methods	Lectures	x

	Demonstrations	
	Hands on/gaming	
	Exercises	
	Visits at facilities	
	Other (please describe):	
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
Creative Commons (CC) Licenses	CC-Attribution-NonCommercial-NoDerivatives	
Number of topics	9	
Lecture content		
1	Sustainable transport	
2	Smart solutions in sustainable transportation planning	
3	Sustainable urban development and mobility plans	
4	Transportation planning principles	
5	Transportation planning models	
6	Transport impacts	
7	Environmental impact assessment	
8	Safety impact assessment	
9	Suggested literature	

Table 3.6: Course C4 (2017)

Course: C4 (2017)	
Title	**Operation and management of intermodal transport systems: freight interchanges**
Thematic area	Governance
Responsible Institute	University of Thessaly, Greece
Lecturers	Dr. Giannis Adamos Prof. Eftihia Nathanail
Aim	• This course is oriented to the operation and management of freight interchanges • It analyzes the organization of interchanges regarding operational functionality, management and efficiency of services.
Learning outcomes	
• Provide an understanding of how stakeholder engagement and management works • Conduct an operational analysis, with the use of integrated management and operation practices, which are based on structures met in several European countries and case studies • Recognize and assess implications revealing from different regulatory, operational and managerial structures • Analyze the impacts of interchanges on local economy and the role they have in land use planning.	
Prerequisites (if any)	
-	
Language	English
Hours	2
Key words	Interchange, operation, management, stakeholders, transshipment, information and communication technologies.
Syllabus	The course analyzes the involvement of stakeholders and stakes, and respective questions are answered, such as: “Why, when and which stakeholders to involve?”, “What is public involvement, and what kind of public should be involved within the interchange decision-making process”, etc. In addition, the course analyzes the organization of interchanges in terms of operational functionality, management, practicalities, services and efficiency, while the impacts on local economy and land use planning are also introduced. **Course topics:** • Background • Stakeholders • Interchange types • Aspects of interchange typology • Development • Operation • Management • Information and Communications Technologies

	• Main principles for management and operational structures • Case studies • Suggested literature	
Bibliography	• Ballis, A., 2004. Introducing Level of Service Standards for Intermodal Freight Terminals. Transportation Research Record: Journal of the Transportation Research Board, Vol 1873, Washington DC, pp. 79-88. • Banister, D. & Berechman, Y., 2001. Transport investment and the promotion of economic growth. Journal of Transport Geography, 9(2001) 209-218. • Bask, A. 1999. Third Party Relationships in Logistics Services, Helsinki School of Economics and Business Administration, Licentiate Thesis, Helsinki. 140 p. • European Commission, 2001. White Paper " European transport policy for 2010: Time to decide (CEC, 2001). • European Commission, 2006. Keep Europe Moving. Sustainable mobility for our continent. Mid-term review of the European Commission’s 2001 transport White Paper. ISBN 92-79-02312-8. Luxemburg: Office for Official Publications of the European Communities, 2006. • European Communities, 2009. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Action Plan of Urban Mobility. COM (2009) 490 final. Brussels, Belgium. • European Commission, 2011. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. White Paper. COM (2011) 144 final. European Commission. Brussels, Belgium. • Gogas, M., Papoutsis, K., Nathanail, E., Adamos, G. & Kapetanopoulou, P., 2012. A comparison study on urban-interurban interfaces on ports – The Constantza and Thessaloniki ports case studies. 2nd International Conference on Supply Chains, Katerini, Greece, October 5-6, 2012. • Harris, I., Wang, Y. & Wang, H., 2015. ICT in multimodal transport and technological trends: Unleashing potential for the future. Int. J. Production Economics 159 (2015) 88-103. • IMONODE, 2005. WP3: Supply side – Intermodal network analysis. IMONODE – Efficient Integration of Cargo Transport Modes & Nodes in CADSES area. • Monzon, A. & Di Ciommo, F. (Editors), 2015. CITY-HUBs: Sustainable and Efficient Interchange Stations. Taylor and Francis Group. • Nathanail, E., 2007. "Developing an integrated logistics terminal network in the CADSES area", Transition Studies Review, issue 45. • NOVELOG, 2016a. NOVELOG Deliverable D2.2. Urban freight and service transport in European cities. • Papoutsis, E. Nathanail, 2016. Facilitating the Selection of City Logistics Measures through a Concrete Measures Package: A Generic Approach Transportation Research Procedia 12, 679-691. • NOVELOG, 2016b. NOVELOG Deliverable D5.1. City cases implementation. • STRAIGHTSOL, 2014a. STRAIGHTSOL Deliverable D5.1. Demonstration assessments. • STRAIGHTSOL, 2014b. STRAIGHTSOL Deliverable D5.3. Business models for innovative and sustainable urban-interurban transport.	
Teaching methods	Lecture	x
	Demonstration	

	Hands on/games	
	Exercises	
	Visits at facilities	
	Other (describe): Case studies	x
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	11	
Lecture content		
Background		
1	Background	
Stakeholders		
2	Stakeholders’ engagement and management	
3	Why, when, which and how to involve stakeholders	
4	Public involvement	
5	Levels of involvement	
Operational and management structures		
6	Interchange types	
7	Aspects of interchange typology	
8	Development	
9	Operation	
10	Management	
11	Information and Communications Technologies	
12	Main principles for management and operational structures	
Applications		
13	Urban Freight Transport solutions	
14	Case studies	
Guidance to further knowledge acquisition		
15	Suggested literature	
Urban Freight Transport solutions		

Title	**Operation and management of intermodal transport systems: freight interchanges**
Thematic area	Governance
Responsible Institute	University of Thessaly
Lecturers	Dr. Giannis Adamos Prof. Eftihia Nathanail
Respective topic for method	All
Method description	In this part of the lecture, a number of Urban Freight Transport solutions are presented, as they have been implemented or will be implemented in specific European cities. These solutions are: multimodality for urban freight, urban consolidation centers, transhipment facilities, city lockers, loading/unloading and parking, businesses recognition scheme, and public transport for freight.
Case study	
Title	**Operation and management of intermodal transport systems: freight interchanges**
Thematic area	Governance
Responsible Institute	University of Thessaly
Lecturers	Dr. Giannis Adamos Prof. Eftihia Nathanail
Respective topic for method	All
Method description	In this course, two case studies are used as part of the teaching methods. The first case study regards the Kuehne_Nagel rail tracking and warehouse management demonstration, and the second one, refers to a cross-case comparison of Constantza Port in Romania, and Thessaloniki Port in Greece.

Table 3.7: Course C4 (2018)

Course: C4 (2018)	
Title	**Operation and management of intermodal transport systems: passenger interchanges**
Thematic area	Governance
Responsible Institute	University of Thessaly, Greece
Lecturer	Dr. Giannis Adamos
Aim	• This course is oriented to the operation and management of passenger interchanges • It analyzes the organization of interchanges regarding operational functionality, management and efficiency of services • The impacts of the interchanges operation on local economy and land use planning are also addressed.
Learning outcomes	
• Provide an understanding of how stakeholder engagement and management works • Conduct an operational analysis, with the use of integrated management and operation practices, which are based on structures met in several European countries and case studies • Recognize and assess implications revealing from different regulatory, operational and managerial structures • Analyze the impacts of interchanges on local economy and the role they have in land use planning, in terms of revenues for local enterprises, new start-up businesses, new jobs, etc.	
Prerequisites (if any)	
-	
Language	English
Hours	2
Key words	Interchange, operation, management, stakeholders, accessibility, urban planning, integrated information systems, ticketing.
Syllabus	The course analyzes the involvement of stakeholders and stakes, and respective questions are answered, such as: “Why, when and which stakeholders to involve?”, “What is public involvement, and what kind of public should be involved within the interchange decision-making process”, etc. In addition, the course analyzes the organization of interchanges in terms of operational functionality, management, practicalities, services and efficiency, while the impacts on local economy and land use planning are also introduced. **Course topics:** • Background • Stakeholders • Interchange types • Operation key factors • Operation • Management

	• Interchange management plan • Special definition plan • User feedback • Integrated information systems and ticketing • Accessibility • Main principles for management and operational structures • The role of interchanges in urban planning • Case studies • Suggested literature	
Bibliography	• Banister, D. & Berechman, Y., 2001. Transport investment and the promotion of economic growth. Journal of Transport Geography, 9(2001) 209-218. • City-HUB, 2013. City-HUB Deliverable D2.3. Lessons from descriptive case studies – recommendations for City-HUB model. • City-HUB, 2013. City-HUB Deliverable D4.1. Integrated management of efficient urban interchanges. • City-HUB, 2015. City-HUB Deliverable D5.2. City-HUB Handbook. • European Commission, 2001. White Paper " European transport policy for 2010: Time to decide (CEC, 2001). • European Commission, 2006. Keep Europe Moving. Sustainable mobility for our continent. Mid-term review of the European Commission's 2001 transport White Paper. ISBN 92-79-02312-8. Luxemburg: Office for Official Publications of the European Communities, 2006. • European Communities, 2009. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Action Plan of Urban Mobility. COM (2009) 490 final. Brussels, Belgium. • European Commission, 2011. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. White Paper. COM (2011) 144 final. European Commission. Brussels, Belgium. • GUIDE Terzis, G., Last, An. GUIDE – Urban Interchanges – A Good Practice Guide – Final Report prepared for EC DG VII. April, 2000. • Grotenhuis, J.W., W.W. Bart and P. Rietveld, 2007. "The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort saving". Transport Policy, Vol. 14, pp. 27-38. • Monzon, A. & Di Ciommo, F. (Editors), 2015. CITY-HUBs: Sustainable and Efficient Interchange Stations. Taylor and Francis Group. • PIRATE project, 2001. Final report. Accessed by http://www.transport-research.info/web/projects/project_details.cfm?ID=593 on 11/03/2013.	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	
	Exercises	
	Visits at facilities	
	Other (describe): Case studies	x
	Homework	

Evaluation methods	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	15	

Lecture content	
Background	
1	Background
Stakeholders	
2	Stakeholders' engagement and management
3	Why, when, which and how to involve stakeholders
4	Public involvement
5	Levels of involvement
Operational and management structures	
6	Interchange types
7	Operation key types
8	Operation
9	Management
10	Interchange management plan
11	Special definition plan
12	User feedback
13	Integrated information systems and ticketing
14	Accessibility
15	Main principles for management and operational structures
16	The role of interchanges in urban planning
Applications	
17	Case studies
Guidance to further knowledge acquisition	
18	Suggested literature

Case study	
Title	**Operation and management of intermodal transport systems – passenger interchanges**
Thematic area	Governance

Responsible Institute	University of Thessaly
Lecturer	Dr. Giannis Adamos
Respective topic for method	All
Method description	In this course, a number of case studies is used as part of the teaching methods. Good practices in several topics, i.e. operation and management structures are presented, while the findings of a number of surveys conducted in specific European interchanges are also introduced.

Table 3.8: Course C5

Course: C5	
Title	**Optimization of intermodal transport systems**
Thematic area	Governance
Responsible Institute	University of Thessaly (UTh), Greece
Lecturer	Prof. Eftihia Nathanail
Aim	The aim of this course is to introduce students with the principle of optimization, and the mathematical models that are built to facilitate decisions, in the context of reaching the optimum taking into account applying restrictions.
Learning outcomes	
• Identifying variables and relationships that govern in an optimization problem. • Develop mathematical formulations that take into account the optimization of the objective function, safeguarding the satisfaction of constraints and limitations. • Use computer programs that solve optimization problems.	
Prerequisites (if any)	
-	
Language	English
Hours	3
Key words	Optimization, mathematical formulations, linear programming technique, integer lineal programming technique
Syllabus	The course identifies the components that formulate a problem and the decision variables that need to be estimated for its solution. Firstly, it introduces the student to the network structure of the problem, and the conversion in mathematical terms of the decision variables and the constraints that apply. It presents the concept of linear programming, and the alternative ways to formulate an optimization problem, depending on the variables to be defined by the analyst. The linear programming technique is explained in depth and presented through the solution of examples. A more specific category of linear programming, integer linear programming is also studied. In this case, the variables may only obtain integer values, which restricts the number of possible solutions. Finally, the transportation problem is described and solved, as well as other specific applications that deal with vehicle routing, resource allocation and facility location. **Course topics:** • Basic concepts • Basic elements • Optimization Rules • Optimization Techniques • Software and applications • Guidance to further knowledge acquisition

Bibliography	• Anjos, M. F. and Vieira V.C.M. (2016). Mathematical optimization approaches for facility layout problems: The state-of-the-art and future research directions, European Journal of Operational Research, Volume 261, Issue 1, 16 August 2017, Pages 1-16. • Arnone, M., Mancini, S. and Rosa, A. (2014). Formulating a Mathematical Model for Container Assignment Optimization on an Intermodal Network Procedia - Social and Behavioral Sciences, Volume 111, 5 February 2014, Pages 1063-1072. • D. W. Wang, J. W. Wang, R. Y. Zhang and Z. Guo, (2007). Ed. Intelligent Optimization Methods. Higher Education Press, Beijing, 2007. • Daskin MS, “Networks and discrete location”, Wiley, New York, NY, 1995. • Flötteröd, G. (2017). A search acceleration method for optimization problems with transport simulation constraints, Transportation Research Part B: Methodological, Volume 98, April 2017, Pages 239-260. • Gambardella, L.M., Mastrolilli, M., Rizzoli, A.E. and Zaffalon, M. (2001). An optimization methodology for intermodal terminal management. Journal of intelligent manufacturing 12:521:534. • Hao, C. and Yue, Y. (2016). Optimization on Combination of Transport Routes and Modes on Dynamic Programming for a Container Multimodal Transport System, Procedia Engineering, Volume 137, 2016, Pages 382-390. • Pedersen, M. B., Madsen, O. B. G., & Nielsen, O. A. (2005). Optimization models and solution methods for intermodal transportation. • Sörensen, K. and Vanovermeire, C. (2013). Bi-objective optimization of the intermodal terminal location problem as a policy-support tool Computers in Industry, Volume 64, Issue 2, February 2013, Pages 128-135. • Sun, Y., Lang, M., and Wang, D., (2015). Optimization Models and Solution Algorithms for Freight Routing Planning Problem in the Multi-Modal Transportation Networks: A Review of the State-of-the-Art. The Open Civil Engineering Journal, 2015, 9, 714-723. • Taha Hamdy (2011). Operations Research: An introduction. Prendice Hall. • Yang, K., Yang, L., Gao, Z. (2016). Planning and optimization of intermodal hub-and-spoke network under mixed uncertainty, Transportation Research Part E: Logistics and Transportation Review, Volume 95, November 2016, Pages 248–266. • Wang, Q. B. and Z. X. Han (2010). “The optimal routes and modes selection in container multimodal transportation networks,” Int. Conf. Optoelectron. Image Process., vol. 2, pp. 573-576, 2010.	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	
	Exercises	
	Visits at facilities	
	Other (describe): Case studies	
Evaluation methods	Homework	
	Class project	
	Interim examination	

	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	6	

Lecture content	
1	Basic concepts
2	Basic elements
3	Optimization Rules
4	Optimization Techniques
5	Software and applications
6	Guidance to further knowledge acquisition

Table 3.9: Course C6

Course: C6	
Title	**Intelligent services for passenger transportation**
Thematic area	Smart solutions
Responsible Institute	Fraunhofer Institute for Factory Operation and Automation IFF, Otto-von-Guericke-University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Aim	• Get introduced to public transport management and its technical services • Get a research summary covering passenger transport (modes) and an overview of information technology for the passenger transport market • Understand the use of telematics to manage public transport networks and the development and implementation of flexible, reliable, and efficient multimodal transport concepts • Gain an overview of possible IT application fields for passenger transport (e.g. ticketing, routing, etc.).
Learning outcomes	
• Acquire knowledge about smart information systems for multimodal travel and platforms to coordinate integrated transport services • Understand the levels of ITS deployment and their possibilities for passenger networks • Introduction to the use of essential tools to conduct strategic analyses for network planning and optimization • Understand the aim and scope of Transport Demand Management • Understand the combination of strengths of different transport modes (multimodal concepts).	
Prerequisites (if any)	
-	
Language	English
Hours	2
Key words	Logistics, Intelligent transport services, multimodal transport, passenger transport
Syllabus	This course is composed of two parts, a lecture style introduction to the topic of intelligent services for passenger transport and an exercise section. The lecture includes the topics of intermodal and multimodal passenger concepts, the analysis and summary of research findings and recommendations concerning IT-services to improve passenger transport, general ideas of smart information systems for intermodal travel and platforms to coordinate integrated transport services, as well as the use of real time information and smart combination of transport modes facilitates more efficient use of existing infrastructure. The exercise section is divided into two parts itself. The assessment of a case study with the objective of deepening the understanding of application fields and assessing applied intelligent services and two exercises. The first exercise aims to facilitate the understanding of Transport Demand Management while the second aims at evaluating and subsequently discussing current and future application fields in the students' local environment. The first exercise section is done individually, while the second is intended to be done in small groups.

	The course will conclude with a presentation of local application fields, a summary of the workshop, and an evaluation of intelligent services for passenger transport based on a critical discussion. **Course topics:** • Mobility goals • Public transport management • Passenger transport modes • Information technology for passenger transport market • Telematics for public transport network • IT application fields for passenger transport (ticketing, real-time information service, transport demand management)
Bibliography	• Austin, J. (2016): Passenger Transport Operations, Transport Demand Management, World Road Association, available online at: http://rno-its.piarc.org/en/user-services/passenger-transport (accessed on 28 Sep. 2016). • Berg Insight (2013): ITS in Public Transport, Berg Insight, 3rd ed., available online at: www.berginsight.com/reportpdf/productsheet/bi-its3-ps.pdf (accessed on 7 Oct. 2016). • BMVI (2014/2015): Verkehr in Zahlen 2014/2015, Ed.: Bundesministerium für Verkehr und digitale Infrastruktur, available online at: http://www.umweltbundesamt.de/daten/verkehr/modal-split-des-personen-gueterverkehrs (accessed 11 Oct. 2016). • Broaddus, A., Litman, T., Menon, G. (2009): Transportation Demand Management, Training Document, Division 44, Water, Energy and Transport, Sustainable Urban Transport Project (SUTP), gtz, Federal Ministry for Economic Cooperation and Development, available online at: http://www.sutp.org/files/contents/documents/resources/H_Training-Material/GIZ_SUTP_TM_Transportation-Demand-Management_EN.pdf (accessed 23 Jan. 2017). • Gnap, J., et al. (n.d.): Improving of information for passengers of urban public transport in Košice, University of Zilina, Faculty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport, available online at: www.southeast-europe.net/document.cmt?id=848 (accessed on 10 Oct. 2016). • Intertraffic (2016): Intertraffic Amsterdam, Smart Mobility, available online at: http://www.intertraffic.com/amsterdam/innovations/smart-mobility (accessed 10 Oct. 2016). • Litman, T. (2016): Guide to Calculating Mobility Management Benefits, Victoria Transport Policy Institute, 250-360-1560, available online at: http://www.vtpi.org/tdmben.pdf (accessed 23 Jan. 2017). • Nökel, K., Gentile, G. (2016): Modelling Public Transport Passenger Flows in the Era of Intelligent Transport Systems, Springer, Cham. • Passenger Transport (2013): Thematic Research Summary: Passenger Transport, Ed.: Transport Research and Innovation Portal on behalf of DG MOVE, available online at: http://www.kowi.de/Portaldata/2/Resources/fp/trip-passenger-transport.pdf (accessed 10 Oct. 2016). • Rodrigue, J-P et al. (2017): The Geography of Transport Systems, Hofstra University, Department of Global Studies & Geography, available online at: http://people.hofstra.edu/geotrans (accessed 5 Oct. 2016).

	• Siemens (2013): Integrated Mobility Platform; Siemens Infrastructure & Cities - Traffic Solutions, available online at: http://www.siemens.co.uk/traffic/pool/documents/brochure/imp-4pp.pdf (accessed on 5 Oct. 2016). • Wilson, N. (2009): The Role of Information Technology in Improving Transit Systems, Transportation at MIT, Lecture, available online at: http://transportation.mit.edu/news/role-of-it (accessed on 28 Sep. 2016).	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	
	Exercises	x
	Visits at facilities	
	Other (describe) ……critical discussion and summary…………………………	x
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
Creative Commons (CC) Licenses	CC-Attribution-NonCommercial-NoDerivatives	
Number of topics	6	
Lecture content		
1	Background	
2	Theoretical methodologies	
3	Mobility goals	
4	Public transport management	
5	Passenger transport modes	
6	Information technology for passenger transport market	
7	Telematics for public transport network	
8	IT application fields for passenger transport	
9	Ticketing	
10	Real-Time Information Service	
11	Transport Demand Management	
12	Applications – Case study	

13	Suggested Literature
Case study	
Title	Intelligent services for passenger transportation: Possibilities for the use of smart cards
Thematic area	Smart solutions: Ticketing and Data Collection
Responsible Institute	Otto-von-Guericke-University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Respective topic tor method	9, 12
Method description	A case study is used to assess current application fields of intelligent services for passenger transport and to allow for a deepening of the understanding of application fields.
Exercises	
Title	Transport Demand Management & Intelligent services for passenger transportation: Current applications and future application fields in the students local environment
Thematic area	TDM & Smart solutions: Application fields and possibilities
Responsible Institute	Otto-von-Guericke-University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Respective topic for method	4, 8, 13
Method description	Understanding of TDM tools and possibilities Assessment and identification of currently applied intelligent services in the close environment of the students. This is done to support the understanding of the current situation and future potentials. Following the students are to develop future application scenarios in groups and present their ideas in the class.
Other	
Title	Intelligent services for passenger transportation: Conclusion of the workshop
Thematic area	Smart solutions: Evaluation of intelligent services for passenger transport, critical discussion, and summary of the workshop
Responsible Institute	Otto-von-Guericke-University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Respective topic for method	-
Method description	Concluding the main topics and findings are recapitulated. A critical discussion, involving all participants, of potentials and risks of intelligent services is initiated to conclude the lecture.
Additional literature	
Title	Intelligent services for passenger transportation

Thematic area	Smart solutions
Responsible Institute	Otto-von-Guericke-University Magdeburg, Germany
Lecturer	Dr.-Ing. Henning Strubelt
Instructions	
- *Gnap, J., et al. (n.d.): Improving of information for passengers of urban public transport in Košice, University of Zilina, Faculty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport, available online at: www.southeast-europe.net/document.cmt?id=848 (accessed on 10 Oct. 2016).* - *Litman, T. (2016): Guide to Calculating Mobility Management Benefits, Victoria Transport Policy Institute, 250-360-1560, available online at: http://www.vtpi.org/tdmben.pdf (accessed 23 Jan. 2017).* - *Nökel, K., Gentile, G. (2016): Modelling Public Transport Passenger Flows in the Era of Intelligent Transport Systems, Springer, Cham.* - *Sładkowski, A., Pamuła, W. (2016): Intelligent Transportation Systems – Problems and Perspectives, Springer, Cham.*	

Table 3.10: Course C7

<table>
<tr><th colspan="2">Course: C7</th></tr>
<tr><td>**Title**</td><td>**Smart information technologies in freight transport logistics**</td></tr>
<tr><td>**Thematic area**</td><td>Smart solutions</td></tr>
<tr><td>**Responsible Institute**</td><td>Fraunhofer Institute for Factory Operation and Automation IFF,
Otto von Guericke University Magdeburg</td></tr>
<tr><td>**Lecturer**</td><td>Olaf Poenicke, Oliver Meier</td></tr>
<tr><td>**Aim**</td><td>Teaching of basics for ICT for freight relevant applications for
• Identification (Auto-ID)
• Image Processing and Localization
• 3D-Scanning
• Tracking and Tracing</td></tr>
<tr><td colspan="2">**Learning outcomes**</td></tr>
<tr><td colspan="2">The audience gains basic information and experience (demonstration and hands-on) about modern information and communication technologies that are relevant in logistics processes (transport as also intra logistics).
The overview on the different types of technology is the basis for the future digitalization of logistics processes and the development of new smart services for logistics applications.
Furthermore open fields for R&D can be identified to discuss approaches for future international collaborative R&D projects.</td></tr>
<tr><td colspan="2">**Prerequisites (if any)**</td></tr>
<tr><td colspan="2">• Basic knowledge about logistics
• Technical understanding</td></tr>
<tr><td>**Language**</td><td>English</td></tr>
<tr><td>**Hours**</td><td>2</td></tr>
<tr><td>**Key words**</td><td>Information Systems, Smart Logistics, Auto-ID, Image Processing, Localization, 3D-Scanning, Tracking & Tracing</td></tr>
<tr><td>**Syllabus**</td><td>The course will be divided into three modules.
Module 1 – will teach the basics of the different technologies as listed above. Starting from an overview on ICTs relevant for logistics applications, single relevant technologies like RFID, Image processing, 3D scanning and Tracking & Tracing will be explained in detail. The Module 1 will also give a brief overview on typical applications of the ICTs and development trends.
Duration approx. 75 mins.
Module 2 – will give short demonstrations and a hands-on for the technologies of RFID, 3D scanning and Tracking & Tracing. The aim of the Module is to deepen the understanding of these technologies – the possible usage as also the limitations of the technologies within different application environments and conditions.
Duration approx. 30 mins.
Module 3 – will give the opportunity to discuss and identify possible applications and trends of ICT for Smart Logistics. It is also possible to discuss open questions for single contents of the other two modules.</td></tr>
</table>

	Duration approx. 15 mins.	
Bibliography	• Schenk, M. (Hrsg.): Produktion und Logistik mit Zukunft – Digital Engineering and Operation. Springer, 2015. • Richter, K.: Lecture – Telematik und Identtechnik, Otto-von-Guericke-Universität Magdeburg, 2015/2016. • Finkenzeller, K. (Hrsg.): RFID-Handbuch: Grundlagen und praktische Anwendungen von Transponders, kontaktlosen Chipkarten und NFC. • Krampe, H., Lucke, H., Schenk, M. (Hrsg.): Grundlagen der Logistik: Theorie und Praxis logistischer Systeme. Huss Verlag, 2012. • Bartneck, N., Klaas, V., Schönherr, H.: Prozesse optimieren mit RFID und Auto-ID. Publicis Publishing, 2008. • Roth, A. (Hrsg.): Einführung und Umsetzung von Industrie 4.0: Grundlagen, Vorgehensmodell und Use Cases aus der Praxis. Springer, 2016. • Poenicke, O.: Workshop – Grundlagen Auto-ID und RFID, Fraunhofer IFF, 2016. • Norms and Standards – e.g. GS1 – Tag Data Standard (version 1.9); VDA 5500; DIN 66277 • Young, I., Gerbrands, J., van Vliet, L.: Fundamentals of Image Processing. Delft University, 2007. http://homepages.inf.ed.ac.uk/rbf/CVonline/LOCAL_COPIES/TUDELFT/FIP2_3.pdf • Borstell, H. et al: Pallet Monitoring System Based on a Heterogeneous Sensor Network for Transparent Warehouse Processes; 9th Workshop Sensor Data Fusion: Trends, Solutions, and Applications; Bonn, 08.-10.10.2014. • Borstell, H. et al: Toward Mobile Monitoring of Cargo Compartment Using 3D Sensors for Real-Time Routing, To appear in: Lect. Notes Logistics, Jan Dethloff et al. (Eds): Logistics Management, 978-3-319-13176-4, Springer, 2015. http://www.springer.com/de/book/9783319131764 • Bendriss, S., Benabdelhafid, A. (2011): Multimodal transport information system : modelling approach for goods traceability in: International journal of business information systems : IJBIS Olney, Bucks. : Inderscience Enterprises Vol. 7, No. 4 (2011), p. 365-387. Band: 7:4<365-387. • Gleissner, H., Möller, K. (2011): Case Studies in Logistics. Gabler Verlag, Wiesbaden. • Laudon, K. C., Laudon, J. P. (2014): Management Information Systems: Managing the digital Firm. Pearson Education Limited, Essex. • Olson, D. L. (2012): Supply Chain Information Technology. Business Expert Press, LLC, New York. • Turner, Vernon, D. Reinsel, J. F. Gantz und S. Minton (2014). White Paper: The Digital Universe of Opportunities: Rich Data and the Increasing Value of the Internet of Things. International Data Corporation (IDC), Framingham, USA.	
Teaching methods	Lecture	x
	Demonstration	x
	Hands on/games	x
	Exercises	
	Visits at facilities	

	Other (describe)	
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe)	
Creative Commons (CC) Licenses		
Number of topics		
Lecture content		
1	Background information systems	
2	Auto-ID and IT infrastructure	
3	Image Processing and image based localisation	
4	3D scanning	
5	Tracking and Tracing	
Demonstration		
Title	Smart Technologies for Efficient Transport Logistics	
Thematic area	Smart solutions	
Responsible Institute	Fraunhofer Institute for Factory Operation and Automation IFF	
Lecturer	Olaf Poenicke	
Respective topic for method	All	
Method description	Short demonstrations and a hands-on for the two technologies of RFID and 3D scanning are given. The aim of the Module is to deepen the understanding of these technologies – the possible usage as also the limitations of the technologies within different application environments and conditions. (See PP)	
Demonstration 2		
Title	Fraunhofer Telematics	
Thematic area	Tracking & Tracing	
Responsible Institute	Fraunhofer Institute for Factory Operation and Automation IFF, Otto von Guericke University Magdeburg	
Lecturer	Oliver Meier	
Respective topic for method	Tracking & Tracing	
Method description	Demonstration 2 includes a short description of the T&T-system “Fraunhofer Telematics” and two fields of application for it: T&T of chemical goods in multimodal transport chains and inventory management for large components.	

	The aim of the Module is to deepen the understanding of these technologies – the possible usage as also the limitations.
Hands on/games	
Title	Smart Technologies for Efficient Transport Logistics
Thematic area	Smart solutions
Responsible Institute	Fraunhofer Institute for Factory Operation and Automation IFF
Lecturer	Olaf Poenicke
Respective topic for method	All
Method description	Short demonstrations and a hands-on for the two technologies of RFID and 3D scanning are given. The aim of the Module is to deepen the understanding of these technologies – the possible usage as also the limitations of the technologies within different application environments and conditions. (See PP)

Table 3.11: Course C8

Course: C8	
Title	**Design of passenger transport interchanges**
Thematic area	Smart solutions
Responsible Institute	University of Thessaly, Greece
Lecturers	Dr. Giannis Adamos
Aim	• Gain skills to design medium and large scale infrastructure and increase the perception of creating effective and efficient solutions that rely on safety principles • Understand the design requirements and special characteristics of passenger interchanges for designing accessible infrastructure • The course aims at achieving a synergy between substantive technical knowledge and safety consideration knowledge.
Learning outcomes	
• Acquire practical knowledge of design aspects for passenger transport interchanges • Possess a good understanding of passenger interchanges, know design principles of accessibility and acquire basic engineering skills in interchange planning • Provide an understanding of the fundamental relationships involved in the design of passenger interchanges by integrating facilities, retailing, passenger transfer and considering interactions with other sectors and future challenges • Ensure that students have a sound understanding of the key issues affecting the planning, safety and comfort of passenger terminals.	
Prerequisites (if any)	
-	
Language	English
Hours	3
Key words	Interchange, design, users, access/egress, facilities, accessibility, safety, way-finding, permeability, legibility
Syllabus	This course is composed of two educational areas: 1) Design and safety principles of transport terminal infrastructure, and 2) Passenger terminal design. The course covers the access/egress aspects of passenger interchanges as local area, the transport and transfer of passengers for intermodal transport, the development and integration of facilities and retailing within the interchange. Also, attention is paid to safety and security, to aspects that facilitate passengers to understand the facility, such as way-finding, permeability, legibility and inclusivity, and to the physical accessibility aspects of designing transport interchanges. The course is supplemented by a series of case studies to demonstrate the design of the main transport infrastructure in the European Union. Especially, medium to large-scale infrastructure is included, for which all the above aspects are covered with up-to-date and extensive good practices met in specific case studies, such as the Moncloa interchange in Spain, the Kamppi interchange in Finland, the New Railway Station of Thessaloniki in Greece, the Kőbánya-Kispest interchange in Hungary and other.

	Course topics: • Background • Basic concepts in design • Interchange zones • Key interchange factors • Transport operators and managers viewpoint • Policy and governance viewpoint • Users' viewpoint • Access/egress • Transport and transfer • Design principles • Facilities and retailing • Safety and security • Accessibility • Inclusive information • Comfort • ITS in interchange design • Design typologies and requirements • Case studies • Suggested literature
Bibliography	• Brons, M., Givoni, M., Rietveld, P., 2009. Access to railway stations and its potential in increasing rail use. *Transportation Research Part A: Policy and Practice* 43(2): 136–149. • Di Ciommo, F., J. M. Vassallo, J.M. & Oliver, A., 2009. Private funding of intermodal exchange stations in urban areas. *Transportation Research Record: Journal of the Transportation Research Board* 2115(12): 20–26. • Edwards, B., 2011. *Sustainability and the Design of Transport Interchanges*. Abingdon, UK: Routledge. • FDOT, 2007. Quality/Level of Service Handbook, Florida Department of Transportation (http://www.dot.state.fl.us/planning/systems/sm/los/). • Green, C. and Hall, G., 2009. Better Rail Stations, Department for Transport. • Grotenhuis, J-W., B. W. Wiegmans and P. Rietveld. 2007. The desired quality of integrated multimodal travel information in public transport: Customer needs for time and effort savings. *Transport Policy* 14(1): 27–38. • GUIDE Terzis, G., Last, An. GUIDE – Urban Interchanges –A Good Practice Guide –Final Report prepared for EC DG VII. April, 2000. • Ministry of Transport, NSW, 2008. Guidelines for the Development of Public Transport Interchanges, MoT, NSW. • Monzon, A. & Di Ciommo, F. (Editors), 2015. CITY-HUBs: Sustainable and Efficient Interchange Stations. Taylor and Francis Group. • Network Rail, 2011. Guide to Station Planning and Design, Issue 1, Network Rail, London. • Rail Safety and Standards Board, 2013. Guidance on the implementation of station travel plans. RSSB. • Sintropher Project, 2011. Good Practice in Transport Interchanges, Sinotropher Project, UCL. • Sputnic, 2009. Guidelines in market organisation—Public transport integration. Sputnic project—Strategies for public transport in cities.

	http://documents.rec.org/publications/SPUTNIC2MO_ptintegration_AUG2009_ENG.pdf. • Translink, 2011. Transit Passenger Facility Design Guidelines, Translink, Burnaby. • Transport for London, 2009. Interchange Best Practice Guidelines, Transport for London, London. • Wefering, F., S. Rupprecht, Buhrmann, S. & Bohler-Baedeker, S., 2013. Guidelines. Developing and implementing a sustainable urban mobility plan. Germany: Rupprecht Consult. http://www.sustainable-urban-mobility-plans.org/docs/SUMP_guidelines.doc.	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	
	Exercises	
	Visits at facilities	x
	Other (describe): Case studies	x
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	19	

Lecture content	
Background	
1	Background
Theoretical methodologies	
2	Basic concepts in design
3	Interchange zones
4	Key interchange factors
5	Transport operators and managers viewpoint
6	Policy and governance viewpoint
7	Users' viewpoint
Guidance and recommendations	
8	Access/egress
9	Transport and transfer
10	Design principles

11	Facilities and retailing
12	Safety and security
13	Accessibility
14	Inclusive information
15	Comfort
16	ITS in interchange design
Design typologies and requirements	
17	Scaling of services at the interchange
18	Urban transport interchange place
19	Method for an interchange typology
20	Facilities/services requirements
Applications	
21	Case studies
Guidance to further knowledge acquisition	
22	Suggested literature
Case studies	
Title	**Design of passenger transport interchanges**
Thematic area	Smart solutions
Responsible Institute	University of Thessaly
Lecturer	Dr. Giannis Adamos
Respective topic for method	All
Method description	In this course, a number of case studies is used as part of the teaching methods. Good practices in several topics, i.e. accessibility, safety and security, access/egress, comfort, facilities and retailing are presented, while the findings of a number of surveys conducted in specific European interchanges are also introduced.
Visits at facilities	
Title	**Design of passenger transport interchanges**
Thematic area	Smart solutions
Responsible Institute	University of Thessaly
Lecturer	Dr. Giannis Adamos
Respective topic for method	All
Method description	Students will have the opportunity to visit a passenger or freight interchange in Riga, in order to see and understand how an urban interchange is designed, managed and operated, under real conditions. A shortlist of potential facilities

	includes: Riga International Coach Terminal, Intermodal transport interchange at Alfa shopping center, Riga international airport and Latvian post sorting complex.

Table 3.12: Course C9

Course: C9	
Title	**Design of freight transport interchanges**
Thematic area	Smart Solutions
Responsible Institute	University of Thessaly (UTh), Greece
Lecturer	Prof. Eftihia Nathanail
Aim	Gain skills to design intermodal freight infrastructures and increase seamless transhipment and secure interconnections.
Learning outcomes	
• Knowledge of design aspects and main functions of intermodal freight terminals • Good understanding of requirements of freight transport terminals and the complexity introduced by multi-disciplinarity of the associated activities • Integrating freight servicing facilities, with special services, such as 3rd and 4th party logistics, and other facilitations.	
Prerequisites (if any)	
Language	English
Hours	3
Key words	European legal framework, accessibility, multimodal transport infrastructure
Syllabus	This course will focus on the components of an intermodal freight terminal and will analyse the parameters that have to be estimated and assessed, in order to provide the input data for designing the terminal. It will present the European regulation framework for designing and interconnecting freight transport interchanges and will reveal the relativeness of transportation planning with regional and urban development procedures. The main modules which comprise these terminals will be presented, and their functionalities and interactions will be explained. **Course topics:** • Introduction • European legal framework – guidelines • Background • Typology of freight transport interchanges • Cases studies • Suggested literature
Bibliography	• Ballis, A. (2006). Freight Villages: Warehouse Design and Rail Link Aspects. Presented at 85th Annual Meeting of the Transportation Research Board, Washington, D.C., p.16. • CEC, Transport Infrastructure Needs Assessment in Central and Eastern Europe - TINA project. • Department of Justice. (2010). 2010 ADA Standards for Accessible Design. Retrieved from http://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards.pdf. • European Conference of Ministers of Transport, 2002, Transport Infrastructure Regional Study in the Balkans (TIRS).

	• Europlatforms, 1996, Europlatforms E.E.I.G. Yearbook 1996, Bruxelles/Bologna. • GVZ Frankfurt. (2013). Freight Village Frankfurt (ODER). Logistics Hub for Combined Traffic between East and West. Retrieved December 15, 2013, from http://www.gvz-ffo.de/cms /?lang=en#prettyPhoto. • Hampton Roads Transportation Planning Organization. (n.d.) Freight Transportation Advisory Committee. Retrieved April 23, 2014, from http://www.hrtpo.org/page/freight-transportation-advisory-committee-%28ftac%29/. • Nathanail E., 2007, "Developing an integrated logistics terminal network in the CADSES area", Transition Studies Review, May 2007, Volume 14, Issue 1, pp 125-146. • VREF, Center of Excellence for Sustainable Urban Freight Systems, Improving Freight System Performance in Metropolitan Areas: Planning Guide Planning and Design Considerations (coe-sufs.org/wordpress/ncfrp33/), accessed 30/6/2016. • Windborne International Group, 1994, Intermodal Freight Centers in Europe: a Strategic Analysis. • World Bank, 2000, The Road to Stability and Prosperity in Southeastern Europe, March.	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	
	Exercises	
	Visits at facilities	
	Other (describe): Case studies	x
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	6	

Lecture content	
1	Introduction
2	European legal framework - guidelines
3	Background
4	Typology of freight transport interchanges
5	Case studies
6	Suggested literature

Note: For the lecture development, the official ALLIACE presentation template (powerpoint) should be used.	
Case study	
Title	**Design of freight transport interchanges**
Thematic area	Smart Solutions
Responsible Institute	University of Thessaly (UTh), Greece
Lecturer	Prof. Eftihia Nathanail
Respective topic for method	Case studies
Method description	Presentation of basic elements and demonstration of videos for the case studies of the Port of Rotterdam and the Manchester Airport as freight transport interchanges.

Table 3.13: Course C10

Course: C10	
Title	**Smart equipment for freight transshipment**
Thematic area	Smart solutions
Responsible Institute	Fraunhofer Institute for Factory Operation and Automation IFF
Lecturer	Dipl.-Wirt.-Inform. Oliver Meier
Aim	• Give a technology and trend overview addressing smart solutions for freight transport • Provide a clear understanding of smart solutions for freight transport applications and services that could be delivered • Explore alternative fuels and propulsion technologies with application to intermodal terminals
Learning outcomes	
• Acquire practical knowledge of smart solutions for freight transport • Possess a good understanding of smart solutions for freight transport, • know design principles of accessibility and acquire basic engineering skills in the transport planning • Provide an understanding of the fundamental relationships involved in the design of freight transport by integrating facilities, retailing, freight transfer and considering interactions with other sectors and future challenges	
Prerequisites (if any)	
• Basic knowledge about logistics • Technical understanding	
Language	English
Hours	2
Key words	Smart Logistics, Auto-ID, Image Processing, Localization, 3D-Scanning
Syllabus	The course will be divided into five modules. **Module 1** – against the background of current challenges will give an overview of current transhipment technologies and their advantages and disadvantages within their application area. **Module 2** – against the background of current societal requirements and EU targets, future transhipment technologies and concepts will be presented, by highlighting their improvements in comparison with the current technologies and their disadvantages. **Module 3** – will introduce transhipment places for contextualisation of transhipment technology use. The students should be equipped with necessary analysing and planning instruments and therefore should know the different types of transhipment places. Some innovative examples will be described. **Module 4** – will introduce into eco-friendly solutions by presenting electric cars and cargo bikes for last mile logistics. **Module 5** – will test the gained knowledge of the students by the help of a case study to the topic "International Transport Chain".
Bibliography	• Sladkowski, Alexander (2012): Rail Transport-Systems Approach, Springer.

	• Gabler Lexikon Logistik (2012). Springer. • Puettmann, Carolin (2010): Collaborative planning in intermodal freight transportation. Gabler. • Lun, Y.H.V. (2010): Shipping and logistics management. Springer. • Mattfeld, Dirk Christian (2006): The management of transshipment terminals, Springer. • Bak, Monika (2016): Transport development challenges in the twenty-first century; Springer. • Meyr, Herbert (2010): Supply Chain Management and Advanced Planning, Springer. Zadek, Hartmut (2017): Lecture „Transportation Technology and Logistics“, Otto von Guericke University Magdeburg.	
Teaching methods	Lecture	x
	Demonstration	x
	Hands on/games	x
	Exercises	(x)
	Visits at facilities	
	Other (describe)	
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe)	
Creative Commons (CC) Licenses	CC-Attribution-NonCommercial-NoDerivatives	
Number of topics	5	
Lecture content		
1	Challenges of Transshipment	
2	Transshipment Technologies	
3	Places of Transshipment	
4	Alternative Fuels	
5	Summary and Case Study	
Exercise		
Title	**Smart equipment for freight transshipment**	
Thematic area	Smart solutions	
Responsible Institute	Fraunhofer Institute for Factory Operation and Automation IFF	
Lecturer	Dipl.-Wirt.-Inform. Oliver Meier	

Respective topic for method	All
Method description	The method used for the exercise is a case study about “International Transport Chains”. An inefficient international transport chain with single routes for every delivery will be given. The students have to improve the transport chain by using the information given in the course. They have to choose appropriate technologies and list their advantages. They have to argue conclusively why they have chosen the particular technology, transhipment place, etc.

Table 3.14: Course C11

Course: C11	
Title	**Decision making methodologies**
Thematic area	Decision making
Responsible Institute	University of Thessaly, Greece
Lecturer	Prof. Eftihia Nathanail Dr. Lambros Mitropoulos
Aim	The course aims to help students to understand the basic decision making methodologies by exploring different characteristics and features of each one and demonstrate how these can be applied in real life problems.
Learning outcomes	
• Apply basic steps of decision making • Understand key methods for supporting logistics decision making • Set goals, objectives and organize alternatives • Understand most important decision making methods and problem building given alternatives and different stakeholders • Evaluate alternatives with different units by considering normalization techniques • Perform analysis, synthesis, and address problem issues and develop critical thinking skills to treat tradeoffs between alternatives • Manage data and build decision support models in spreadsheets • Use available tools for performing decision making.	
Prerequisites (if any)	
-	
Language	English
Hours	3
Keywords	Decision making, social cost benefit analysis, multi-stakeholder multi-criterial analysis.
Syllabus	The students are exposed to (a) social cost benefit analysis and (b) multicriteria assessment methodologies. Social costs and benefits are analysed, through various techniques, such as monetarization, normalization etc. and will guide to the estimation of financial indicators, Net Present Value, Internal Rate of Return, Benefit to Cost ratio. Multicriteria analysis introduces a hierarchical process for analysing complicated systems through the identification of stakeholders, their objectives and criteria, selection of alternative solutions, quantification of the criteria through quantitative and qualitative indicators, identification of weights, estimation of the performance index of the solution. **Course topics:** • Cost benefit and social cost benefit analysis • Multi-stakeholder multi-criteria analysis

	• Weighing • Normalization	
Bibliography	• Beria P., Maltese I., Mariotti I. (2012). Multicriteria versus cost benefit analysis: a comparative perspective in the assessment of sustainable mobility. European Transport Research Review, Volume 4, Issue 3, pp 137–152. • Cascetta E. (2009). Transportation system analysis: models and applications. 2nd edition. Springer. • CE Delft Report (2007). Handbook on estimation of external cost in the transport sector. EC DG Tren. • COM – The European Commission (2007). Greenbook 2007 – Towards a new culture for urban mobility. Commission of the European Communities, Brussels. • Dunn W. N. (2002). Public policy analysis: An introduction, Pearson Prentice Hall, Upper Saddle River. • EVA TREN (2008). Improved decision-aid methods and tools to support evaluation of investment for transport and energy networks in Europe. Deliverable 1. Evaluating the state-of-the-art in investment for transport and energy networks. www.eva-tren.org. • Glenaffric Ltd (2007). Six steps to effective evaluation: A handbook for programme and project managers. • HEATCO (2005). Developing harmonised European approaches for transport costing and project assessment. Deliverable 1: current practice in project appraisal in Europe. • HMT. (2003). Green Book: Appraisal and evaluation in central government. London: HMSO. • Litman T. (1999). Evaluating public transit benefits and cost. Victoria, B.C.: Victoria Transport Policy Institute. • Sinha, K.C. and Labi, S. (2007). Transportation decision making. Principles of project evaluation and programming. Wiley.	
Teaching methods	Lectures	x
	Demonstrations	
	Hands on/gaming	
	Exercises	x
	Visits at facilities	
	Other (please describe): Case study	
Evaluation methods	Homework	
	Class project	x
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	7	

Lecture content	
1	Background
2	Cost benefit and social cost benefit analysis
3	Multi-stakeholder Multi-criteria analysis
4	Weighing
5	Normalization
6	Sustainable urban logistics - The Evalog Tool
7	Suggested literature

Exercise	
Title	Decision making methodologies
Thematic area	Decision making
Responsible Institute	University of Thessaly
Lecturer	Prof. Eftihia Nathanail Dr. Lambros Mitropoulos
Respective topic for method	All
Method description	Students will be provided an excel based exercise where they will be asked to conduct a social cost benefit analysis SCBA for a logistic measure (consolidation center) implemented in Riga, Latvia. Each student will have to complete the input fields in the excel sheet and understand how transport impacts are monetized and internalized in the evaluation process. Students will be separated in different groups to represent different location scenarios and impacts. Final results of the evaluation will be shared in the class.

Table 3.15: Course C12a (2017)

Course: C12a (2017)	
Title	**Data collection methods: Freight Transportation Surveys**
Thematic area	Decision making
Responsible Institute	University of Thessaly (UTh), Greece
Lecturer	Prof. Eftihia Nathanail
Aim	The aim of this course is to: • Provide an understanding of qualitative methods in data collection • Present how a qualitative freight transportation survey is organized • Provide an overview of the practical problems of sample design, the collection and application of transport-related data • Introduce the process of surveys' analysis results in order to draw useful conclusions.
Learning outcomes	
• Identify appropriate methods for urban freight transport, traffic and spatial data collection. • Understand the role of sampling in data collection • Setting up a transport survey from A TO Z	
Prerequisites (if any)	
-	
Language	English
Hours	1
Key words	Data collection, surveys, qualitative methods, sampling
Syllabus	This course will present a step-by-step guidebook for organizing and conducting transport surveys with focus on freight transport surveys. As a first step it will provide the key elements and the principles that should be followed upon the setup of a survey. Sampling, data collection methods and techniques for qualitative data and survey design are introduced and developed as processes in sequence, presenting at the same time their strengths and weaknesses. As a last step the statistical analysis of the qualitative is further explained to the attendants. **Course topics:** • Introduction • Sampling & Statistical analysis • Data collection methods • Strengths and weaknesses of each method • Urban freight transportation survey • Guidance to further knowledge acquisition
Bibliography	• Abdel-Aty M., (2003), "Hybrid Distribution and Response Techniques for an Origin-Destination Travel Survey", ITE Journal, pp. 22-27.

	• Amekudzi, A., Meyer, M., & Ross, C. (2011). Transportation planning for sustainability guidebook. Washington, D.C.: U.S. Federal Highway Administration. • Andrés Monzón, Floridea Di Ciommo, Sara Hernández, Eftihia Nathanail, Giannis Adamos, Maria Tsami, Ricardo Poppeliers, Odile Heddebaout, Tuuli Jarvi, Marko Nokkala, Juno Kostiainen, Derek Palmer, Clare Harmer, Katie Millard, Jardar Andersen, Petter Christiansen, Albert Gabor, Adam Pusztai, Almos Virag, Jan Spousta, 2015. CITY-HUBs: Sustainable and Efficient Interchange Stations. Taylor and Francis Group, 2015. • Bayart, C., Bonnel, P., & Morency, C. Survey mode integration and data fusion. • Bonnel, P. (2009). Transport survey methods. Bingley, UK: Emerald. • Cambridge Systematics (1996), “Inc. Travel Survey Manual”, Prepared for the U.S. Department of Transportation and the U.S. Environmental Protection Agency. Washington, D.C., USA. • Cascetta E., (1984), “Estimation of trip matrices from traffic counts and survey data: a generalized least squares estimator”, Trasportation research, Vol. B, pp. 289-299, USA. • Crevo C., Niedowski R., D. Scott, (1995) “Design and Conduct of a Statewide Household Travel Survey in Vermont”, Transportation Research Record 1477, Transportation Research Board, National Research Council, Washington DC, pp 26-30. • Hagen L., Zhou H., Pirinccioglu F., (2006), “Development of Revised Methodology for Collecting Origin-Destination Data”, Florida Department of Transportation (FDOT), USA. • Nathanail E., 2007, “Developing an integrated logistics terminal network in the CADSES area”, Transition Studies Review, May 2007, Volume 14, Issue 1, pp 125-146. • NOVELOG project (2016). Framework for Data, Information and Knowledge Collection for Urban Freight and Service Demand Understanding. Deliverable 2.1. • Ortuzar J.D., Willumsen L.G., (1990), “Modeling transport”, 4th edition (published 2011), Wiley. • Peter Stopher. Collecting, Managing, and Assessing Data Using Sample Surveys. Cambridge University Press, 2012. 246p. • Survey Sampling. Theory and Methods, 2nd edition. Arijit Chaudhuri, Horst Stenger. Charman&Hall, 2005.- 380 p. • Transport Survey Methods: Best Practice for Decision Making Editor(s): Johanna Zmud, Martin Lee-Gosselin, Marcela Munizaga, Juan Antonio Carrasco, ISBN: 978-1-78-190287-5 eISBN: 978-1-78-190288-2 • Travel survey methods, freight data systems, and asset management 2011. (2011). Washington, D.C. • Travel Survey Methods. Quality and Future Directions. Edited By Peter Stopher, Cheryl Stecher. Elsevier, 2006.706 p. • Yatskiv, A. Grakovski and E. Yurshevich. An overview of different methods available to observe traffic flows using new technologies. In: Proceedings of the international conference NTTS, 5-7 March 2013, Brussels, Belgium, 2013.	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	

	Exercises	
	Visits at facilities	
	Other (describe): Case studies	
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	6	

Lecture content	
1	Introduction
2	Sampling & Statistical analysis
3	Data collection methods
4	Strengths and weaknesses of each method
5	Urban freight transportation survey
6	Guidance to further knowledge acquisition

Table 3.16: Course C12a (2018)

Course: C12a (2018)	
Title	**Data collection methods: Travel Surveys**
Thematic area	Decision making
Responsible Institute	University of Thessaly (UTh), Greece
Lecturer	Prof. Eftihia Nathanail
Aim	The aim of this course is to: • Provide an understanding of qualitative methods in data collection • Present how a qualitative travel survey is organized • Provide an overview of the practical problems of sample design, the collection and application of transport-related data • Introduce the process of surveys' analysis results in order to draw useful conclusions.
Learning outcomes	
• Identify appropriate methods for traffic and spatial data collection. • Understand the role of sampling in data collection • Setting up a transport survey from A TO Z	
Prerequisites (if any)	
-	
Language	English
Hours	1
Key words	Data collection, surveys, qualitative methods, sampling
Syllabus	This course will present a step-by-step guidebook for organizing and conducting transport surveys with focus on passenger transport survey. As a first step it will provide the key elements and the principles that should be followed upon the setup of a survey. Sampling, data collection methods and techniques for qualitative data and survey design are introduced and developed as processes in sequence, presenting at the same time their strengths and weaknesses. As a last step the statistical analysis of the qualitative is further explained to the attendants. **Course topics:** • Introduction • Setting up a travel survey • Sampling • Data collection methods • Strengths and weaknesses of each method • Statistical analysis • Guidance to further knowledge acquisition
Bibliography	• Abdel-Aty M., (2003), "Hybrid Distribution and Response Techniques for an Origin-Destination Travel Survey", ITE Journal, pp. 22-27.

	• Amekudzi, A., Meyer, M., & Ross, C. (2011). Transportation planning for sustainability guidebook. Washington, D.C.: U.S. Federal Highway Administration. • Andrés Monzón, Floridea Di Ciommo, Sara Hernández, Eftihia Nathanail, Giannis Adamos, Maria Tsami, Ricardo Poppeliers, Odile Heddebaout, Tuuli Jarvi, Marko Nokkala, Juno Kostiainen, Derek Palmer, Clare Harmer, Katie Millard, Jardar Andersen, Petter Christiansen, Albert Gabor, Adam Pusztai, Almos Virag, Jan Spousta, 2015. CITY-HUBs: Sustainable and Efficient Interchange Stations. Taylor and Francis Group, 2015. • Bayart, C., Bonnel, P., & Morency, C. Survey mode integration and data fusion. • Bonnel, P. (2009). Transport survey methods. Bingley, UK: Emerald. • Cambridge Systematics (1996), “Inc. Travel Survey Manual”, Prepared for the U.S. Department of Transportation and the U.S. Environmental Protection Agency. Washington, D.C., USA. • Cascetta E., (1984), “Estimation of trip matrices from traffic counts and survey data: a generalized least squares estimator”, Trasportation research, Vol. B, pp. 289-299, USA. • Crevo C., Niedowski R., D. Scott, (1995) “Design and Conduct of a Statewide Household Travel Survey in Vermont”, Transportation Research Record 1477, Transportation Research Board, National Research Council, Washington DC, pp 26-30. • Hagen L., Zhou H., Pirinccioglu F., (2006), “Development of Revised Methodology for Collecting Origin-Destination Data”, Florida Department of Transportation (FDOT), USA. • Ortuzar J.D., Willumsen L.G., (1990), “Modeling transport”, 4th edition (published 2011), Wiley. • Peter Stopher. Collecting, Managing, and Assessing Data Using Sample Surveys. Cambridge University Press, 2012. 246p. • Survey Sampling. Theory and Methods, 2nd edition. Arijit Chaudhuri, Horst Stenger. Charman&Hall, 2005.- 380 p. • Transport Survey Methods: Best Practice for Decision Making Editor(s): Johanna Zmud, Martin Lee-Gosselin, Marcela Munizaga, Juan Antonio Carrasco, ISBN: 978-1-78-190287-5 eISBN: 978-1-78-190288-2 • Travel Survey Methods. Quality and Future Directions. Edited by Peter Stopher, Cheryl Stecher. Elsevier, 2006.706 p. • Yatskiv, A. Grakovski and E. Yurshevich. An overview of different methods available to observe traffic flows using new technologies. In: Proceedings of the international conference NTTS, 5-7 March 2013, Brussels, Belgium, 2013.	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	
	Exercises	
	Visits at facilities	
	Other (describe): Case studies	
Evaluation methods	Homework	
	Class project	

	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	7	

Lecture content	
1	Introduction
2	Setting up a travel survey
3	Sampling
4	Data collection methods
5	Strengths and weaknesses of each method
6	Statistical analysis
7	Guidance to further knowledge acquisition

Table 3.17: Course C12b (2017)

<table>
<tr><th colspan="2">Course: C12b (2017)</th></tr>
<tr><td>Title</td><td>Data collection methods: Historical and observed data</td></tr>
<tr><td>Thematic area</td><td>Decision making</td></tr>
<tr><td>Responsible Institute</td><td>Otto von Guericke University Magdeburg, Germany
Fraunhofer Institute for Factory Operation and Automation IFF</td></tr>
<tr><td>Lecturer</td><td>M.Sc. David Weigert</td></tr>
<tr><td>Aim</td><td>• Participants receive a basic introduction to decision theory and their extensive use in logistics
• Main goal is the application of a holistic concept in the field of big data and data mining in logistics from the problem analysis to solution.
• Get introduced to Big Data, Data Science and Data Analytics.
• Enable participants to give conclusions from theory to practice.</td></tr>
<tr><td colspan="2">Learning outcomes</td></tr>
<tr><td colspan="2">• Understanding of the handling, function and application and use of the currently available data sources in transportation logistics
• Acquire basic knowledge of Big Data, Data Science and Data Analytics
• Acquire knowledge about using of Big Data and Data Analytics in Transportation
• Enable the analysis and definition of complex data analysis</td></tr>
<tr><td colspan="2">Prerequisites (if any)</td></tr>
<tr><td colspan="2">-</td></tr>
<tr><td>Language</td><td>English</td></tr>
<tr><td>Hours</td><td>2</td></tr>
<tr><td>Key words</td><td>Data collection, historical data, observed data, sampling, big data, visualization, fusion techniques.</td></tr>
<tr><td>Syllabus</td><td>The course is divided into 3 segments. Basic study on decision theory, data acquisition and methods for analysis, collection and evaluation as well as the comprehensive application of a holistic concept for the analysis and modeling of large amounts of data. Always from the aspect of logistics. The goal is to provide the participants with basic content on quantitative methods, tools and terms in order to specifically understand the problem of large amounts of data. The area of logistics, especially transport logistics, emits countless data sets. For this purpose the participants should be informed and, in a real case study, the application of a developed concept for a holistic analysis and modeling of logistical problems. Due to the extensive terminology and the current state of the art, it is important to make targeted delimitations in the world of logistics. It should be clear that there is not only one solution to deal with Big Data within the logistics. The participants should made aware of the facts and be given an extended insight.

Course topics:
• Introduction
• Quantitative and Qualitative
• Big Data, Data Science and Data Analytics in Transportation</td></tr>
</table>

	• Analysis and Visualization • Big Data Example • Case-Study - Freight airport • Summary
Bibliography	• Alvarenga, Carlos A. und R. C. Schoenthaler (2003). A new take on supply chain event management. Supply Chain Management Review. • Anwar, A., Nagel, T. & Ratti, C., 2014. Traffic Origins: A Simple Visualization Technique to Support Traffic Incident Analysis.. s.l., IEEE Pacific Visualization Symposium. • Ashbrook, Daniel und T. Starner (2003). Using GPS to learn significant locations and predict movement across multiple users. Personal and Ubiquitous Computing, 7(5):275–286. • Baader, Andraes und S.Montanus (2008). Transparency in Global Supply Chain Networks - Methods and Tools for Integrated Supply Chain Event Management. In: Ijioui, Raschid, H. Emmerich und M. Ceyp, Hrsg.: Strategies and Tactics in Supply Chain Event Management, S. 3–11. Springer-Verlag, Berlin Heidelberg. • Barfus, Katja (2010). Entwicklung eines Vorgehensmodells zur strategischen Planung des logistischen Netzes einer verteilten Produktion. Fraunhofer Verlag, Stuttgart. • Beierle, Christoph und G. Kern-Isberner (2006). Methoden wissensbasierter Systeme - Grundlagen - Algorithmen - Anwendungen. Friedr. Vieweg & Sohn Verlagsgesellschaft | GWV Fachverlage GmbH, Wiesbaden, 3. Aufl. • Bernard, Thomas (2011). Entscheidungsunterstützung durch Data-Mining-Werkzeuge. Automatisierungs-ATLAS 2011, SPS-Magazin, 5:608–610. • P Brandau, Annegret und J. Tolujevs (2013). Modelling and analysis of logistical state data. Transport and Telecommunication, 14(2):102–115. • Brandau, Annegret und J. Tolujew (2011). Logistics Event Management. In: Schenk,Michael, Hrsg.: 9./10. Forschungskolloquium am Fraunhofer IFF 2010 – Forschung vernetzen - Innovationen beschleunigen, S. 47–51, Magdeburg. Fraunhofer Verlag. • Cunha, Catherine da, B. Agard und A. Kusiak (2005). Improving manufacturing quality by re-sequencing assembly operations: a data-mining approach. In: 18th International Conference on Production Research - ICPR 18, Fisciamo, Italy. University of Salerno. • P Dong, Guozhu und J. Pei (2007). Sequence Data Mining. Springer Science+Business Media, LLC. • Düsing, Roland (2006). Knowledge Discovery in Databases - Begri, Forschungsgebiet, Prozess und System. In: Chamoni, Peter und P. Gluchowski, Hrsg.: Analytische Informationssysteme- Business Intelligence-Technologien und -Anwendungen, S. 241–262. Springer, Berlin Heidelberg, 3.Aufl. • Fayyad, Usama, G. Piatetsky-Shapiro und P. Smyth (1996a). From data mining to knowledge discovery in databases. AI Magazine, 17(3):37–54. • Fayyad, Usama M., G. Piatetsky-Shapiro und P. Smyth (1996b). From data mining to knowledge discovery: an overview. In: Fayyad, Usama M., G. Piatetsky-Shapiro, P. Smyth und R. Uthurusamy, Hrsg.: Advances in Knowledge Discovery and Data Mining, Kap. 1, S. 1–34. AAAI Press / The MIT Press, Menlo Park, California.

	• Ghezzi, Carlo, M. Jazayeri und D. Mandrioli (1991). Fundamentals of Software Engineering. Prentice-Hall, Inc. • McKinsey Global Institute (2011). Big data: The next frontier for innovation, competition, and productivity, McKinsey & Company • OECD/ITF (2015). Big Data and Transport: Understanding and assessing options, Study 2015 • Säuberlich, Frank (2000). KDD und Data Mining als Hilfsmittel zur Entscheidungsunterstützung. Peter Lang GmbH Europäischer Verlag der Wissenschaften, Frankfurt a. M. • Windt, Katja, M. Knollmann und M. Meyer (2011). Anwendung von Data Mining Methoden zur Wissensgenerierung in der Logistik - Kritische Reflexion der Analysefähigkeit zur Termintreueverbesserung. In: Spath, Dieter, Hrsg.: Wissensarbeit - zwischen strengen Prozessen und kreativem Spielraum, Schriftenreihe der Hochschulgruppe für Arbeits- und Betriebsorganisation e. V. (HAB), S. 223–249. GITO, Berlin.	
Teaching methods	Lecture	x
	Demonstration	
	Hands on/games	
	Exercises	
	Visits at facilities	
	Other (Case-Study)	x
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	4	
Lecture content		
1	Introduction	
2	Quantitative and Qualitative	
3	Big Data, Data Science and Data Analytics in Transportation	
4	Analysis and Visualization	
5	Big Data Example	
6	Case-Study - Freight airport	
7	Summary	
Case Study		
Title	Data collection methods: Big data in transport	

Thematic area	Decision making
Responsible Institute	Otto von Guericke University Magdeburg, Germany Fraunhofer Institute for Factory Operation and Automation IFF
Lecturer	M.Sc. David Weigert
Respective topic for method	All
Method description	*One of the application example is a simplified model of a real German freight airport is used as a logistical system. At the airport, aircraft containers are unloaded from the arriving aircraft, stored in the warehouse and subsequently loaded into the departing aircraft. The containers in question are partly refrigerated containers and contain fragile goods. It is assumed that the logistic objects of the cargo bay are equipped with auto-ID, localization and sensor technologies and thus state data are available for monitoring the system. The strategic airport management has decided to develop and implement an information system for operational monitoring of the airport. The holistic concept is carried out during the requirements engineering phase by the operational logistics manager together with the software developer.*

Table 3.18: Course C12b (2018)

Course: C12b	
Title	**Data collection methods: Historical and observed data**
Thematic area	Decision making
Responsible Institute	Otto von Guericke University Magdeburg, Germany Fraunhofer Institute for Factory Operation and Automation IFF
Lecturer	M.Sc. David Weigert
Aim	• Participants receive a basic introduction how real-time data and technological advancements facilitate decision making in passenger transport • Overview of quantitative methods in data collection for passenger transport • Get introduced to Big Data, Data Science and Data Analytics • Enable to give conclusions from theory to practice in case of passenger transport.
Learning outcomes	
• Understanding of the handling, function and application and use of the currently available data sources in passenger transport • Acquire basic knowledge of Big Data, Data Science and Data Analytics • Acquire knowledge about using of Big Data and Data Analytics in passenger transport • Enable the analysis and definition of complex data analysis	
Prerequisites (if any)	
Language	English
Hours	2
Key words	Data collection, historical data, observed data, sampling, big data, visualization, fusion techniques.
Syllabus	The course is divided into 3 segments. Basic study on decision theory, data acquisition and methods for analysis, collection and evaluation as well as the comprehensive application of the analysis and modelling of large amounts of data. The goal is to provide the participants with basic content on quantitative methods, tools and terms in order to specifically understand the problem of large amounts of data in passenger transport. The forward-looking field of passenger transport enables a plurality of data recording and data analysis. Here, sources and uses of data of passengers are to be analysed, for example, to identify new business models. The techniques described for determining the needs of passengers and the change in conventional change management enable and require a new, trusting approach to the collection of personal data. **Course topics:** • Introduction • Quantitative and Qualitative • Big Data, Data Science and Data Analytics in Transportation • Analysis and Visualization • Big Data Example • Case-Study – London Case • Summary

Bibliography	• Anwar, A., Nagel, T. & Ratti, C., 2014. Traffic Origins: A Simple Visualization Technique to Support Traffic Incident Analysis.. s.l., IEEE Pacific Visualization Symposium. • Ashbrook, Daniel und T. Starner (2003). Using GPS to learn significant locations and predict movement across multiple users. Personal and Ubiquitous Computing, 7(5):275–286. • Beierle, Christoph und G. Kern-Isberner (2006). Methoden wissensbasierter Systeme - Grundlagen - Algorithmen - Anwendungen. Friedr. Vieweg & Sohn Verlagsgesellschaft | GWV Fachverlage GmbH, Wiesbaden, 3. Aufl. • Brandau, Annegret und J. Tolujevs (2013). Modelling and analysis of logistical state data. Transport and Telecommunication, 2013, Volume 14, No 2, 102–115 Transport and Telecommunication Institute, Lomonosova 1, Riga, LV-1019, Latvia • Dong, Guozhu und J. Pei (2007). Sequence Data Mining. Springer Science+Business Media, LLC. • Düsing, Roland (2006). Knowledge Discovery in Databases - Begri, Forschungsgebiet, Prozess und System. In: Chamoni, Peter und P. Gluchowski, Hrsg.: Analytische Informationssysteme- Business Intelligence-Technologien und -Anwendungen, S. 241–262. Springer, Berlin Heidelberg, 3.Aufl. • Fayyad, Usama M., G. Piatetsky-Shapiro und P. Smyth (1996b). From data mining to knowledge discovery: an overview. In: Fayyad, Usama M., G. Piatetsky-Shapiro, P. Smyth und R. Uthurusamy, Hrsg.: Advances in Knowledge Discovery and Data Mining, Kap. 1, S. 1–34. AAAI Press / The MIT Press, Menlo Park, California. • Freitas A.A., Lavington S.H. (2000) Data Mining Tools. In: Mining Very Large Databases with Parallel Processing. The Kluwer International Series on Advances in Database Systems, vol 9. Springer, Boston, MA • Gerike, R and Lee-Gosselin M (2015). Workshop Synthesis: Improving Methods to Collect Data on Dynamic In: Behavior and Processes. Transportation Research Procedia. Volume 11, 2015, Pages 32-42 • McKinsey Global Institute (2011). Big data: The next frontier for innovation, competition, and productivity, McKinsey & Company (Study 2011) • OECD/ITF (2015). Big Data and Transport: Understanding and assessing options (Study 2015) • Reades, J., Calabrese, F., Sevtsuk, A., & Ratti, C. (2007). Cellular census: Explorations in urban data collection. IEEE Pervasive computing, 6(3). • Säuberlich, Frank (2000). KDD und Data Mining als Hilfsmittel zur Entscheidungsunterstützung. Peter Lang GmbH Europäischer Verlag der Wissenschaften, Frankfurt a. M. • Tao, S., Corcoran, J., Mateo-Babiano, I., & Rohde, D. (2014). Exploring Bus Rapid Transit passenger travel behaviour using big data. Applied Geography, 53, 90-104. • Zaitseva, E., Kvassay, M., Levashenko, V., & Kostolny, J. (2015). Introduction to knowledge discovery in medical databases and use of reliability analysis in data mining. In Computer Science and Information Systems (FedCSIS), 2015 Federated Conference on (pp. 311-320). IEEE.	
Teaching methods	Lecture	x
	Demonstration	

	Hands on/games	
	Exercises	
	Visits at facilities	
	Other (Case-Study)	x
Evaluation methods	Homework	
	Class project	
	Interim examination	
	Final examinations	
	Other (describe) ……………………………………….	
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Number of topics	7	

Lecture content	
1	Introduction
2	Quantitative and Qualitative
3	Big Data, Data Science and Data Analytics in passenger transport
4	Analysis and Visualization
5	Big Data Example
6	Case-Study - London
7	Summary

Case study	
Title	Data collection methods: Big data in transport
Thematic area	Decision making
Responsible Institute	Otto von Guericke University Magdeburg, Germany Fraunhofer Institute for Factory Operation and Automation IFF
Lecturer	David Weigert
Respective topic for method	All
Method description	*Transport for London (TfL) oversees a network of buses, trains, taxis, roads, cycle paths, footpaths and even ferries which are used by millions every day. Running these vast networks integral many people's lives in one of the world's busiest cities, gives TfL access to huge amounts of data. This is collected through ticketing systems as well as sensors attached to vehicles and traffic signals, surveys and focus groups, and of course social media.* *TfL has two main priorities for collecting and analyzing this data: planning services, and providing information to customers. London is growing at a phenomenal rate. The population is currently 8.6 million and is expected to grow to 10m very quickly. The company needs to understand how they relate to customers (passengers) and how they manage their transportation needs.*

	Passengers want good services and value for money, they want to see the TfL being innovative and progressive in order to meet those needs. *Oyster prepaid travel cards were first issued in 2003 and have since been expanded across the network. Passengers effectively "charge" them by converting real money from their bank accounts into "Transport for London money" which are swiped to gain access to buses and trains. This enables a huge amount of data to be collected about precise journeys that are being taken.*

3.2 Lectures

The updated version of the program's lectures is presented in the Annex. The material has been updated after the 1st summer school "Sustainable Transport Interchanges Program" in Riga, Latvia and is expected to be updated again, after the realization of the 2nd summer school.

4 References

ALLIANCE, 2016a. ALLIANCE Deliverable D2.3. Course material on smart solutions for the interconnection of transportation networks.

ALLIANCE, 2016b ALLIANCE Deliverable D2.2. Research, educational and training program in Latvia and the region.

ALLIANCE, 2016c. ALLIANCE Deliverable D2.1. Good practices of research, educational and training programs on smart solutions for the interconnection of transportation networks.

Annex

alliance

Research methodology and teamwork setup

Transport and Telecommunication Institute, Latvia

University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426

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alliance

General information

Course title	Research methodology and teamwork setup
Hours	1
Lecturer/Institution	**Prof.Irina Yatskiv (Jackiva)** Transport and Telecommunication Institute Jackiva.I@tsi.lv **Prof. Eftihia Nathanail** University of Thessaly enath@uth.gr
Teaching methods	Lecture
Prerequisites	-

Aim and learning outcomes

- **Aim:**
  - Present techniques of conducting literature review
  - Guide how to use databases, search engines and electronic libraries
  - Explain how to write a scientific report
  - Explain how to prepare and present research work
  - Organize teams for conducting the summer school project
- **Learning outcomes:**

On successful completion of the course, students will:

attain knowledge on how

- to work with databases, search engines and electronic libraries to retrieve information about a topic
- to prepare a research paper, literature review, monograph, dissertation and poster

be able to

- plan a programme of research
- conduct state-of-the-art in research direction
- document methodology and results
- work as a team member
- communicate with colleagues about their research.

Content

i. Research Methodology

1. Research process: definition, phases, methods
2. Scientific document types
   - Review Paper
   - Thesis
   - Technical Report
   - Case Study
   - Scientific Article
   - Scientific Proposal
3. Guidelines for good research work
4. Disseminating your research
5. Citations and references
6. Research ethics

ii. Teamwork setup

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Research process

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Research process

- **Research** can be defined as the search for knowledge, or as any systematic investigation, with an open mind, to establish novel facts, solve new or existing problems, prove new ideas, or develop new theories.

There is no one best way to conduct research and the answer to ALL research methods questions is, "it depends" (Latham, 2014).

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Research process

- **Research Process:** includes all actions required to attain new knowledge, and/or develop new theories
- **Purposes of Research**
  - Exploration
  - Description
  - Explanation
- **Research core rules**
  - Problem must be clearly recognized
  - Determine information already available and what further information is required, as well as the best approach for obtaining it
  - Obtain and assess information objectively to help inform the decision

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Phases

- Problem definition
- Literature review
- Hypothesis formulation
- Selection of research design, subjects, and data collection techniques
- Data collection
- Data processing and analysis
- Interpretation, Conclusions, and Recommendations

Various steps of a research process are not mutually exclusive; nor they are separate & distinct.

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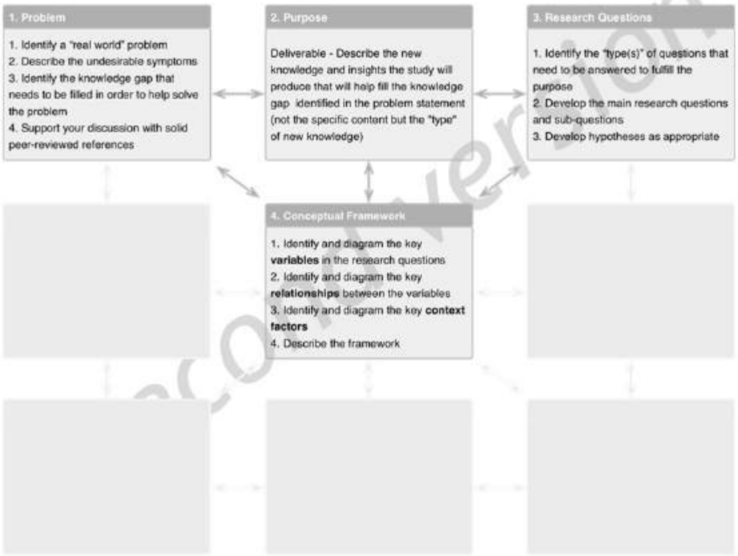
Research method framework:
"T" or foundation of problem, purpose, research questions and conceptual framework



1. Problem

1. Identify a "real world" problem
2. Describe the undesirable symptoms
3. Identify the knowledge gap that needs to be filled in order to help solve the problem
4. Support your discussion with solid peer-reviewed references

2. Purpose

Deliverable - Describe the new knowledge and insights the study will produce that will help fill the knowledge gap identified in the problem statement (not the specific content but the "type" of new knowledge)

3. Research Questions

1. Identify the "type(s)" of questions that need to be answered to fulfill the purpose
2. Develop the main research questions and sub-questions
3. Develop hypotheses as appropriate

4. Conceptual Framework

1. Identify and diagram the key **variables** in the research questions
2. Identify and diagram the key **relationships** between the variables
3. Identify and diagram the key **context factors**
4. Describe the framework

Source: Latham, 2014

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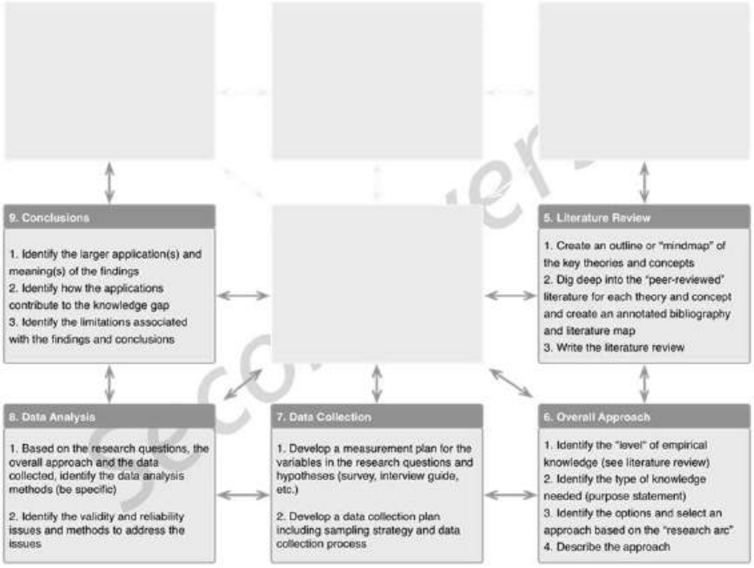
Research method framework:
Developing the "U" or Methodology



9. Conclusions

1. Identify the larger application(s) and meaning(s) of the findings
2. Identify how the applications contribute to the knowledge gap
3. Identify the limitations associated with the findings and conclusions

5. Literature Review

1. Create an outline or "mindmap" of the key theories and concepts
2. Dig deep into the "peer-reviewed" literature for each theory and concept and create an annotated bibliography and literature map
3. Write the literature review

8. Data Analysis

1. Based on the research questions, the overall approach and the data collected, identify the data analysis methods (be specific)

2. Identify the validity and reliability issues and methods to address the issues

7. Data Collection

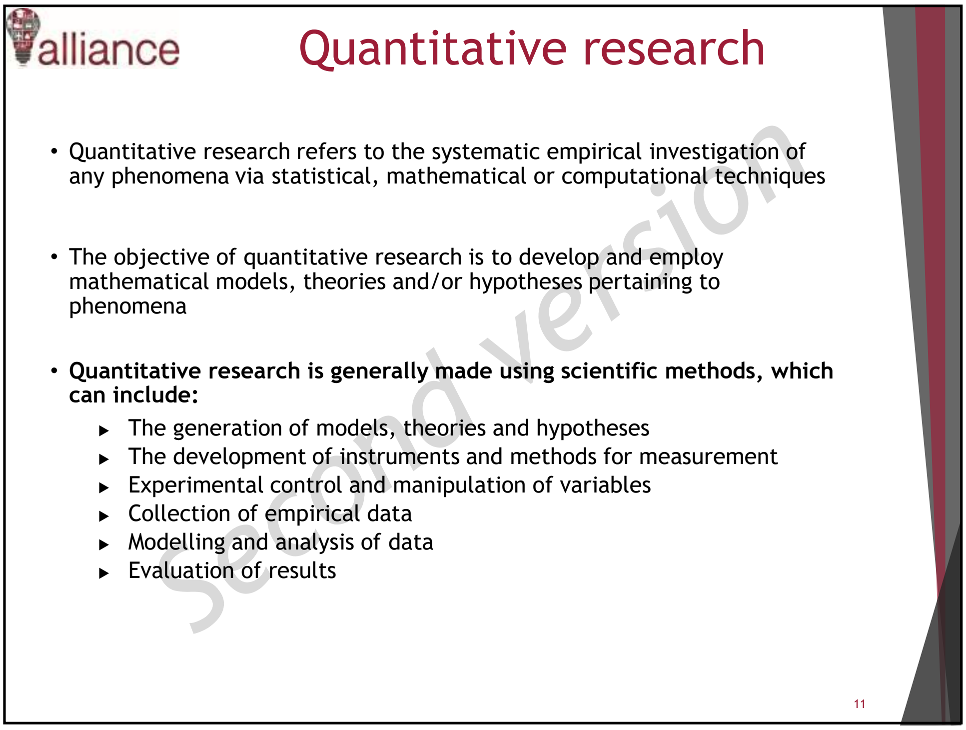
1. Develop a measurement plan for the variables in the research questions and hypotheses (survey, interview guide, etc.)

2. Develop a data collection plan including sampling strategy and data collection process

6. Overall Approach

1. Identify the "level" of empirical knowledge (see literature review)
2. Identify the type of knowledge needed (purpose statement)
3. Identify the options and select an approach based on the "research arc"
4. Describe the approach

Source: Latham, 2014

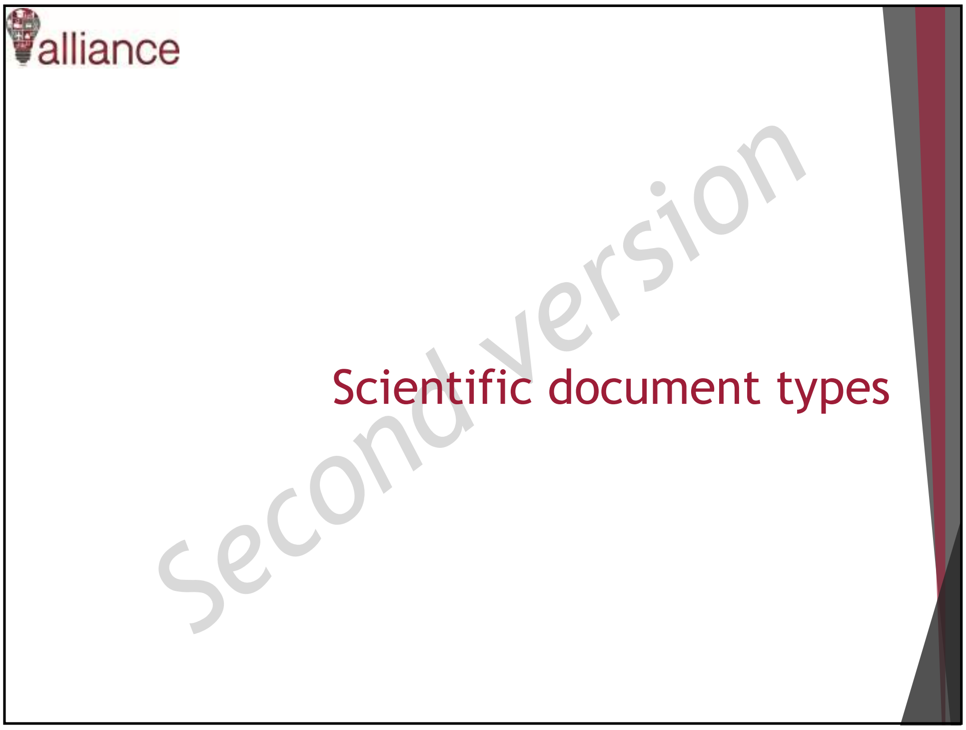


Quantitative research

- Quantitative research refers to the systematic empirical investigation of any phenomena via statistical, mathematical or computational techniques

- The objective of quantitative research is to develop and employ mathematical models, theories and/or hypotheses pertaining to phenomena

- **Quantitative research is generally made using scientific methods, which can include:**
  - The generation of models, theories and hypotheses
  - The development of instruments and methods for measurement
  - Experimental control and manipulation of variables
  - Collection of empirical data
  - Modelling and analysis of data
  - Evaluation of results



Scientific document types

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Scientific document types

1. Review papers
2. Theses (Doctoral dissertations, Master theses, Theses of undergraduate studies)
3. Technical Report
4. Case study
5. Scientific article
6. Scientific proposal

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1. Review Paper (1/2)

Extended literature review:

- Similar to literature review, as part of other scientific work (article, thesis etc.)
- Stand alone document
- Well structured review methodology

Structure in summary

a. Introduction

- define or identify the general topic, issue, or area of concern (provide a context for why you're reviewing the literature)
- depending on your topic, you can point out
  - *a. overall trends in what has been published about the topic; or*
  - *b. conflicts in theory, methodology, evidence, and conclusions; or*
  - *c. gaps in research and scholarship; or*
  - *d. a single problem or new perspective of immediate interest.*
- establish your reason for reviewing the literature
- explain the criteria you used in analysing the literature and how you organized the review
- when necessary, state why certain literature is or is not included.

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1. Review Paper (2/2)

Structure in summary (continue)

b. Body

- Can follow several possible organizing principles:
  - a. chronological
  - b. thematic
  - c. methodological
- Once you've decided on your organizing principle, demonstrate how the articles you've chosen follow this approach
- Remember that you are analysing and synthesizing the articles you've read. Your paper should not be merely a list of summaries. Each paragraph should address a concept, not an author.

c. Conclusion

- summarize major contributions of significant studies and articles to the body of knowledge under review
- point out major methodological flaws or gaps in research, inconsistencies in theory and findings, and areas or issues pertinent to future study
- tween the central topic of the literature review and a larger area of study, such as a discipline, a scientific endeavour, or a profession.

Source: (University of Wisconsin, 2009)

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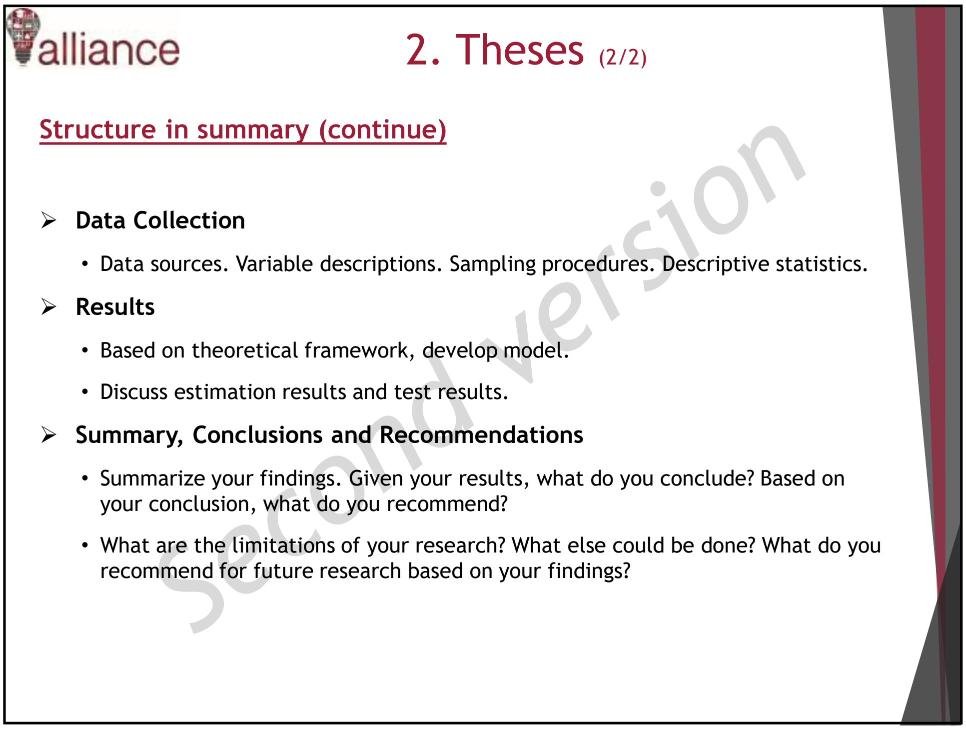
2. Theses (1/2)

Diploma Theses, Master Theses & Dissertations:

- go through a lengthy review process
- the author has his/her work reviewed by peers (fellow professors or researchers) for both content clarity and grammar.

Structure in summary

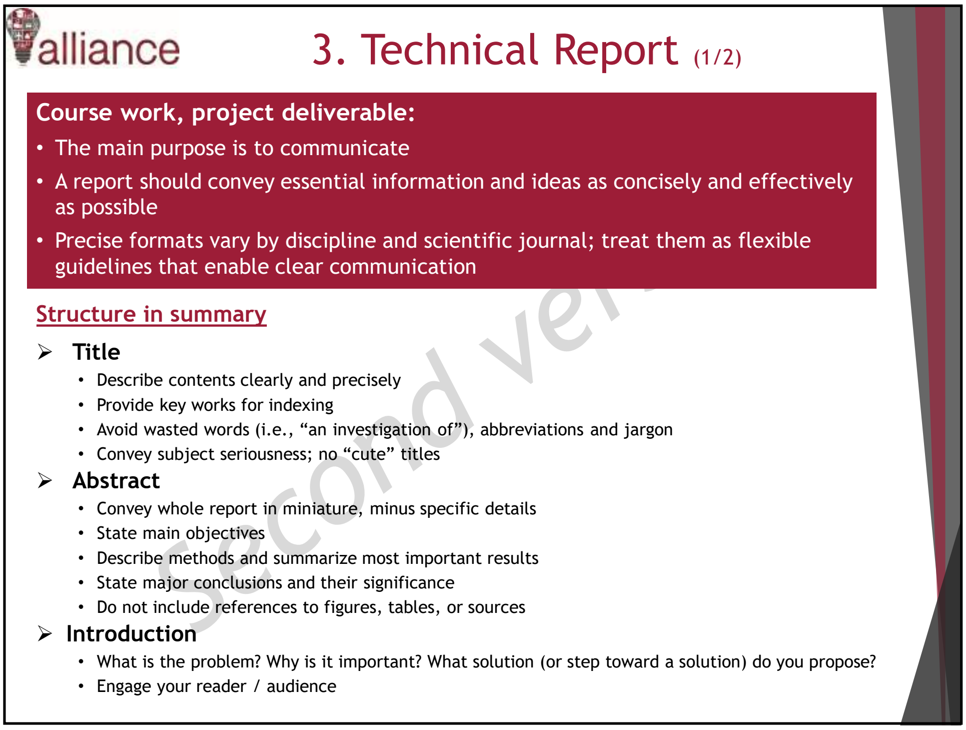
- **Introduction**
  - Problem Statement: Why is this research important? What are the objectives of this study? What are the testable hypotheses?
  - Outline of thesis/dissertation.
- **Literature Review**
  - Review of relevant literature. Compare/contrast previous literature do.
  - How does your work extend the knowledge frontier, cover the gaps?
- **Research Methodology**
  - Develop the theoretical framework underlying research.



2. Theses (2/2)

Structure in summary (continue)

- **Data Collection**
  - Data sources. Variable descriptions. Sampling procedures. Descriptive statistics.
- **Results**
  - Based on theoretical framework, develop model.
  - Discuss estimation results and test results.
- **Summary, Conclusions and Recommendations**
  - Summarize your findings. Given your results, what do you conclude? Based on your conclusion, what do you recommend?
  - What are the limitations of your research? What else could be done? What do you recommend for future research based on your findings?



3. Technical Report (1/2)

Course work, project deliverable:

- The main purpose is to communicate
- A report should convey essential information and ideas as concisely and effectively as possible
- Precise formats vary by discipline and scientific journal; treat them as flexible guidelines that enable clear communication

Structure in summary

- **Title**
  - Describe contents clearly and precisely
  - Provide key works for indexing
  - Avoid wasted words (i.e., “an investigation of”), abbreviations and jargon
  - Convey subject seriousness; no “cute” titles
- **Abstract**
  - Convey whole report in miniature, minus specific details
  - State main objectives
  - Describe methods and summarize most important results
  - State major conclusions and their significance
  - Do not include references to figures, tables, or sources
- **Introduction**
  - What is the problem? Why is it important? What solution (or step toward a solution) do you propose?
  - Engage your reader / audience

3. Technical Report (2/2)

Structure in summary (continue)

- **Methods**
  - How did you study the problem? What did you use? (materials) How did you proceed? (methods/procedures)
  - Provide enough detail for study replication and order procedures by type or chronology
  - Do not mix results with procedures
- **Results**
  - Report main result(s) supported by selected data and order multiple results logically (i.e., "most to least important; simple to complex; etc".)
  - Use past tense
  - Do not simply repeat table data; select key info; do not interpret results
- **Discussion**
  - What do your observations mean? How do your results fit into a broader context?
  - What conclusions can you draw?
  - Summarize the most important findings and move from specific discussion to general
  - Do not over-generalize
  - Avoid speculation that cannot be tested in foreseeable future
- **Appendices (Tables and Figures)**

4. Case study

Processes, organizations etc.:

- Present the background of a process or organization
- Discuss strengths and weaknesses
- Draw useful conclusions

Structure in summary

- **Title page**
  - Authors' names, title of project, name of supervisor, date of submission
- **Extended summary**
  - Topic of case study, aims, current situation, important results, recommendation arising from the study
- **Table of contents**
  - Headings of paragraphs, list of figures, list of tables
- **Introduction**
  - Outline of case study, aims of study, problem identification
- **Main body**
- **Conclusion**
  - How the initial aim was achieved, most important finding in summary, potential constraints
- **Appendices**
  - Additional useful information (maps, tables, data, questionnaires, etc.)
- **References**

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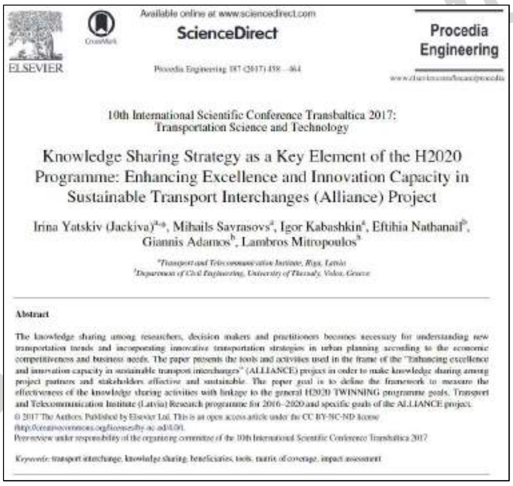
5. Scientific article (1/2)

Conferences, proceedings, scientific journals:

- Innovative idea and methodology
- Progressing knowledge further



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10th International Scientific Conference Transbaltica 2017: Transportation Science and Technology

Knowledge Sharing Strategy as a Key Element of the H2020 Programme: Enhancing Excellence and Innovation Capacity in Sustainable Transport Interchanges (Alliance) Project

Irina Yatskiv (Jackiva)[a,*], Mihails Savrasovs[a], Igor Kabashkin[a], Eftihia Nathanail[b], Giannis Adamos[b], Lambros Mitropoulos[a]

[a]Transport and Telecommunication Institute, Riga, Latvia
[b]Department of Civil Engineering, University of Thessaly, Volos, Greece

Abstract

The knowledge sharing among researchers, decision makers and practitioners becomes necessary for understanding new transportation trends and incorporating innovative transportation strategies in urban planning according to the economic competitiveness and business needs. The paper presents the tools and activities used in the frame of the "Enhancing excellence and innovation capacity in sustainable transport interchanges" (ALLIANCE) project in order to make knowledge sharing among project partners and stakeholders effective and sustainable. The paper goal is to define the framework to measure the effectiveness of the knowledge sharing activities with linkage to the general H2020 TWINNING programme goals, Transport and Telecommunication Institute (Latvia) Research programme for 2016–2020 and specific goals of the ALLIANCE project.

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Peer-review under responsibility of the organizing committee of the 10th International Scientific Conference Transbaltica 2017

Keywords: transport interchange; knowledge sharing; beneficiaries; tools; matrix of coverage; impact assessment

Source: http://www.sciencedirect.com/science/article/pii/S1877705817319306

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5. Scientific article (2/2)

Structure in summary

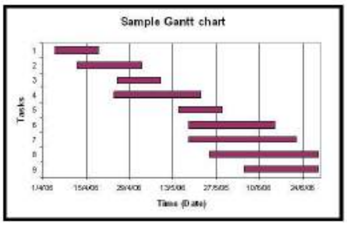
- **Title**
  - Short, dense, attractive
- **Authors, Authors' addresses**
- **Abstract**
  - What this research is about? Which method? Theoretical framework, Main results
- **Keywords**
- **Introduction**
  - Research question, Methodology, Short presentation of article's structure
- **Methodology**
  - Methodological tools
- **Data**
  - Data collection
- **Results - Discussion**
  - Use tables, figures, charts
- **Conclusions**
  - Summary, added value, alignment with research questions and results
- **Acknowledgements**
- **Appendices**
  - Additional useful information (maps, tables, data, questionnaires, etc.)
- **References**

6. Scientific proposal

Response to calls, submission to decision makers:
- Proposing new ideas
- Explaining how to implement a methodology

Structure in summary

- Summary of proposal
    - Short, dense, attractive
  - Abstract
    - What this research is about? Which method? Theoretical framework, Main results
  - State of the art
  - Research questions to be addressed
- Main body
  - Suggested methodology
  - Experience of research team members
  - Timetables and Deliverables
    - Gantt Diagram
  - Requirements in infrastructure and material
  - Budget
- Appendix
  - References
  - Additional material (as appropriate)



Guidelines for good research

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Literature review

❖ conduct an extensive review connected with the problem

❖ find gaps and clarify the state-of-the-art of the research topic

- A literature review goes through earlier research on a topic. It may also review research that has been done on tangential or similar topics that support or even refute the author's hypothesis
- Reviewing literature can be time-consuming, daunting and frustrating, but is also rewarding!
- Its functions are:
  a. Bring clarity and focus to your research problem
  b. Improve your methodology
  c. Broaden your knowledge
  d. Contextualise your findings

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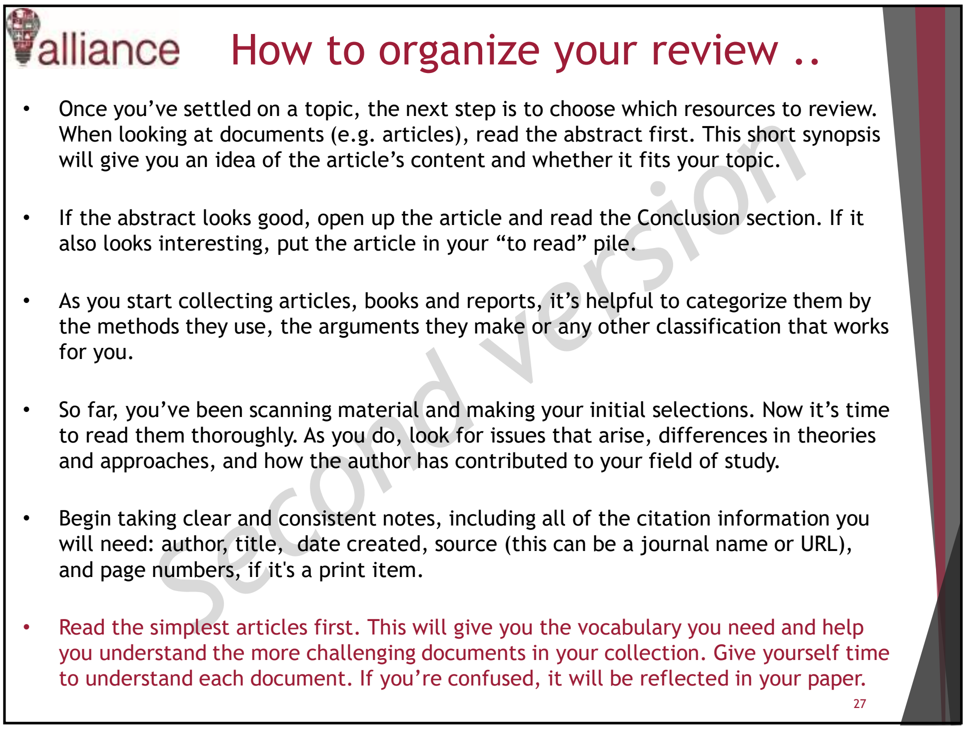
How to perform a search ..

- Explore the documents available by doing a quick search in a database specific to your field
- Once you choose a database, enter your topic and run a search
- To create your search, think about your topic and the words that best describe it. These are your **keywords**
- If your search pulls up thousands of results, this means you need to narrow your topic
- Often databases will suggest ways to focus your topic by providing lists of subtopics. Each click on these will narrow your results further
- If you've tried all these techniques and still don't have a workable topic, ask your professor for help



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How to organize your review ..

- Once you've settled on a topic, the next step is to choose which resources to review. When looking at documents (e.g. articles), read the abstract first. This short synopsis will give you an idea of the article's content and whether it fits your topic.
- If the abstract looks good, open up the article and read the Conclusion section. If it also looks interesting, put the article in your "to read" pile.
- As you start collecting articles, books and reports, it's helpful to categorize them by the methods they use, the arguments they make or any other classification that works for you.
- So far, you've been scanning material and making your initial selections. Now it's time to read them thoroughly. As you do, look for issues that arise, differences in theories and approaches, and how the author has contributed to your field of study.
- Begin taking clear and consistent notes, including all of the citation information you will need: author, title, date created, source (this can be a journal name or URL), and page numbers, if it's a print item.
- Read the simplest articles first. This will give you the vocabulary you need and help you understand the more challenging documents in your collection. Give yourself time to understand each document. If you're confused, it will be reflected in your paper.

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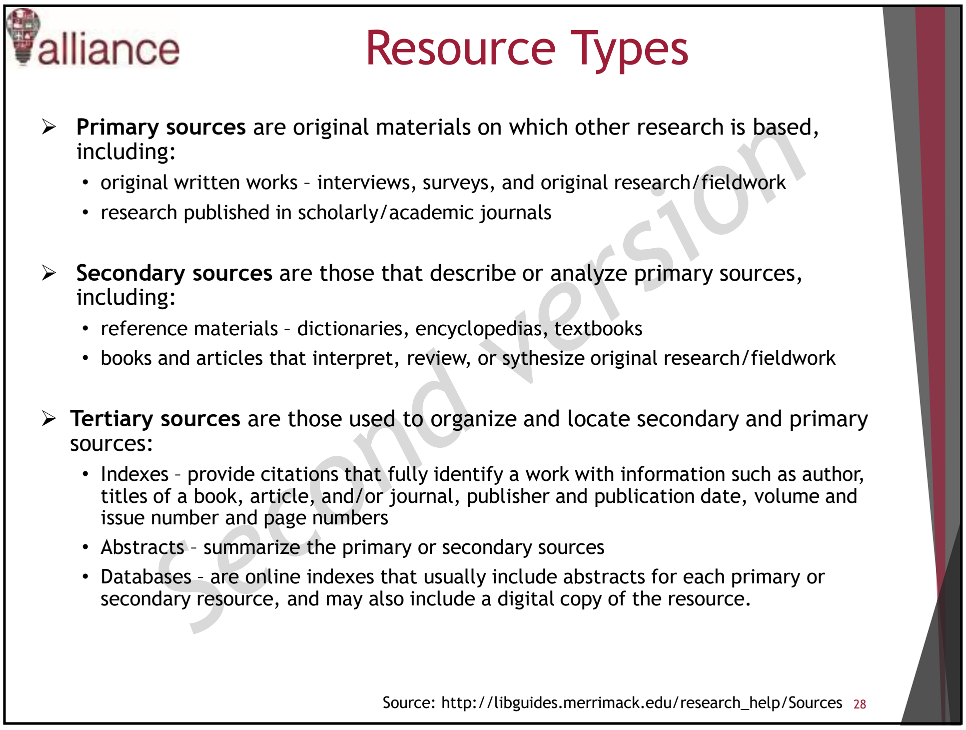

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Resource Types

- **Primary sources** are original materials on which other research is based, including:
  - original written works – interviews, surveys, and original research/fieldwork
  - research published in scholarly/academic journals
- **Secondary sources** are those that describe or analyze primary sources, including:
  - reference materials – dictionaries, encyclopedias, textbooks
  - books and articles that interpret, review, or sythesize original research/fieldwork
- **Tertiary sources** are those used to organize and locate secondary and primary sources:
  - Indexes – provide citations that fully identify a work with information such as author, titles of a book, article, and/or journal, publisher and publication date, volume and issue number and page numbers
  - Abstracts – summarize the primary or secondary sources
  - Databases – are online indexes that usually include abstracts for each primary or secondary resource, and may also include a digital copy of the resource.

Source: http://libguides.merrimack.edu/research_help/Sources 28

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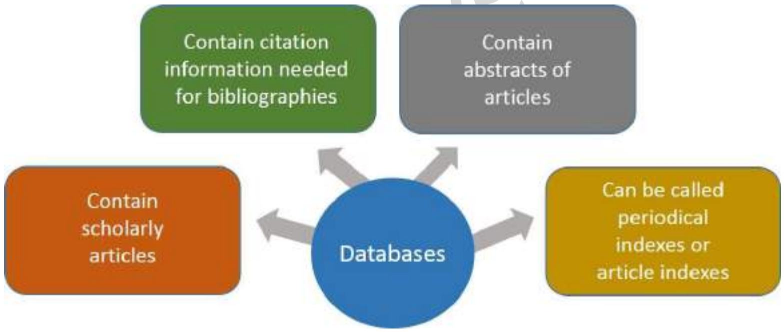
Databases

- Databases are sometimes called the "invisible web" because their information is usually only accessible through paid subscriptions and isn't usually found (indexed) by **search engines such as Google.**
- Database records are organized using a **variety of indexes** such as author and subject but are keyword searchable as well.



Databases

Contain citation information needed for bibliographies

Contain abstracts of articles

Contain scholarly articles

Can be called periodical indexes or article indexes

Source: http://iupui.campusguides.com/c.php?g=334930&p=3203961

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Examples of databases

Database Name	Subject Area	Description	Access	Providers
Academic Search	Multidisciplinary	Provides full text for more than 4,600 journals, incl. approx. 3,900 peer-reviewed titles	Subscription	EBSCO
Directory of open Access Journal	Journals	The Directory of Open Access Journals (DOAJ) lists more than 10,000 open access journals in multiple research areas	Free	Lund University
Google Scholar	Multidisciplinary	Scholarly literature: incl. peer-reviewed papers, theses, books, preprints, abstracts, technical reports from broad areas of research	Free	Google
ScienceDirect	Multidisciplinary	an information source for scientific, technical, and medical research	Subscription	Elsevier
Scirus	Science (General)	A comprehensive science-specific search engine	Free	Elsevier
SCOPUS	Multidisciplinary	The world's largest abstract and citation database of peer-reviewed research literature	Subscription	Elsevier
SpringerLink	Multidisciplinary	Full text scholarly online databases	Free abstracts	Springer
Web of Science	Multidisciplinary	A combination of 3 bases: Science Citation Index Expanded, Social Sciences Citation Index, Arts & Humanities Citation Index and Conference Proceedings Citation Index (Science & Technical Edition).	Subscription	Thomson Reuters

Source: http://iupui.campusguides.com/c.php?g=334930&p=3203961

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Search engines

- ✓ A search engine is an internet tool that locates web pages and sorts them according to specified keywords.
- ✓ Most popular
  - **CiteSeer** - NEC Research Center (scientific literature, citations index; strong in computer science)
  - **Google Scholar** (searches for scholarly articles & resources)
  - **Infomine** (scholarly internet research collections)
  - **Scirus** (scientific information in journals & on the web+)
- ✓ It can be a good tool for research, but finding quality web materials and using them in your writing can be challenging. Use search engines to your advantage:
  - **Identify the web site:** determining the authorship, content, and purpose of the web site
  - Examine for credibility
  - Determine depth and scope of information
  - Assess date of information

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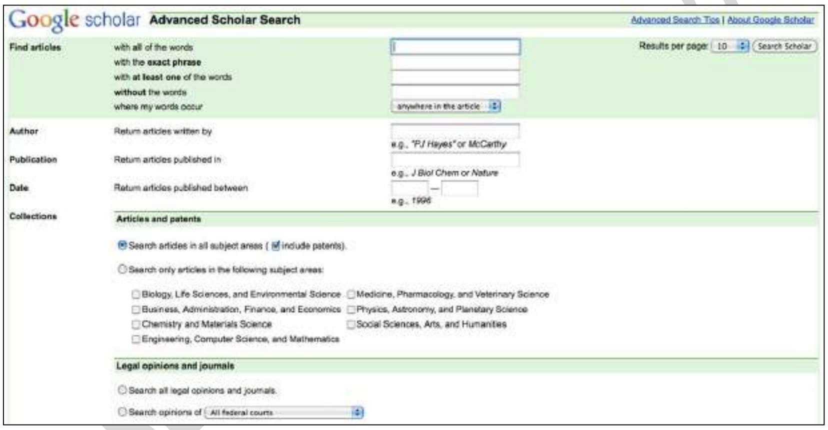
Google scholar



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Electronic Libraries

- ✓ Electronic library is a managed collection of information, that is stored in digital format and accessible over a network
- ✓ Information about digital libraries
  - ✓ LIBWEB U California, Berkeley

    “lists currently over 7200 pages from libraries in over 125 countries”
  - ✓ Digital Library Federation

    “a consortium of libraries and related agencies that are pioneering the use of electronic-information technologies to extend their collections and services”
  - ✓ D-Lib Magazine

    “a solely electronic publication with a primary focus on digital library research and development, including but not limited to new technologies, applications, and contextual social and economic issues”

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Transportation related sources

Database	link	Comment
TRIS	https://ntlsearch.bts.gov/tris/index.do	Transportation related search engine. Article, journals, publishers and authors can be found.
Science.gov	https://www.science.gov/	A USA government gateway to over 50 million pages of authoritatitive selected science information
TLCat	https://ntl.bts.gov/exit/tlcat.html	Transportation Libraries Catalog. Scientific search engine specialized on transportation
Ntis	https://www.ntis.gov/	The National Technical Information Service offers scientific, technical, engineering, and business related articles (abstracts only).
SAE	http://www.sae.org/	Webportal of the Society of Automotive Engineers. Abstracts of papers available for free - full text through payment.
ENGnetBASE	http://www.crcnetbase.com/page/engineering_ebooks	Engineering handbooks publisher - Not available free of charge.
Digital Engineering Library	https://accessengineeringlibrary.com/	Internet Engineering library - Not available free of charge, only abstracts available.

Language and Style in Scientific Writing

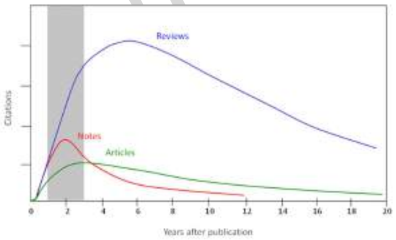
- ✓ Good writing communicates an idea clearly and effectively
- ✓ Should be grammatically sound, with correct spelling, and generally free of errors
- ✓ Define acronyms and any abbreviations not used as standard measurement units
- ✓ Most of the papers, reports, etc. describes what you did, and thus it should be in the past tense, but use present or future tense as appropriate
- ✓ Employ the active rather than passive voice to avoid boring writing and contorted phrases
- ✓ Creating a flow between sentences
- ✓ Avoid:
  - long phrases
  - repetition
  - gender specific pronouns
  - jargon, slang, or colloquial terms
- ✓ Omit needless words

Document components and visibility

- **Review papers:** summarizing recent developments on a specific topic. Highlighting important points that have previously been reported and introduce no new information. Often submitted on invitation. 10+ pages, 5+ figures., 80 ref.

- **Scientific articles**: the most important papers. Often substantial completed pieces of research that are of significance. 8 - 10 pages, 5 - 8 figures, 25 - 40 references

- **Letters / Rapid Communications/ Short communications:** quick and early communication of significant and original advances. Much shorter than full articles (usually strictly limited).< 2500 words, 2 fig. or tables, 6-8 ref.



Source: Elsevier B.V., 2013

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Disseminating your research

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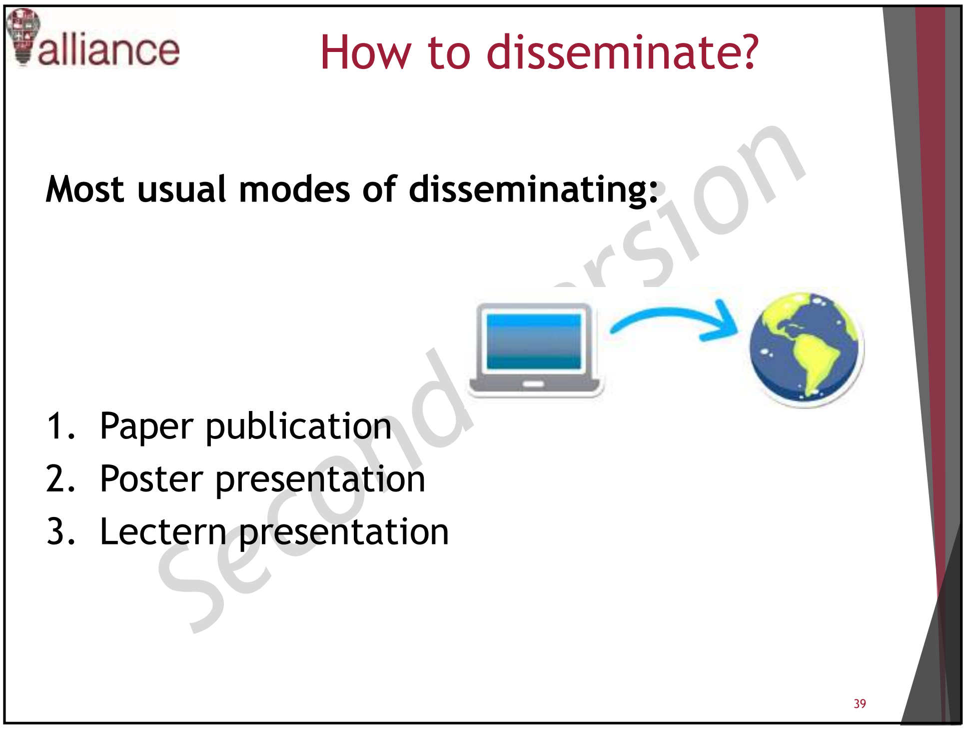
Why to disseminate?

- Promote and exchange knowledge
- Inform the scientific community
- Safeguard research results
- Contact potential co-operators
- Demonstrate accountability
- Facilitate fund raising
- Enable researcher’s promotion

> “The goal of scientific research is publication… A scientific experiment, no matter how spectacular the results are, is not complete until the results are published.” (Day, 1998)



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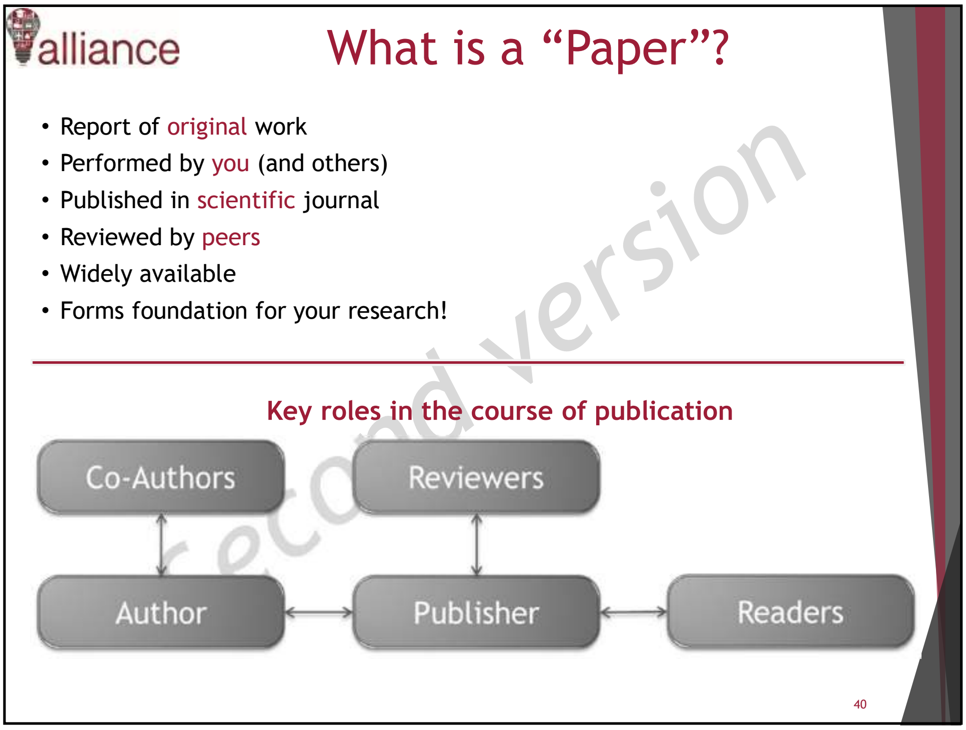
How to disseminate?

Most usual modes of disseminating:

1. Paper publication
2. Poster presentation
3. Lectern presentation



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What is a “Paper”?

- Report of original work
- Performed by you (and others)
- Published in scientific journal
- Reviewed by peers
- Widely available
- Forms foundation for your research!

Key roles in the course of publication

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What’s in a Paper?

Title:	what is this about (shortest summary)?
Authors:	who did it?
Affiliations:	where did they do it?
Abstract:	what did they do (summary)?
Introduction:	what was the question (ends in summary)?
Methods:	how did they get their answer?
Results:	what did they find out?
Discussion:	what do results mean (begins in summary)?
Acknowledgments:	who helped them out?
References:	to whose work did they refer?

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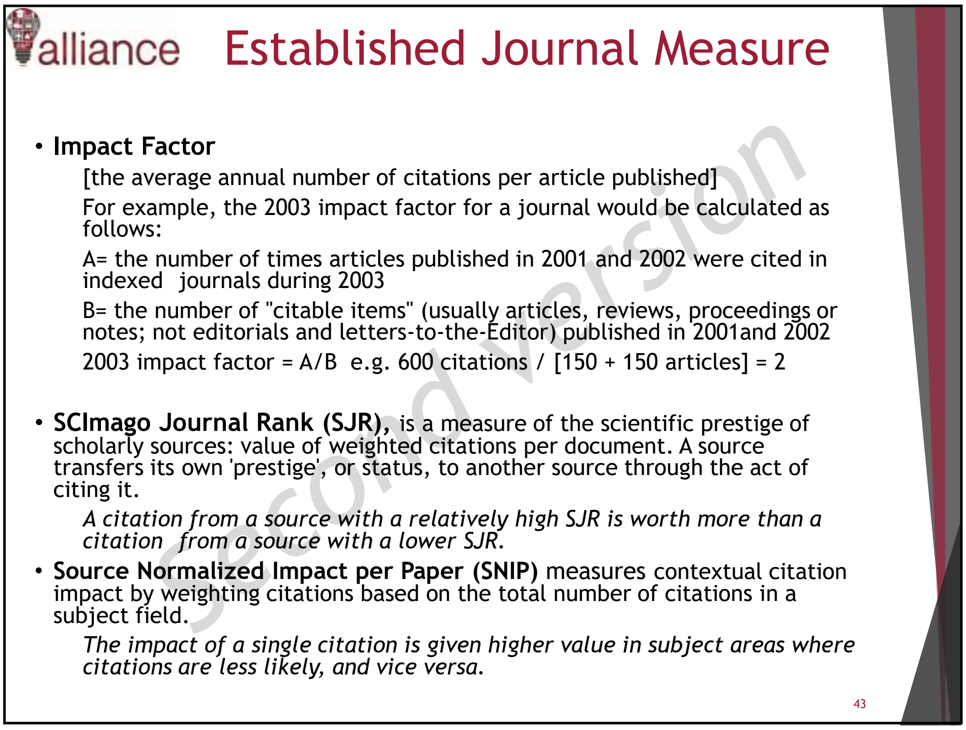
Guide for Journal Publishing

- **(a) Choose one right journal for your work.** DO NOT gamble by scattering your manuscript to many journals. Only submit once!
- **(b) Ask yourself the following questions:**
  - Is the journal peer-reviewed?
  - Who is this journal’s audience?
  - How long will it take to see your article in print?
  - Is this a prestigious journal (Impact Factor)?
- **(c) Owned by:**

  Large publishing corporations
  - Elsevier
  - Harcourt/Pearson
  - Academic Press
  - MacMillan (Nature)

  Scientific Organizations and Societies
  - Society for Neuroscience - Journal of Neuroscience
  - American Chemical Society - http://pubs.acs.org/
  - American Association for the Advancement of Science (AAAS) - Science
- Many are now available online
- Elsevier publishing group: *http://www.elsevier.com/wps/find/homepage.cws_home*



Established Journal Measure

- **Impact Factor**

  [the average annual number of citations per article published]

  For example, the 2003 impact factor for a journal would be calculated as follows:

  A= the number of times articles published in 2001 and 2002 were cited in indexed journals during 2003

  B= the number of "citable items" (usually articles, reviews, proceedings or notes; not editorials and letters-to-the-Editor) published in 2001and 2002

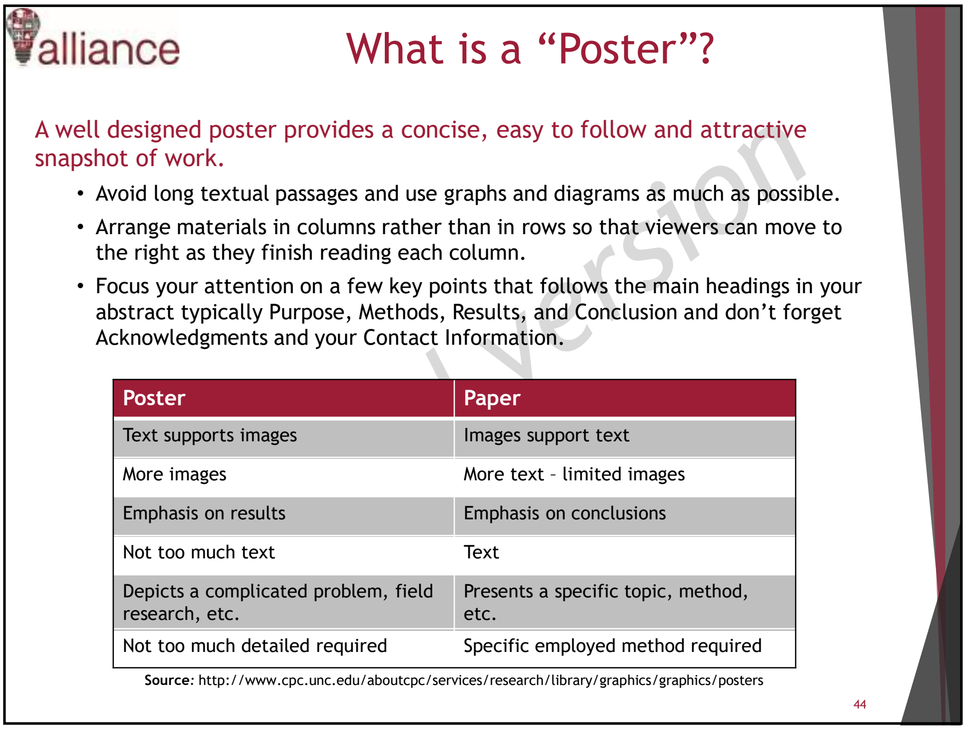
  2003 impact factor = A/B e.g. 600 citations / [150 + 150 articles] = 2

- **SCImago Journal Rank (SJR),** is a measure of the scientific prestige of scholarly sources: value of weighted citations per document. A source transfers its own 'prestige', or status, to another source through the act of citing it.

  A citation from a source with a relatively high SJR is worth more than a citation from a source with a lower SJR.

- **Source Normalized Impact per Paper (SNIP)** measures contextual citation impact by weighting citations based on the total number of citations in a subject field.

  The impact of a single citation is given higher value in subject areas where citations are less likely, and vice versa.



What is a "Poster"?

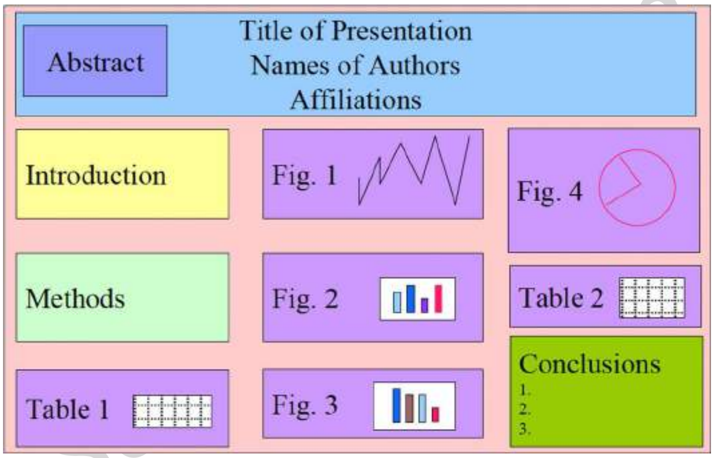
A well designed poster provides a concise, easy to follow and attractive snapshot of work.

- Avoid long textual passages and use graphs and diagrams as much as possible.
- Arrange materials in columns rather than in rows so that viewers can move to the right as they finish reading each column.
- Focus your attention on a few key points that follows the main headings in your abstract typically Purpose, Methods, Results, and Conclusion and don't forget Acknowledgments and your Contact Information.

Poster	Paper
Text supports images	Images support text
More images	More text - limited images
Emphasis on results	Emphasis on conclusions
Not too much text	Text
Depicts a complicated problem, field research, etc.	Presents a specific topic, method, etc.
Not too much detailed required	Specific employed method required

Source: http://www.cpc.unc.edu/aboutcpc/services/research/library/graphics/graphics/posters

What's in a Poster?



Abstract

Title of Presentation
Names of Authors
Affiliations

Introduction

Fig. 1

Fig. 4

Methods

Fig. 2

Table 2

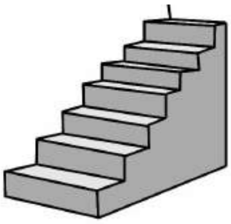
Conclusions
1.
2.
3.

Table 1

Fig. 3

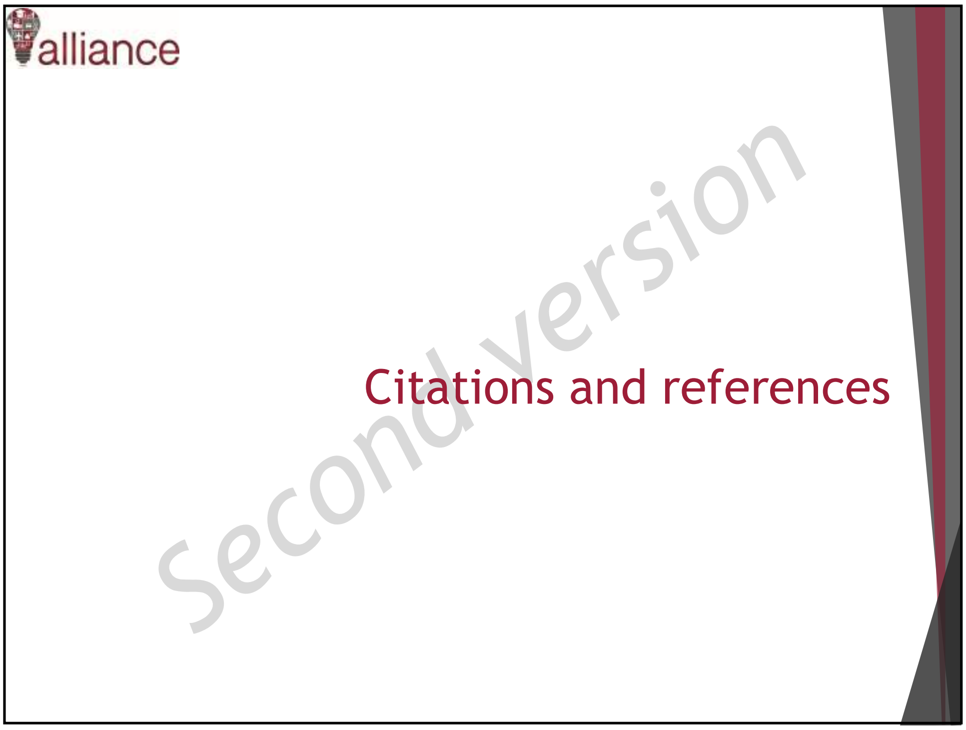
What is "Lectern Presentation"?

- Presentation of your work
- Demonstration of your personal abilities
- Direct evaluation of your work
- Reception of constructive comments, critique
- Promotion of your institute to the audience



1. Design the talk for the audience
2. Prepare thoroughly and rehearse the talk
3. Produce clear, legible slides
4. Arrive early and check the lecture room
5. Speak slowly and loudly
6. Be enthusiastic about what you say
7. Look at the audience as you speak
8. Don't fidget with the slides or the pointer
9. Finish on time (or early)
10. Answer questions courteously and concisely, and admit if you don't know the answer.

Source: (Higham, 1998)



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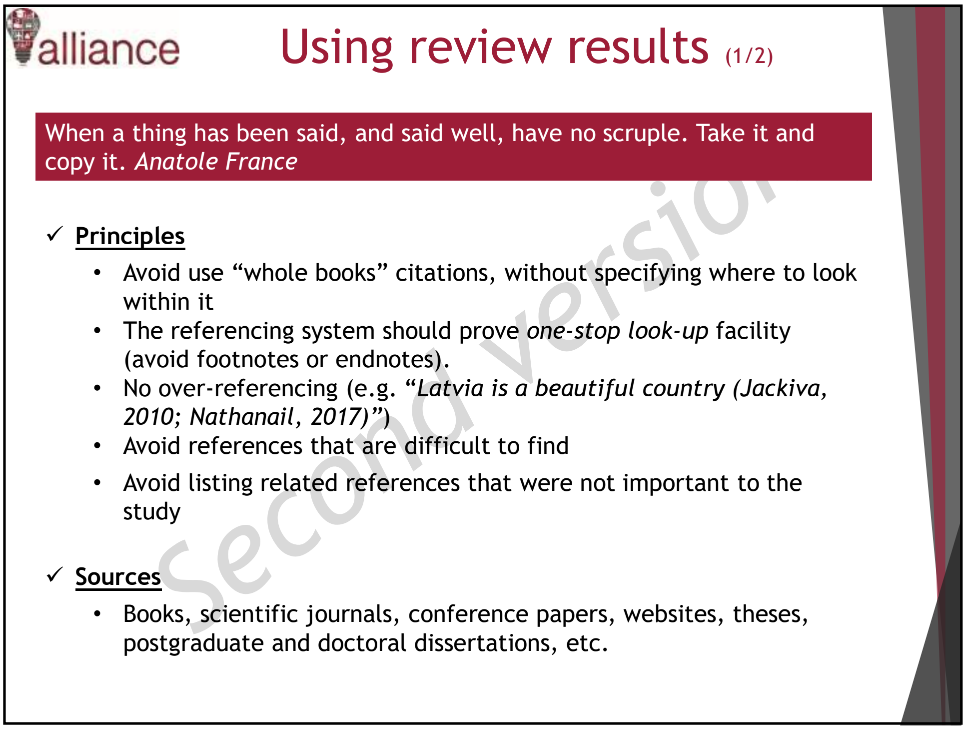
Citations and references



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Using review results (1/2)

When a thing has been said, and said well, have no scruple. Take it and copy it. *Anatole France*

✓ **Principles**

- Avoid use “whole books” citations, without specifying where to look within it
- The referencing system should prove *one-stop look-up* facility (avoid footnotes or endnotes).
- No over-referencing (e.g. “*Latvia is a beautiful country (Jackiva, 2010; Nathanail, 2017)”*)
- Avoid references that are difficult to find
- Avoid listing related references that were not important to the study

✓ **Sources**

- Books, scientific journals, conference papers, websites, theses, postgraduate and doctoral dissertations, etc.

Using review results (2/2)

✓ **Proper selection of references:**
- Show your knowledge in the related area,
- Give credit to other researchers (reviewers are usually chosen from the references)
- Cite good quality work (particularly when citing your own work) and up to date work.

✓ **Related work should:**
- Be organized to serve your topic
- Emphasize on the significance / originality of your work (introducing your work out)

Reference Styles

✓ **Format of references:**
- Consistent with the format, ordering, etc.
- Standard format of books / journal papers / conference papers / Web-sources etc.
- Do NOT use non-standard abbrev.

✓ **There are a few main types of referencing:**
- ➢ **In-text referencing system**
- Harvard (mostly used by Social Sciences, Business, Engineering and Science)
- APA (American Psychological Association (Psychology and some Health Science areas)
- ➢ **Number-note referencing system**
- Oxford and Cambridge (mostly used in Law subjects and occasionally referred to as 'footnoting')
- Vancouver

In-text referencing system

- ❖ Harvard Reference Style

In text reference

Davis and McKay (1996, p.112) note that it is important to be flexible about the system of referencing and adopt whichever style is appropriate.

Full reference

- Avens, D.B. (1993a) Article title: subtitle. Journal Title 46 (Suppl. 2), 617-619
- Avens, D.B. (1993b) Book Title. Publisher, New York.
- Bennett, W.P., Hoskins, M.A., Brady, F.P. (2003) Article title. Journal Title 334 , 31-35.
- Davis, L.B. and McKay, S. 1996, Structures and Strategies: An introduction to Academic Writing, Macmillan Education Australia, Melbourne.

- ❖ APA (American Psychological Association) system

In text reference

Davis and McKay (1996) note that it is important to be flexible about the system of referencing and adopt whichever style is appropriate (p.112).

Full reference

- Davis, L.B. & McKay, S. 1996, Structures and Strategies: An introduction to Academic Writing, Melbourne: Macmillan Education Australia.

- ❖ Chicago
- ❖ AIP (American Institute of Physics)
- ❖ MLA (Modern Language Association)
- ❖ ACS (American Chemical Society)

Number-note referencing system

- OXFORD system

Numbered reference

Davis and McKay note that it is important to be flexible about the system of referencing and adopt whichever style is appropriate [1].

Full reference

[1] Lloyd Davis and Susan McKay, Structures and Strategies: An introduction to Academic Writing, Macmillan Education Australia, Melbourne, 1996, p.112.

- Vancouver system

Numbered reference

Davis and McKay note that it is important to be flexible about the system of referencing and adopt whichever style is appropriate[1].

Full reference

1. Davis, L.B. & McKay, S. Structures and Strategies: An introduction to Academic Writing, Melbourne: Macmillan Education Australia, 1996

Uses numerical order to indicate references; associates references to the citations as they appear in the text

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Research ethics

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Ethics of Research

Scientific misconduct

- Fabrication: making up data or results, and recording or reporting them
- Falsification of results

Publication misconduct

- Plagiarism
- Different forms / severities
- The paper must be original to the authors
- Duplicate submission
- Duplicate publication
- No acknowledgement of prior research and researchers
- No identification of all co-authors

Scientific ethics are not considered to have national variants or characteristics – there is a single ethical standard for science.

Ethics and Authorship

Authorship credit should be based only on substantial contribution to:

- conception and design, **or** data analysis and interpretation
- drafting the article **or** revising it critically for important intellectual content
- **and** final approval of the version to be published

- ✓ All these conditions must be met
- ✓ Participation solely in the acquisition of funding or the collection of data does not justify authorship
- ✓ All authors included on a paper must fulfil the criteria
- ✓ Anyone who does not fulfil the criteria should be excluded.

And agree authorship before starting the study!

Ethics and Plagiarism

Oxford English Dictionary defines plagiarism as:

The action or practice of taking someone else's work, idea, etc., and passing it off as one's own; literary theft.

- Plagiarism, claiming credit for results of others, misreport sources or invent results, data with questionable accuracy, concealing objections that cannot be rebutted, caricaturing or distorting opposing views, destroy or conceal sources and data important for those who follow

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Avoiding plagiarism

In the body of your paper

- **Provide proper citations** for all quotations, summaries, paraphrases, or any other work or idea that is borrowed from others.
- **Using quotations:** When using exact words, phrases, or sentences from a source, make sure to properly use quotation marks and cite where the information was taken from
- **Summarizing & Paraphrasing:**
    - Paraphrasing is when you take the ideas or phrases from a source and rewrite them using your own words.
    - Summarizing is condensing a source into a few lines, focusing on the author’s main points. In both cases, credit is given to the original author or authors.

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ii. Teamwork setup

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Teamwork .... What Is It?

- ✓ A team is defined as a group (a collection of people) who interact to achieve a common goal
  - an effective, well-functioning team is much more than this!
- ✓ Participants in a team care about the group's well-being. They skillfully combine appropriate individual talents with a positive team spirit to achieve results.
- ✓ Greater interpersonal skills are necessary if you are to work together effectively at more complex levels. As skills are developed, more options become available to you regarding the dimension of involvement in a program.

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Groups vs. Teams

What?	Groups	Teams
Members	Independent	Interdependent
Goals	Individual	Shared
Identity	Individual (me)	Shared (we)
Leadership	Often single	Shared
Products	Individual	Collective
Reward	Individual	Collective
Cohesion	None/limited	Esprit
Conflict	Reactive	Expected/proactive

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Assembling a team

- ✓ Team should match research question !!!
- ✓ Skill set (but never forget the general list)
- ✓ Research fluency
- ✓ Collaborative fluency
- ✓ Leadership experience
- ✓ Core values
- ✓ Compatibility

Team assembly mechanisms determine both structure & performance

- ✓ Team performance is influenced by 3 variables:
  - Team size
  - % of newcomers in team: (positive!)
  - Tendency of incumbents to repeat previous collaborations: (negative!)

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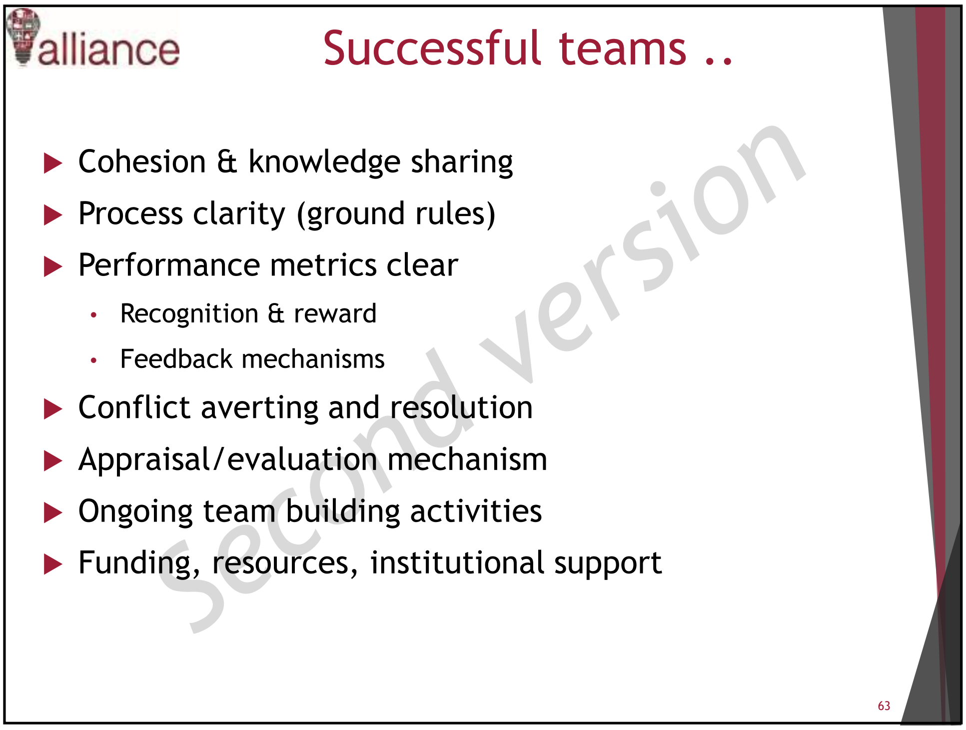
Factors influenced on team work

Positive	Negative
Cooperation and tasks sharing	Lack of common goals and philosophy
Common goals and objectives goal, individual and team timetable	Limited understanding of total program
Openness and willingness to communicate-listening	Poor communication
Constructive criticism	Negative and destructive criticism, negative and sarcastic remarks
Trust, Courtesy and Loyalty	Lack of leadership
Respect for others in spite of professional differences	Over-sensitivity
Respect for professionalism regardless of person's sex, age, and race	Competition among members for individual prestige and recognition
Willingness to talk over problems	No opportunities for team meetings



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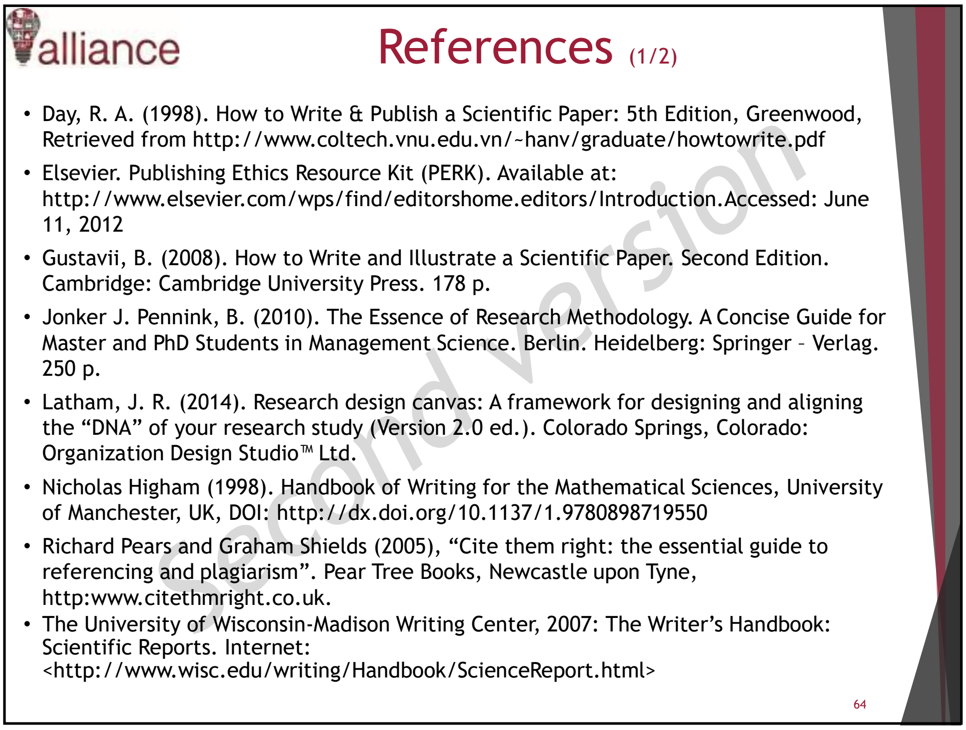
Successful teams ..

- Cohesion & knowledge sharing
- Process clarity (ground rules)
- Performance metrics clear
  - Recognition & reward
  - Feedback mechanisms
- Conflict averting and resolution
- Appraisal/evaluation mechanism
- Ongoing team building activities
- Funding, resources, institutional support



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- Jonker J. Pennink, B. (2010). The Essence of Research Methodology. A Concise Guide for Master and PhD Students in Management Science. Berlin. Heidelberg: Springer – Verlag. 250 p.
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- The University of Wisconsin-Madison Writing Center, 2007: The Writer's Handbook: Scientific Reports. Internet: <http://www.wisc.edu/writing/Handbook/ScienceReport.html>

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- http://writing.wisc.edu/Handbook/ReviewofLiterature.html
- http://www.cpc.unc.edu/aboutcpc/services/research/library/graphics/graphics/posters
- https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3662612/
- http://iupui.campusguides.com/c.php?g=334930&p=3203961
- http://www.coltech.vnu.edu.vn/~hanv/graduate/howtowrite.pdf
- http://libguides.merrimack.edu/research_help/Sources
- http://www.sciencedirect.com/science/article/pii/S1877705817319306

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Suggested Literature

- The Writing Lab & The OWL at Purdue and Purdue University (1995-2011)
- A Guide for Writing Research Papers Based on Modern Language Association, documentation prepared by the Humanities Department as part of The Guide to Grammar and Writing and the Arthur C. Banks Jr. Library Capital Community College Hartford, Connecticut.
- Bates College, How to Write a Paper in Scientific Journal Style and Format, http://abacus.bates.edu/~ganderso/biology/resources/writing/HTWgeneral.html
- Alan Stevens, “Preparing the scientific paper, or: Confessions of a Journal Editor”.
- Kate L. Turabian, “A Manual for Writers of Research Papers, Theses, and Dissertations”, Seventh Edition.
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Thank you for your attention!

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The European policy on intermodal transportation

University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426

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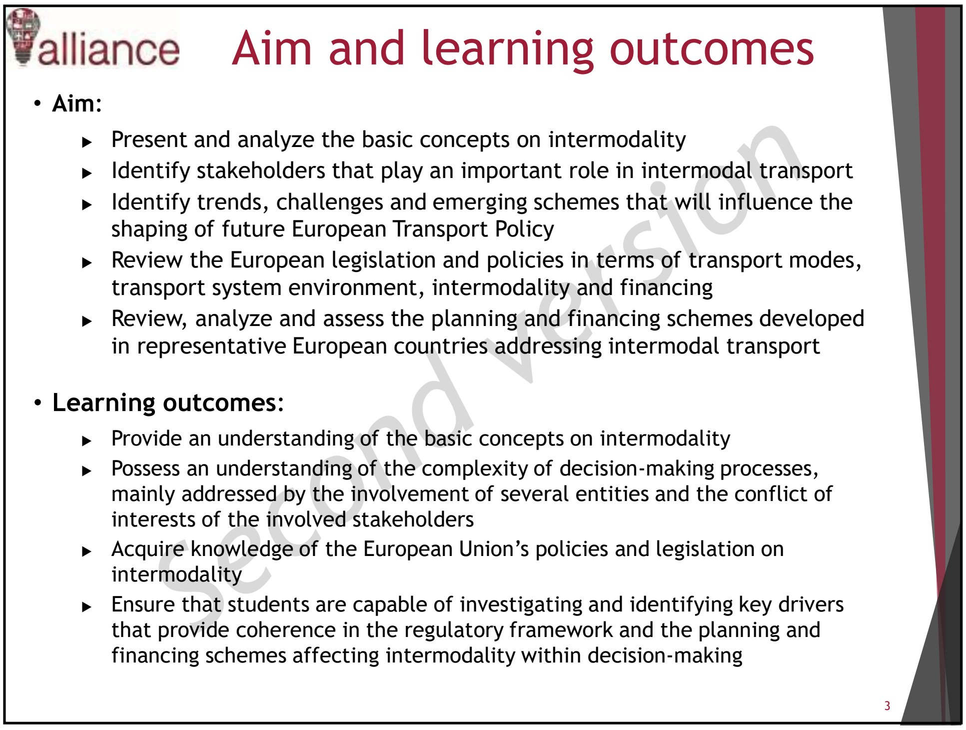
General information

Course title	The European policy on intermodal transportation
Hours	2
Lecturer/Institution	Dr. Giannis Adamos University of Thessaly
Teaching methods	Lecture Case studies
Prerequisites	No



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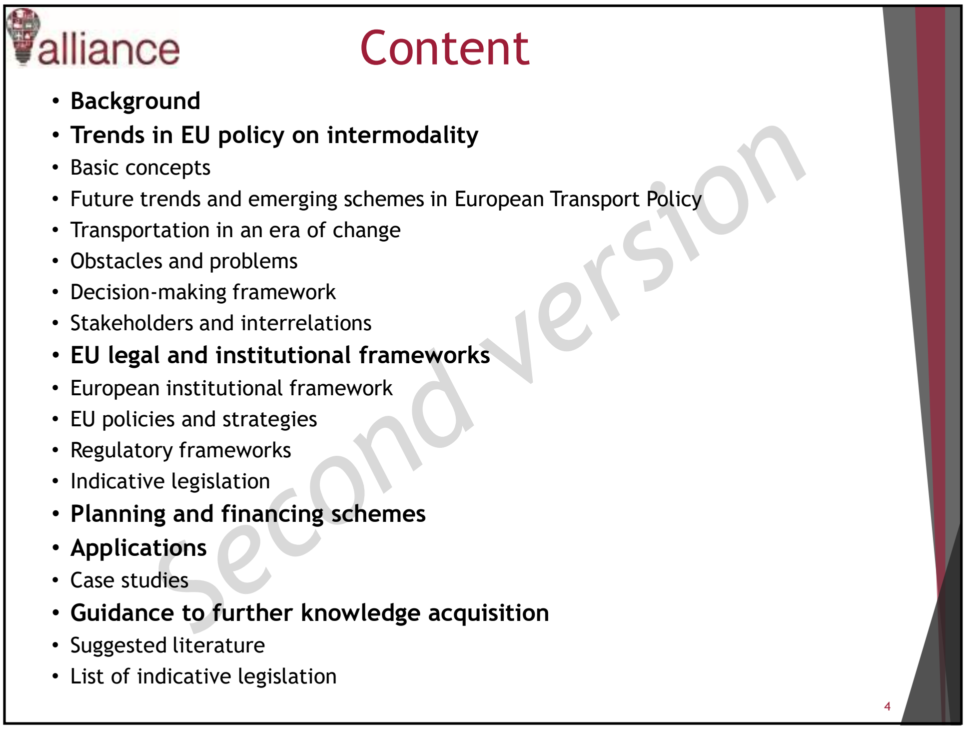
Aim and learning outcomes

- **Aim:**
  - Present and analyze the basic concepts on intermodality
  - Identify stakeholders that play an important role in intermodal transport
  - Identify trends, challenges and emerging schemes that will influence the shaping of future European Transport Policy
  - Review the European legislation and policies in terms of transport modes, transport system environment, intermodality and financing
  - Review, analyze and assess the planning and financing schemes developed in representative European countries addressing intermodal transport
- **Learning outcomes:**
  - Provide an understanding of the basic concepts on intermodality
  - Possess an understanding of the complexity of decision-making processes, mainly addressed by the involvement of several entities and the conflict of interests of the involved stakeholders
  - Acquire knowledge of the European Union's policies and legislation on intermodality
  - Ensure that students are capable of investigating and identifying key drivers that provide coherence in the regulatory framework and the planning and financing schemes affecting intermodality within decision-making



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Content

- **Background**
- **Trends in EU policy on intermodality**
- Basic concepts
- Future trends and emerging schemes in European Transport Policy
- Transportation in an era of change
- Obstacles and problems
- Decision-making framework
- Stakeholders and interrelations
- **EU legal and institutional frameworks**
- European institutional framework
- EU policies and strategies
- Regulatory frameworks
- Indicative legislation
- **Planning and financing schemes**
- **Applications**
- Case studies
- **Guidance to further knowledge acquisition**
- Suggested literature
- List of indicative legislation

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Background

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Background

- Transport is a basic pillar of the European Union (EU) Policy, forming an essential concept for the full operation of the EU single market
- It is vital for fulfilling two of the four liberties set down in the Treaty of Rome:
  - Free movement of people
  - Provision of services across the Community
- The Common Transport Policy[1] (1957) did not show large progress till 1986, when transport was included in the Single European Act[2]
- This Act formed the basis of plans to complete the single market
- The increase of passenger transportation demand and the growth of goods movements cause congestion, environmental impacts, excessive energy consumption and accidents
- For the elimination of these negative impacts, **sustainable transportation** is required

[1] *https://europa.eu/european-union/law/treaties_en*

[2] *http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=LEGISSUM:xy0027&from=EN*

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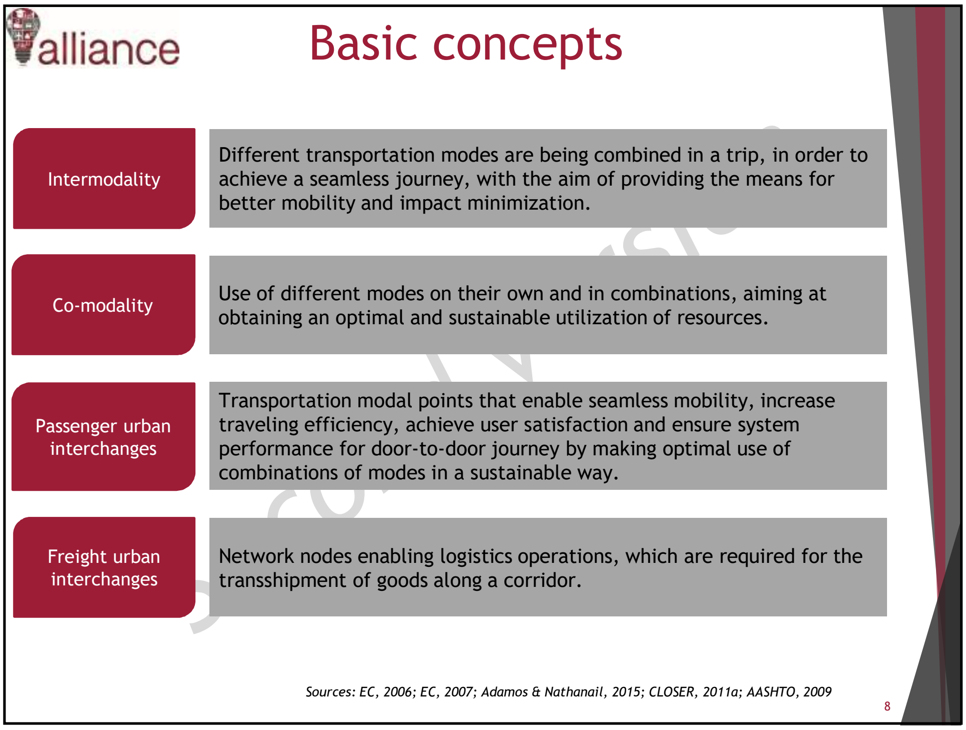
Trends in EU policy on intermodality



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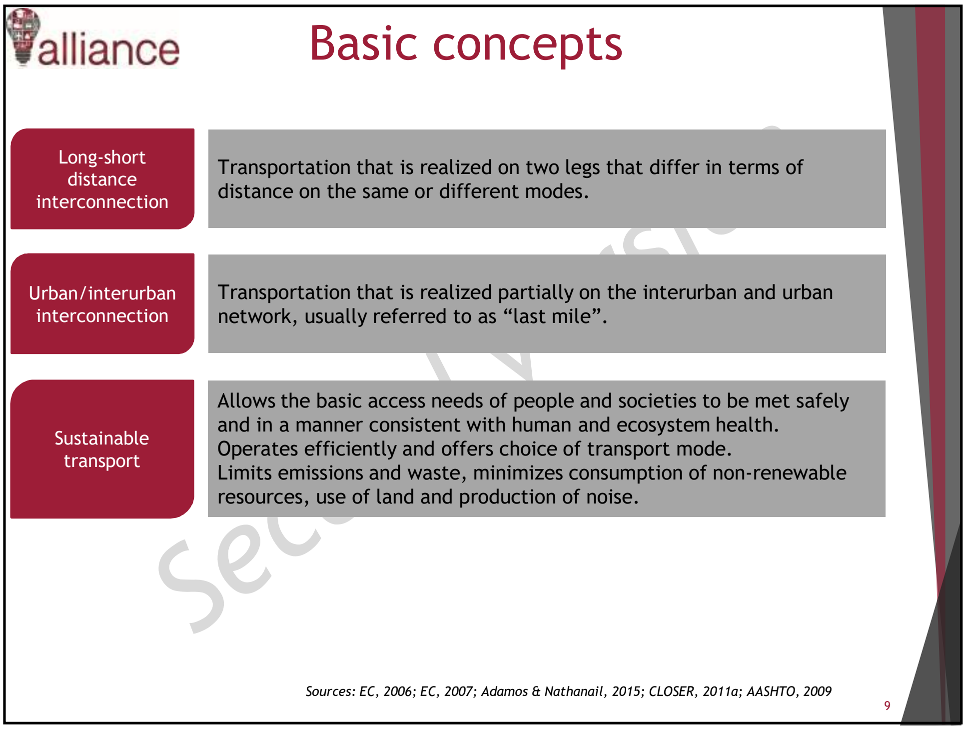
Basic concepts

Intermodality	Different transportation modes are being combined in a trip, in order to achieve a seamless journey, with the aim of providing the means for better mobility and impact minimization.
Co-modality	Use of different modes on their own and in combinations, aiming at obtaining an optimal and sustainable utilization of resources.
Passenger urban interchanges	Transportation modal points that enable seamless mobility, increase traveling efficiency, achieve user satisfaction and ensure system performance for door-to-door journey by making optimal use of combinations of modes in a sustainable way.
Freight urban interchanges	Network nodes enabling logistics operations, which are required for the transshipment of goods along a corridor.

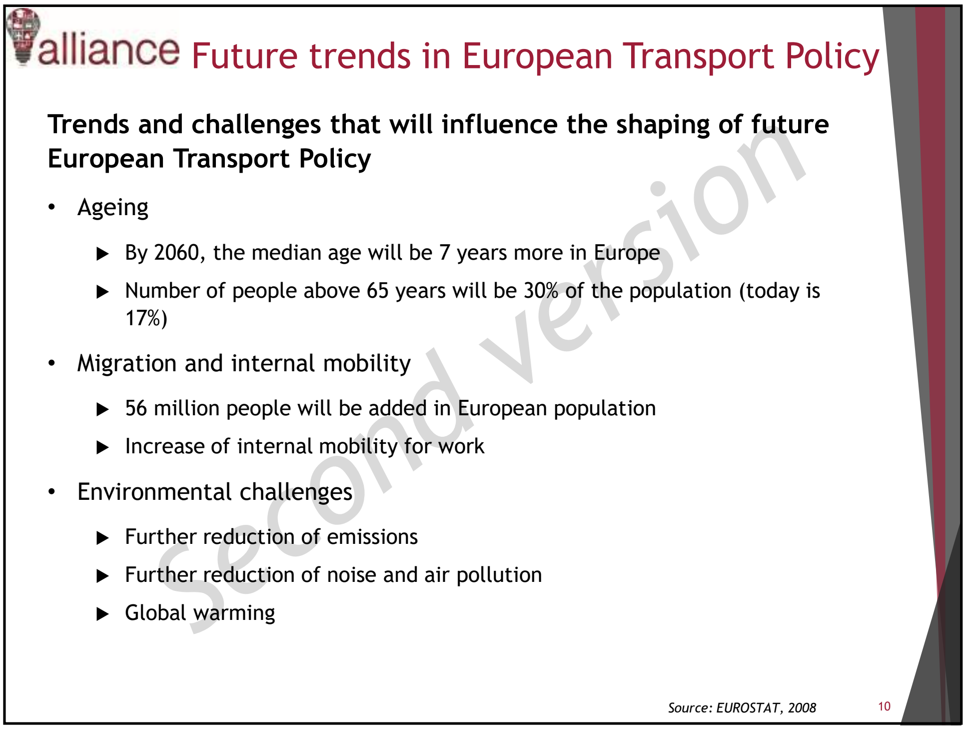
Sources: EC, 2006; EC, 2007; Adamos & Nathanail, 2015; CLOSER, 2011a; AASHTO, 2009



Basic concepts

Long-short distance interconnection	Transportation that is realized on two legs that differ in terms of distance on the same or different modes.
Urban/interurban interconnection	Transportation that is realized partially on the interurban and urban network, usually referred to as “last mile”.
Sustainable transport	Allows the basic access needs of people and societies to be met safely and in a manner consistent with human and ecosystem health. Operates efficiently and offers choice of transport mode. Limits emissions and waste, minimizes consumption of non-renewable resources, use of land and production of noise.

Sources: EC, 2006; EC, 2007; Adamos & Nathanail, 2015; CLOSER, 2011a; AASHTO, 2009



Future trends in European Transport Policy

Trends and challenges that will influence the shaping of future European Transport Policy

- Ageing
  - By 2060, the median age will be 7 years more in Europe
  - Number of people above 65 years will be 30% of the population (today is 17%)
- Migration and internal mobility
  - 56 million people will be added in European population
  - Increase of internal mobility for work
- Environmental challenges
  - Further reduction of emissions
  - Further reduction of noise and air pollution
  - Global warming

Source: EUROSTAT, 2008

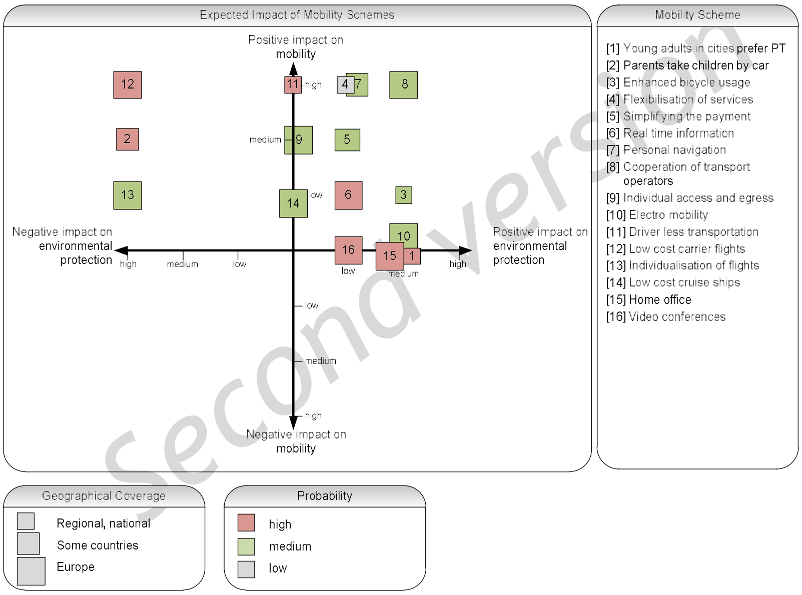
Future trends in European Transport Policy

Trends and challenges that will influence the shaping of future European Transport Policy

- Increasing scarcity of fossil fuels
  - Oil and other fossil fuels will become more expensive
  - Alternative energy sources
  - Concerns about energy security
- Urbanisation
  - 72% of the population in 2007, 84% in 2050
  - Generation of additional congestion and environmental pollution
  - Availability of land (denser cities)
- Global trends affecting European transport policy
  - Globalization, integration with neighboring regions (E. Asia, N. Africa)
  - Economic crises and geopolitical instability
  - By 2050 world population 9 billion

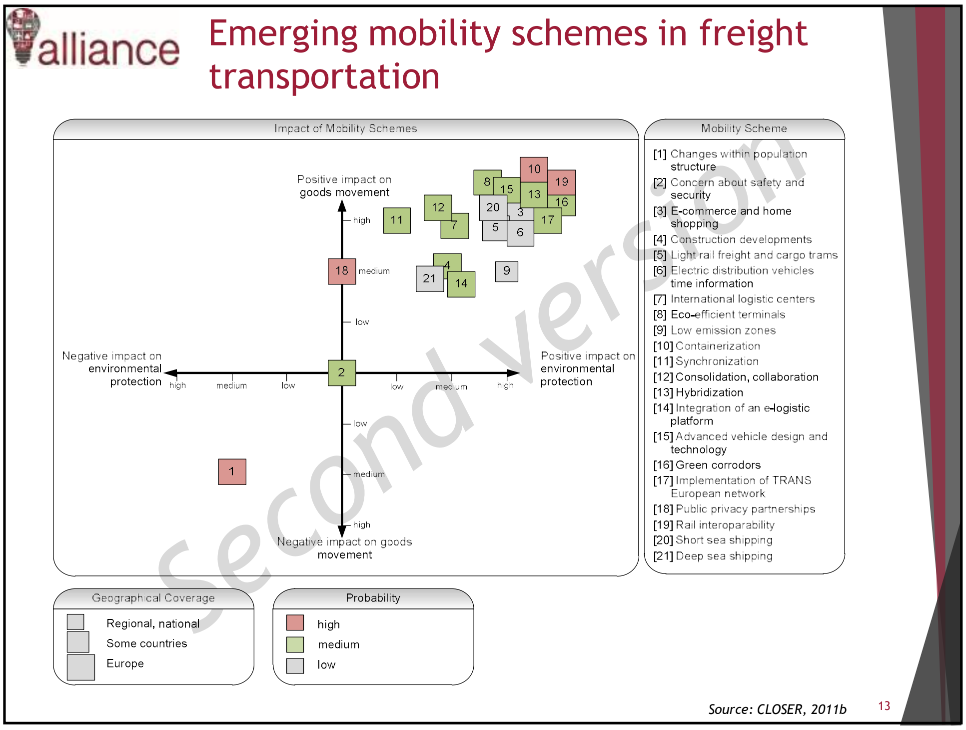
Source: United Nations Population Division, 2009

Emerging mobility schemes in passenger transportation



[1] Young adults in cities prefer PT
[2] Parents take children by car
[3] Enhanced bicycle usage
[4] Flexibilisation of services
[5] Simplifying the payment
[6] Real time information
[7] Personal navigation
[8] Cooperation of transport operators
[9] Individual access and egress
[10] Electro mobility
[11] Driver less transportation
[12] Low cost carrier flights
[13] Individualisation of flights
[14] Low cost cruise ships
[15] Home office
[16] Video conferences

Source: CLOSER, 2011b



Emerging mobility schemes in freight transportation

Mobility Scheme

- [1] Changes within population structure
- [2] Concern about safety and security
- [3] E-commerce and home shopping
- [4] Construction developments
- [5] Light rail freight and cargo trams
- [6] Electric distribution vehicles time information
- [7] International logistic centers
- [8] Eco-efficient terminals
- [9] Low emission zones
- [10] Containerization
- [11] Synchronization
- [12] Consolidation, collaboration
- [13] Hybridization
- [14] Integration of an e-logistic platform
- [15] Advanced vehicle design and technology
- [16] Green corrodors
- [17] Implementation of TRANS European network
- [18] Public privacy partnerships
- [19] Rail interoparability
- [20] Short sea shipping
- [21] Deep sea shipping

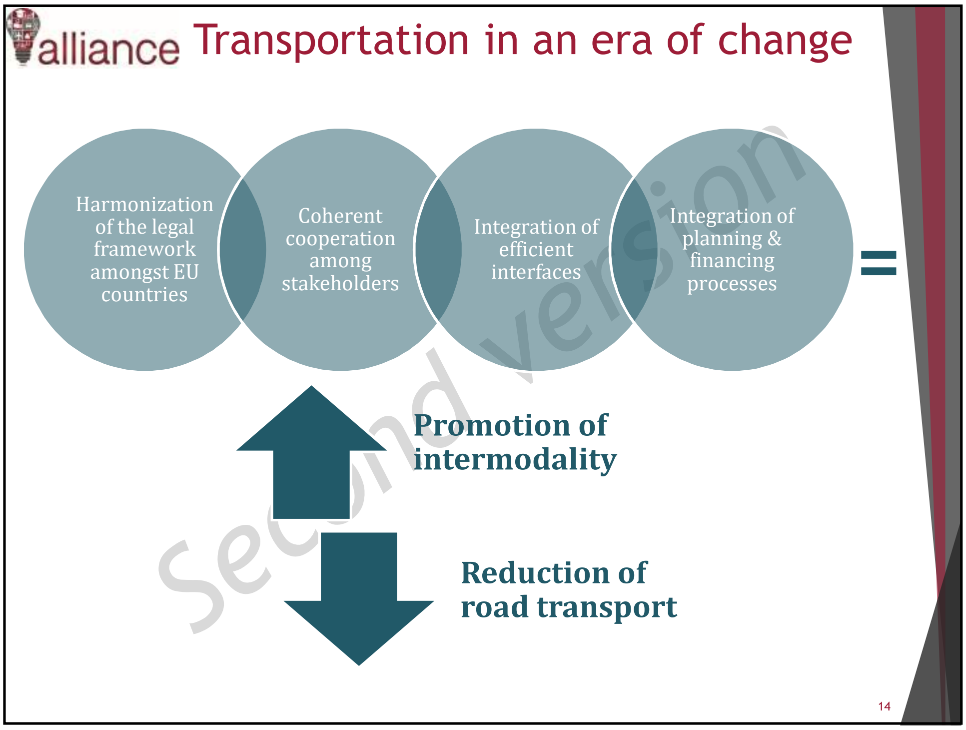
Geographical Coverage

- ▢ Regional, national
- ▢ Some countries
- ▢ Europe

Probability

- 🟥 high
- 🟩 medium
- ⬜ low

Source: *CLOSER, 2011b*



Transportation in an era of change

Promotion of intermodality

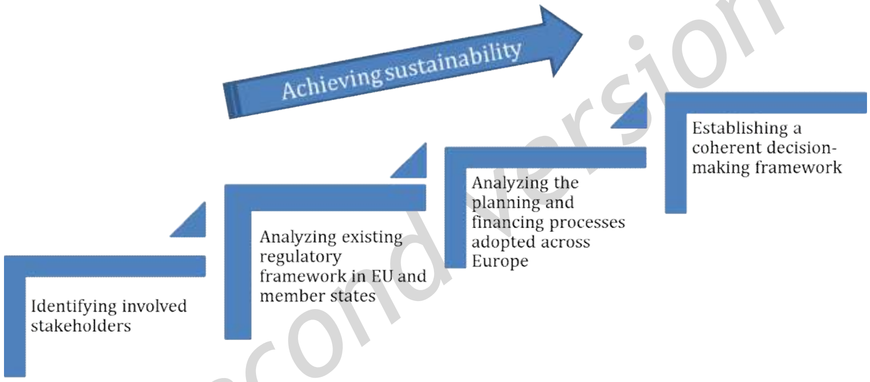
Reduction of road transport

alliance Defining obstacles & problems

- Involvement of more than one entity in the stages of decision making process
- Absence of a strict hierarchical flow chart of responsibilities resulting to complicated procedures
- Conflict of interests of the involved stakeholders
- Absence of the relative legal framework for interconnection
- Lack of obligations regarding intermodality, for existing or new terminals
- Limited national funding for land acquisition
- Lack of required infrastructure

Source: CLOSER, 2012

alliance And how can we enhance intermodality?



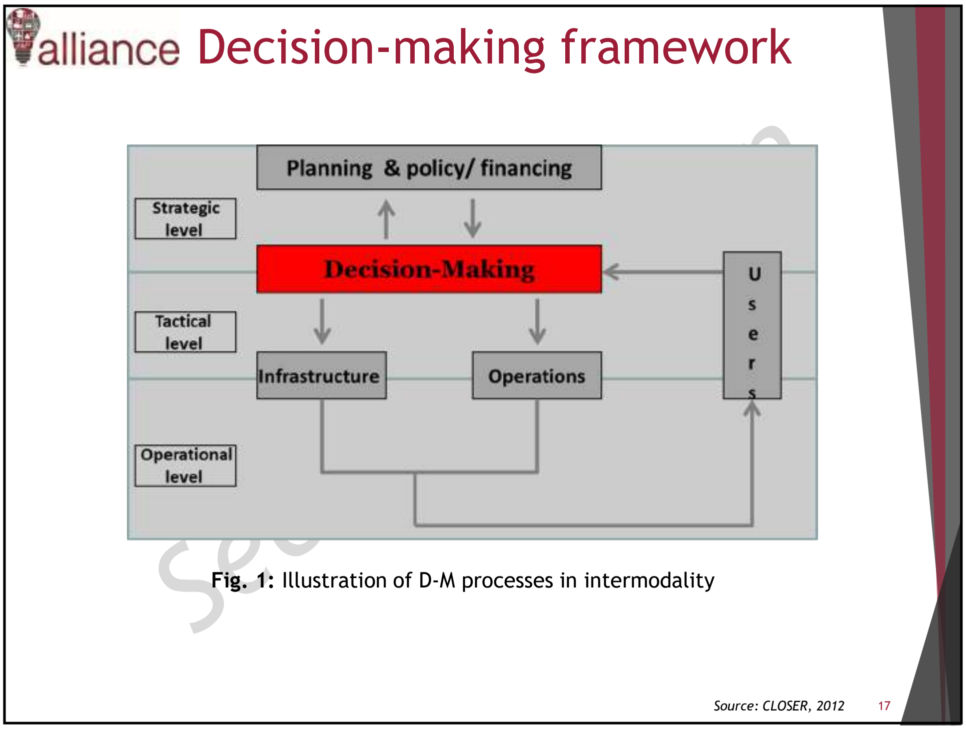
Achieving sustainability

Identifying involved stakeholders

Analyzing existing regulatory framework in EU and member states

Analyzing the planning and financing processes adopted across Europe

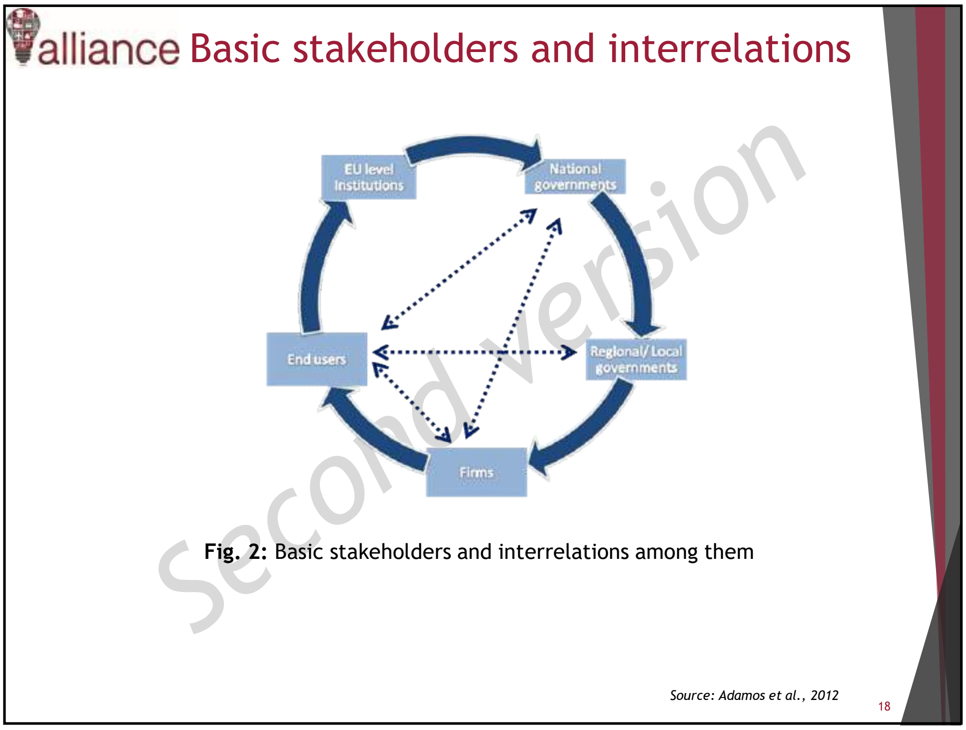
Establishing a coherent decision-making framework



alliance Decision-making framework

Fig. 1: Illustration of D-M processes in intermodality

Source: CLOSER, 2012



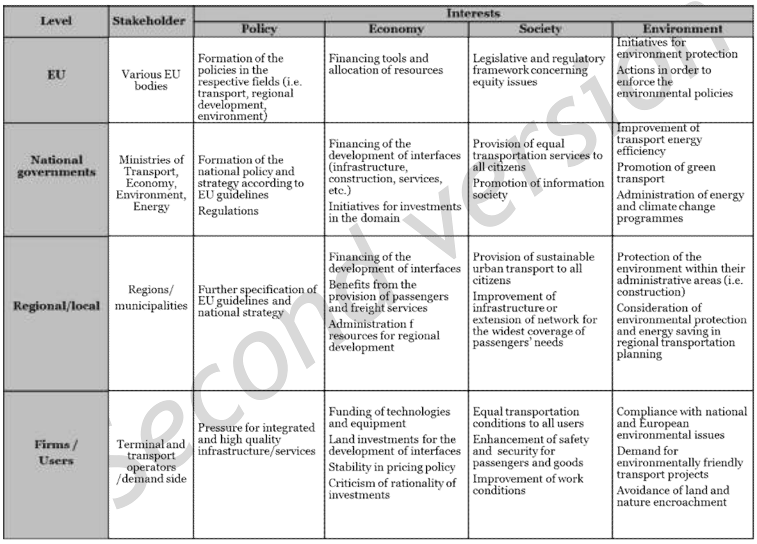
alliance Basic stakeholders and interrelations

Fig. 2: Basic stakeholders and interrelations among them

Source: Adamos et al., 2012

Stakeholders and areas of involvement

Table 1: Stakeholders and areas of involvement



Level	Stakeholder	Interests			
		Policy	Economy	Society	Environment
EU	Various EU bodies	Formation of the policies in the respective fields (i.e. transport, regional development, environment)	Financing tools and allocation of resources	Legislative and regulatory framework concerning equity issues	Initiatives for environment protection Actions in order to enforce the environmental policies
National governments	Ministries of Transport, Economy, Environment, Energy	Formation of the national policy and strategy according to EU guidelines Regulations	Financing of the development of interfaces (infrastructure, construction, services, etc.) Initiatives for investments in the domain	Provision of equal transportation services to all citizens Promotion of information society	Improvement of transport energy efficiency Promotion of green transport Administration of energy and climate change programmes
Regional/local	Regions/ municipalities	Further specification of EU guidelines and national strategy	Financing of the development of interfaces Benefits from the provision of passengers and freight services Administration f resources for regional development	Provision of sustainable urban transport to all citizens Improvement of infrastructure or extension of network for the widest coverage of passengers' needs	Protection of the environment within their administrative areas (i.e. construction) Consideration of environmental protection and energy saving in regional transportation planning
Firms / Users	Terminal and transport operators /demand side	Pressure for integrated and high quality infrastructure/services	Funding of technologies and equipment Land investments for the development of interfaces Stability in pricing policy Criticism of rationality of investments	Equal transportation conditions to all users Enhancement of safety and security for passengers and goods Improvement of work conditions	Compliance with national and European environmental issues Demand for environmentally friendly transport projects Avoidance of land and nature encroachment

Source: Adamos et al., 2012

Transport has gradually become one of the main fields of concern of the European policy, with a continuous expanding scope for action…

EU legal and institutional frameworks

European institutional framework

- European Union (EU) is an organization of economic and political cooperation among governments in which the Members States remain independent sovereign nations
- Founded on four Treaties

✓ The Treaty establishing the European Coal and Steel Community (1951)
✓ The Treaty establishing the European Atomic Energy Consumption (1957)
✓ The Treaty establishing the European Economic Community (1957)
✓ Treaty on European Union (1992)

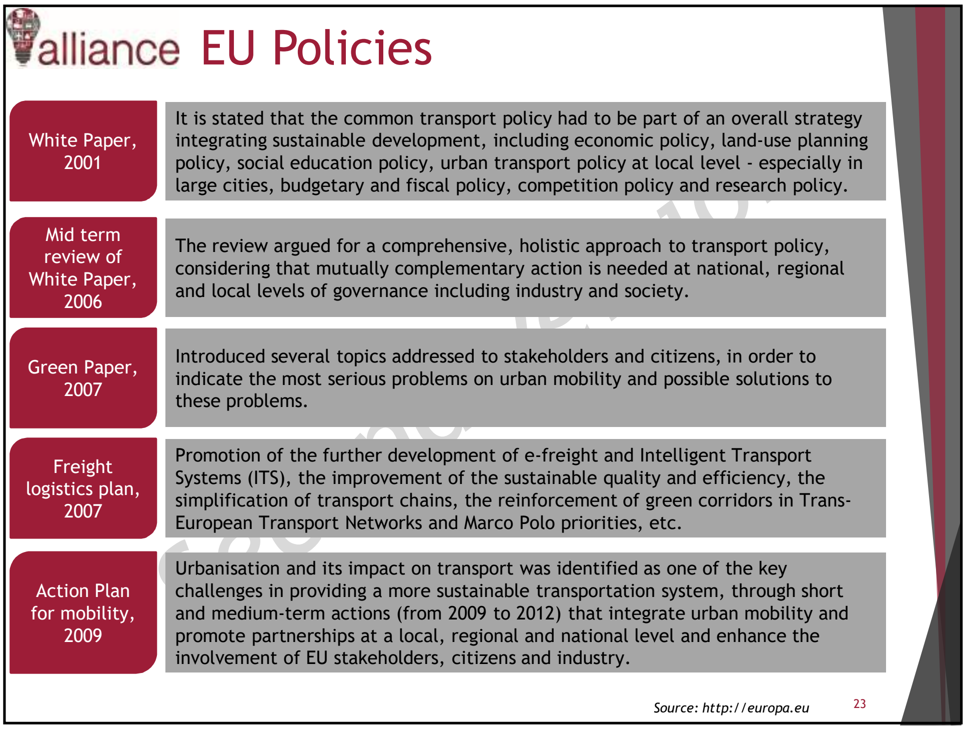
- The above Treaties were amended and resulted in the Single European Act (1986) amending

✓ The European Coal and Steel Community Treaty
✓ The Treaty of Amsterdam (1997)
✓ The Treaty of Nice (2001)
✓ The Treaty of Lisbon (2007)

- EU legal institutions:

✓ European Parliament
✓ Council of the EU
✓ European Commission
✓ Court of Justice
✓ Court of Auditors
✓ Directorate General "Mobility and Transport"
✓ Other:
- *European Economic and Social Committee*
- *European Investment Bank*
- *European Central Bank*

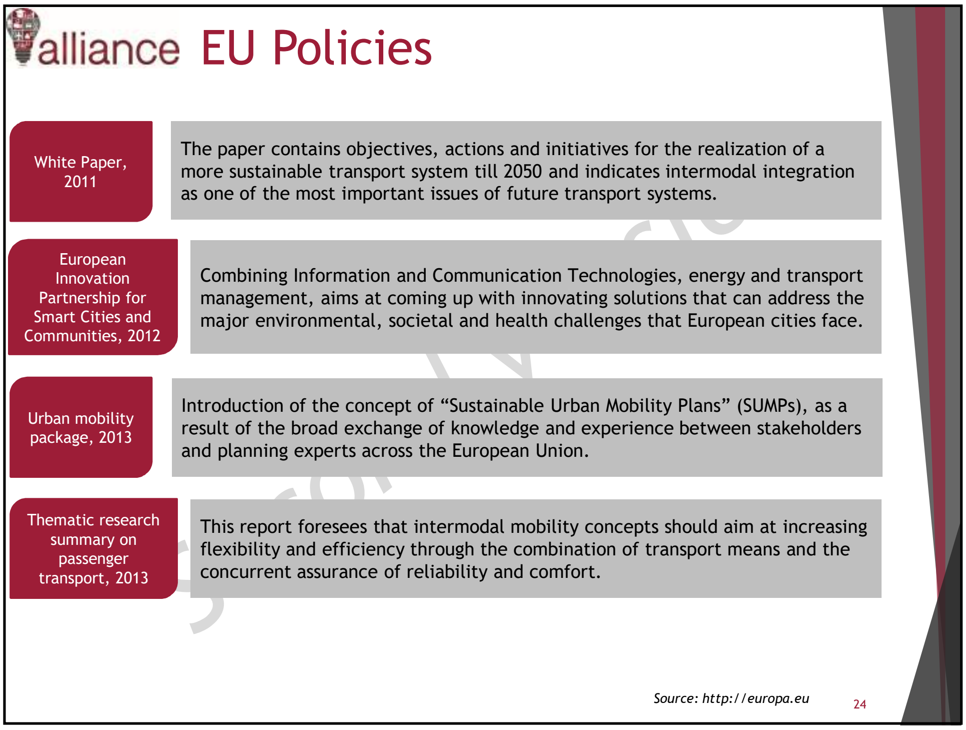
Source: http://europa.eu



EU Policies

White Paper, 2001	It is stated that the common transport policy had to be part of an overall strategy integrating sustainable development, including economic policy, land-use planning policy, social education policy, urban transport policy at local level - especially in large cities, budgetary and fiscal policy, competition policy and research policy.
Mid term review of White Paper, 2006	The review argued for a comprehensive, holistic approach to transport policy, considering that mutually complementary action is needed at national, regional and local levels of governance including industry and society.
Green Paper, 2007	Introduced several topics addressed to stakeholders and citizens, in order to indicate the most serious problems on urban mobility and possible solutions to these problems.
Freight logistics plan, 2007	Promotion of the further development of e-freight and Intelligent Transport Systems (ITS), the improvement of the sustainable quality and efficiency, the simplification of transport chains, the reinforcement of green corridors in Trans-European Transport Networks and Marco Polo priorities, etc.
Action Plan for mobility, 2009	Urbanisation and its impact on transport was identified as one of the key challenges in providing a more sustainable transportation system, through short and medium-term actions (from 2009 to 2012) that integrate urban mobility and promote partnerships at a local, regional and national level and enhance the involvement of EU stakeholders, citizens and industry.

Source: http://europa.eu



EU Policies

White Paper, 2011	The paper contains objectives, actions and initiatives for the realization of a more sustainable transport system till 2050 and indicates intermodal integration as one of the most important issues of future transport systems.
European Innovation Partnership for Smart Cities and Communities, 2012	Combining Information and Communication Technologies, energy and transport management, aims at coming up with innovating solutions that can address the major environmental, societal and health challenges that European cities face.
Urban mobility package, 2013	Introduction of the concept of "Sustainable Urban Mobility Plans" (SUMPs), as a result of the broad exchange of knowledge and experience between stakeholders and planning experts across the European Union.
Thematic research summary on passenger transport, 2013	This report foresees that intermodal mobility concepts should aim at increasing flexibility and efficiency through the combination of transport means and the concurrent assurance of reliability and comfort.

Source: http://europa.eu

alliance EU strategies

Trans-European Transport Networks

In 2014, EU released a transport infrastructure policy for the connection of the continent between East and West, North and South.

The policy aimed at closing the gaps between Member States' transport networks and removing any bottlenecks that do not allow the smooth functioning of the internal market.

For the facilitation of the coordinated implementation of the network, 9 core corridors were introduced:

1. Scandinavian-Mediterranean Core Network Corridor
2. **North Sea-Baltic Core Network Corridor**
3. North Sea-Mediterranean Core Network Corridor
4. Baltic-Adriatic Core Network Corridor
5. Orient-East Med Core Network Corridor
6. Rhine-Alpine Core Network Corridor
7. Atlantic Core Network Corridor
8. Rhine-Danube Core Network Corridor
9. Mediterranean Core Network Corridor

North Sea-Baltic Core Network Corridor

- Connects the ports of Eastern shore of the Baltic Sea with the ports of the North Sea
- It will connect Finland with Estonia by ferry
- It will provide modern road and rail transport links between the 3 Baltic States
- Rail Baltic Project: European standard gauge railway between Tallinn, Riga, Kaunas and North-Eastern Poland

Source: http://europa.eu

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alliance EU strategies

EU strategy for the Baltic Sea Region

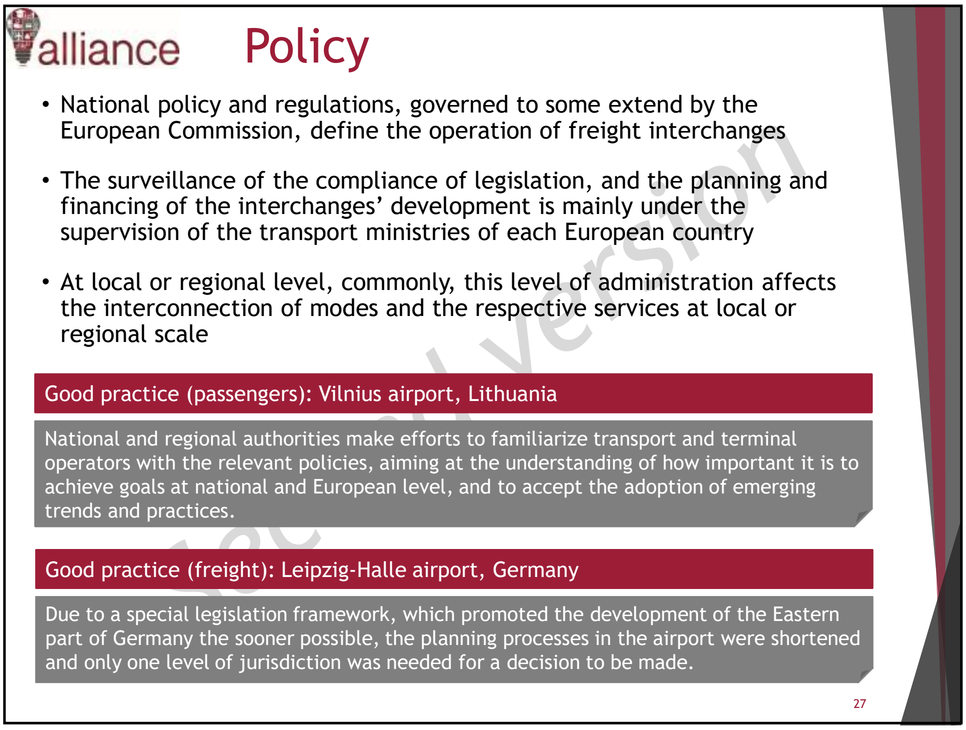
- It is the 1st macro-regional strategy in Europe
- It aims at strengthening cooperation within the large region in order to face several challenges by mutual work and promote a more balanced development in the area
- Challenges

1. To enable a sustainable environment
2. To enhance the region's prosperity
3. To increase accessibility and attractiveness
4. To ensure safety and security in the region

- Opportunities

1. Well-educated workforce, expertise in innovation
2. Spacious and relatively good land environment rich in natural resources
3. Strong tradition of intra-regional cooperation
4. **EU policies and legislation provides a strong base on which to build more effective cooperation**
5. Designation of the Baltic Sea as a Particularly Sensitive Sea Area, ensuring that **the growth of shipping and other maritime activities is sustainable**

Source: http://europa.eu



Policy

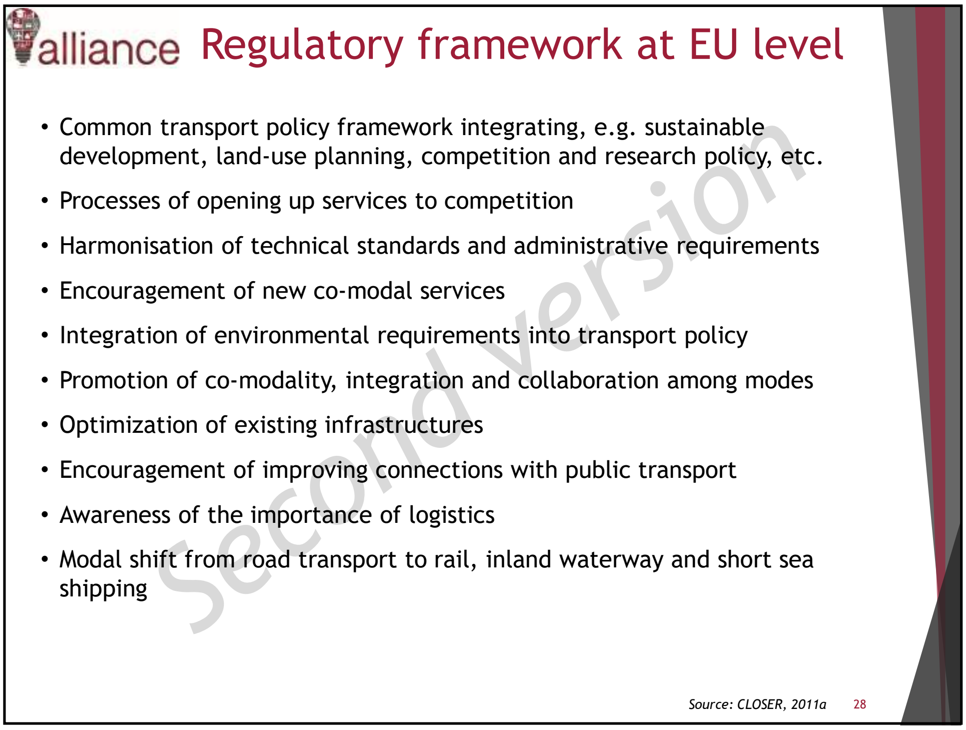
- National policy and regulations, governed to some extend by the European Commission, define the operation of freight interchanges
- The surveillance of the compliance of legislation, and the planning and financing of the interchanges' development is mainly under the supervision of the transport ministries of each European country
- At local or regional level, commonly, this level of administration affects the interconnection of modes and the respective services at local or regional scale

Good practice (passengers): Vilnius airport, Lithuania

National and regional authorities make efforts to familiarize transport and terminal operators with the relevant policies, aiming at the understanding of how important it is to achieve goals at national and European level, and to accept the adoption of emerging trends and practices.

Good practice (freight): Leipzig-Halle airport, Germany

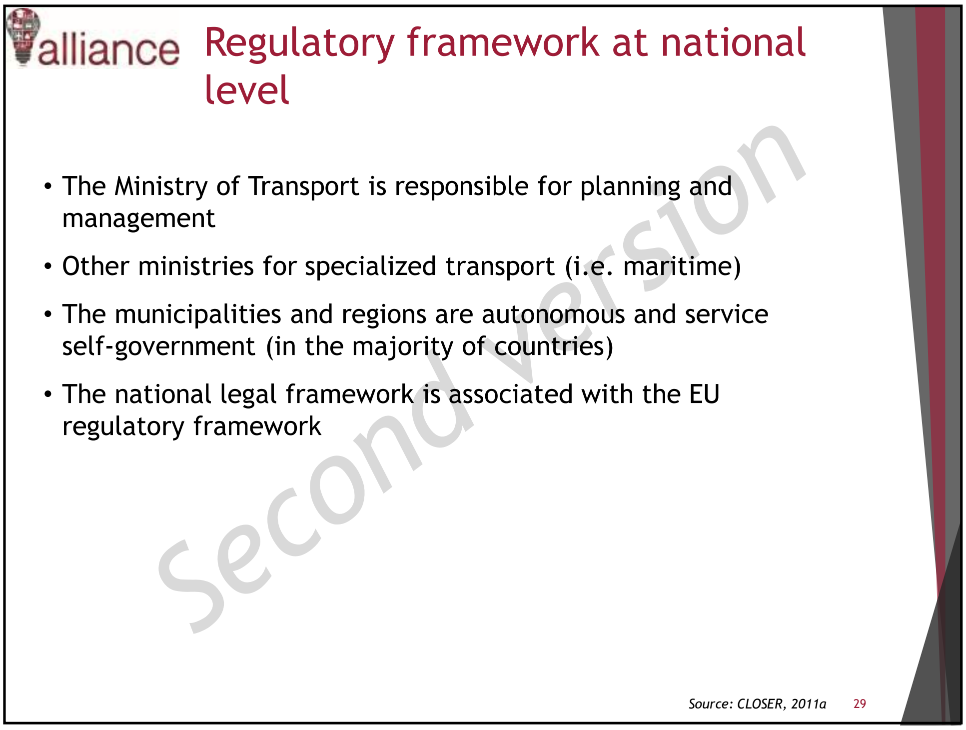
Due to a special legislation framework, which promoted the development of the Eastern part of Germany the sooner possible, the planning processes in the airport were shortened and only one level of jurisdiction was needed for a decision to be made.



Regulatory framework at EU level

- Common transport policy framework integrating, e.g. sustainable development, land-use planning, competition and research policy, etc.
- Processes of opening up services to competition
- Harmonisation of technical standards and administrative requirements
- Encouragement of new co-modal services
- Integration of environmental requirements into transport policy
- Promotion of co-modality, integration and collaboration among modes
- Optimization of existing infrastructures
- Encouragement of improving connections with public transport
- Awareness of the importance of logistics
- Modal shift from road transport to rail, inland waterway and short sea shipping

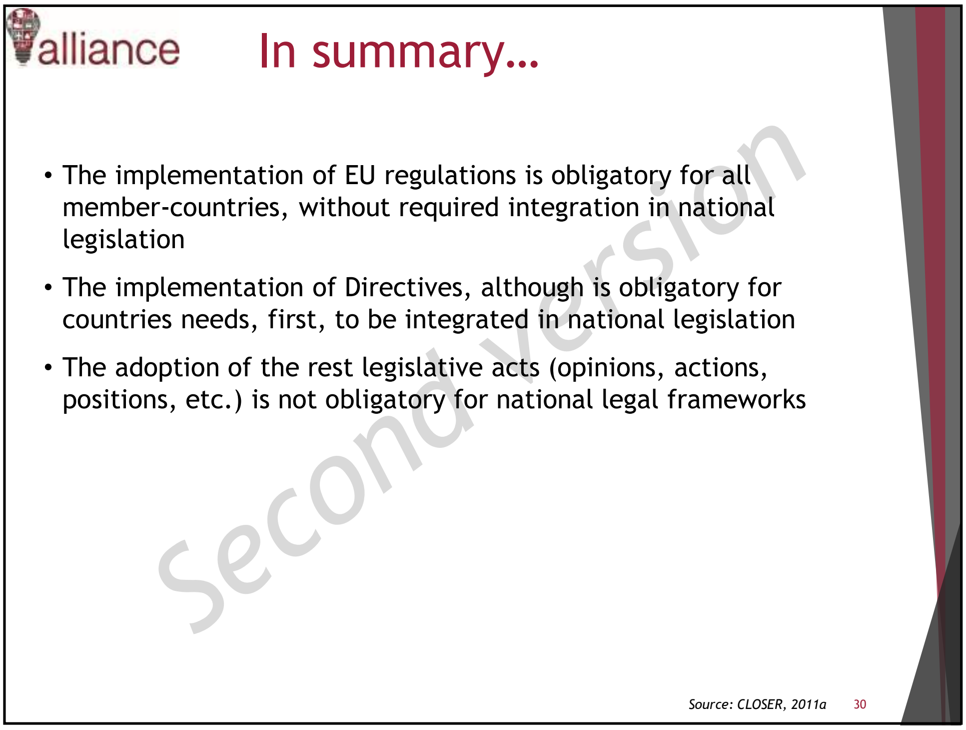
Source: CLOSER, 2011a



Regulatory framework at national level

- The Ministry of Transport is responsible for planning and management
- Other ministries for specialized transport (i.e. maritime)
- The municipalities and regions are autonomous and service self-government (in the majority of countries)
- The national legal framework is associated with the EU regulatory framework

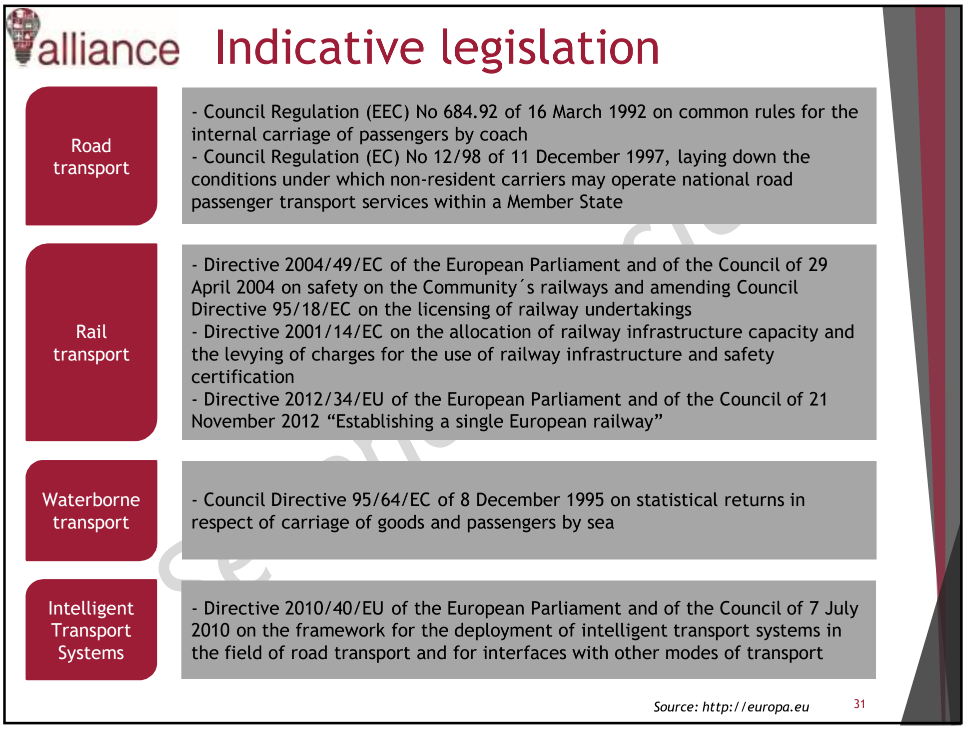
Source: CLOSER, 2011a



In summary…

- The implementation of EU regulations is obligatory for all member-countries, without required integration in national legislation
- The implementation of Directives, although is obligatory for countries needs, first, to be integrated in national legislation
- The adoption of the rest legislative acts (opinions, actions, positions, etc.) is not obligatory for national legal frameworks

Source: CLOSER, 2011a



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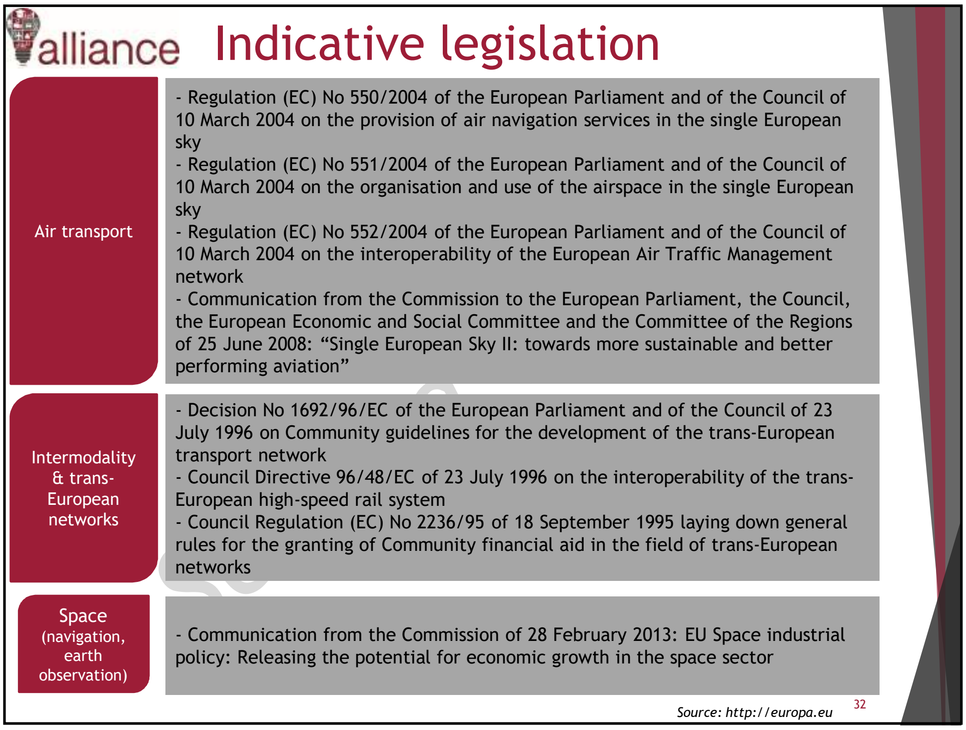
Indicative legislation

Road transport	- Council Regulation (EEC) No 684.92 of 16 March 1992 on common rules for the internal carriage of passengers by coach - Council Regulation (EC) No 12/98 of 11 December 1997, laying down the conditions under which non-resident carriers may operate national road passenger transport services within a Member State
Rail transport	- Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on safety on the Community´s railways and amending Council Directive 95/18/EC on the licensing of railway undertakings - Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification - Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 “Establishing a single European railway”
Waterborne transport	- Council Directive 95/64/EC of 8 December 1995 on statistical returns in respect of carriage of goods and passengers by sea
Intelligent Transport Systems	- Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of intelligent transport systems in the field of road transport and for interfaces with other modes of transport

Source: http://europa.eu



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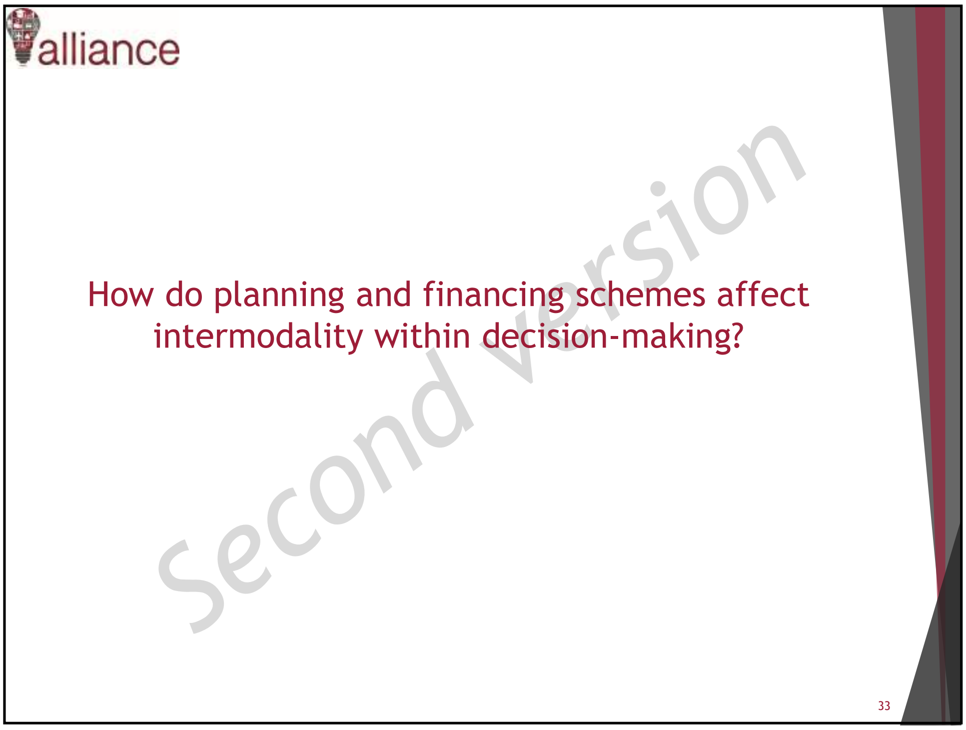
Indicative legislation

Air transport	- Regulation (EC) No 550/2004 of the European Parliament and of the Council of 10 March 2004 on the provision of air navigation services in the single European sky - Regulation (EC) No 551/2004 of the European Parliament and of the Council of 10 March 2004 on the organisation and use of the airspace in the single European sky - Regulation (EC) No 552/2004 of the European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network - Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions of 25 June 2008: “Single European Sky II: towards more sustainable and better performing aviation”
Intermodality & trans-European networks	- Decision No 1692/96/EC of the European Parliament and of the Council of 23 July 1996 on Community guidelines for the development of the trans-European transport network - Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system - Council Regulation (EC) No 2236/95 of 18 September 1995 laying down general rules for the granting of Community financial aid in the field of trans-European networks
Space (navigation, earth observation)	- Communication from the Commission of 28 February 2013: EU Space industrial policy: Releasing the potential for economic growth in the space sector

Source: http://europa.eu



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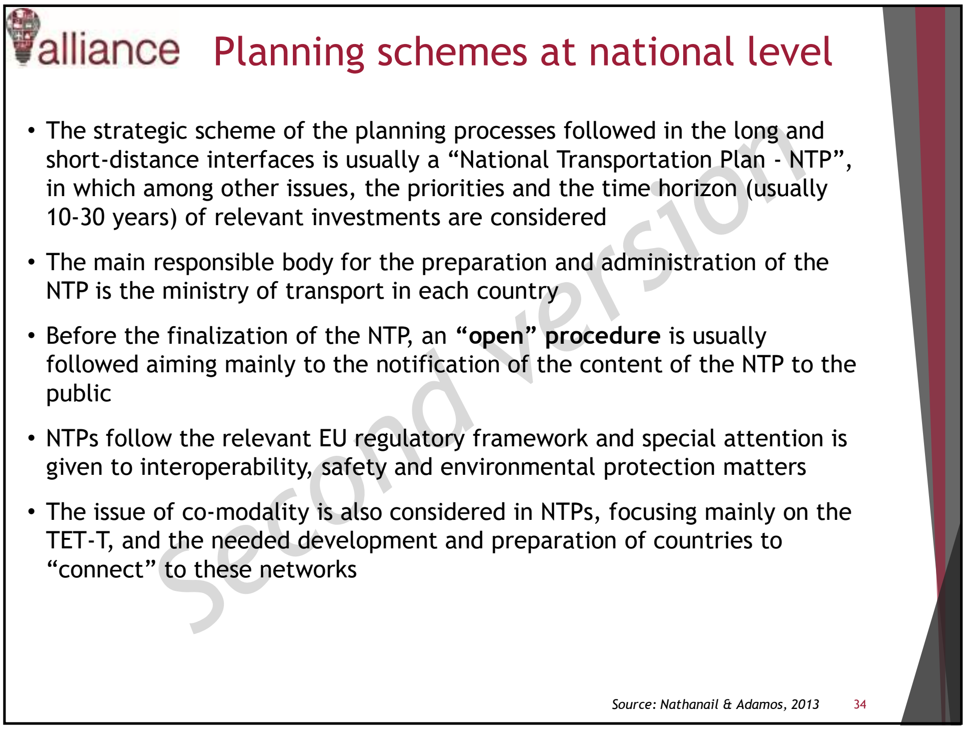
How do planning and financing schemes affect intermodality within decision-making?



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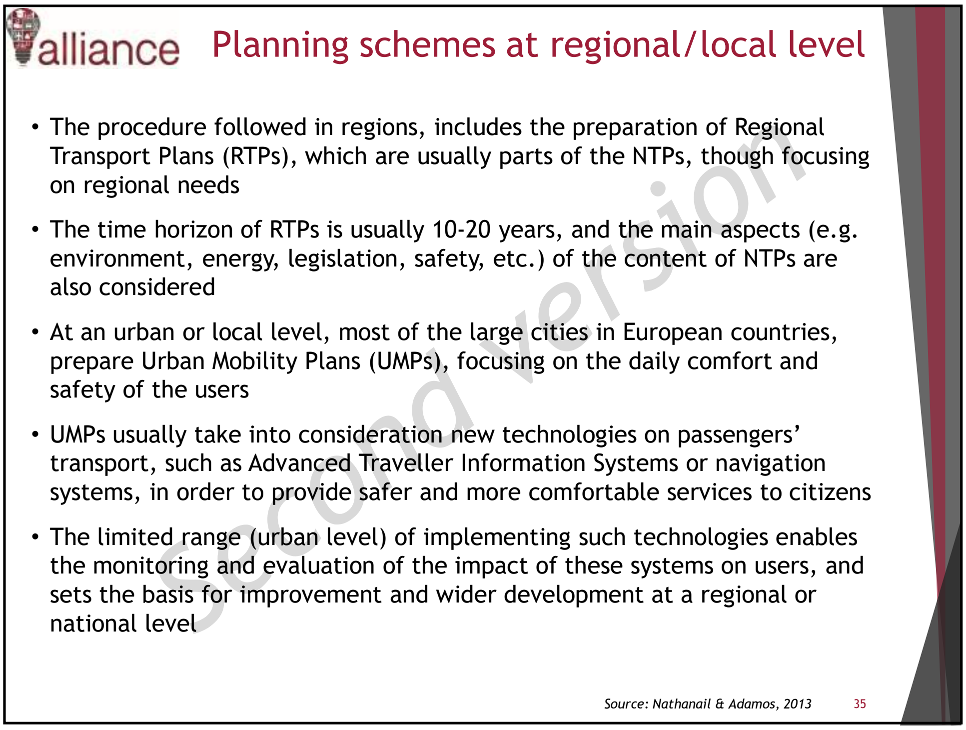
Planning schemes at national level

- The strategic scheme of the planning processes followed in the long and short-distance interfaces is usually a “National Transportation Plan - NTP”, in which among other issues, the priorities and the time horizon (usually 10-30 years) of relevant investments are considered
- The main responsible body for the preparation and administration of the NTP is the ministry of transport in each country
- Before the finalization of the NTP, an **“open” procedure** is usually followed aiming mainly to the notification of the content of the NTP to the public
- NTPs follow the relevant EU regulatory framework and special attention is given to interoperability, safety and environmental protection matters
- The issue of co-modality is also considered in NTPs, focusing mainly on the TET-T, and the needed development and preparation of countries to “connect” to these networks

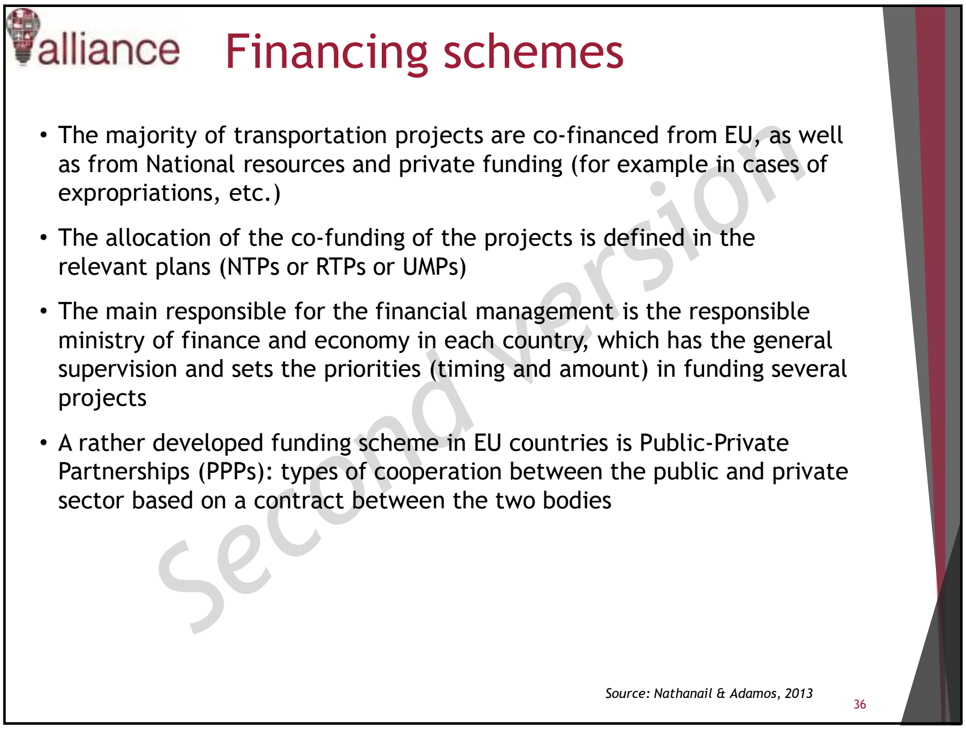
Source: Nathanail & Adamos, 2013



Planning schemes at regional/local level

- The procedure followed in regions, includes the preparation of Regional Transport Plans (RTPs), which are usually parts of the NTPs, though focusing on regional needs
- The time horizon of RTPs is usually 10-20 years, and the main aspects (e.g. environment, energy, legislation, safety, etc.) of the content of NTPs are also considered
- At an urban or local level, most of the large cities in European countries, prepare Urban Mobility Plans (UMPs), focusing on the daily comfort and safety of the users
- UMPs usually take into consideration new technologies on passengers' transport, such as Advanced Traveller Information Systems or navigation systems, in order to provide safer and more comfortable services to citizens
- The limited range (urban level) of implementing such technologies enables the monitoring and evaluation of the impact of these systems on users, and sets the basis for improvement and wider development at a regional or national level

Source: Nathanail & Adamos, 2013



Financing schemes

- The majority of transportation projects are co-financed from EU, as well as from National resources and private funding (for example in cases of expropriations, etc.)
- The allocation of the co-funding of the projects is defined in the relevant plans (NTPs or RTPs or UMPs)
- The main responsible for the financial management is the responsible ministry of finance and economy in each country, which has the general supervision and sets the priorities (timing and amount) in funding several projects
- A rather developed funding scheme in EU countries is Public-Private Partnerships (PPPs): types of cooperation between the public and private sector based on a contract between the two bodies

Source: Nathanail & Adamos, 2013

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Applications

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Ports

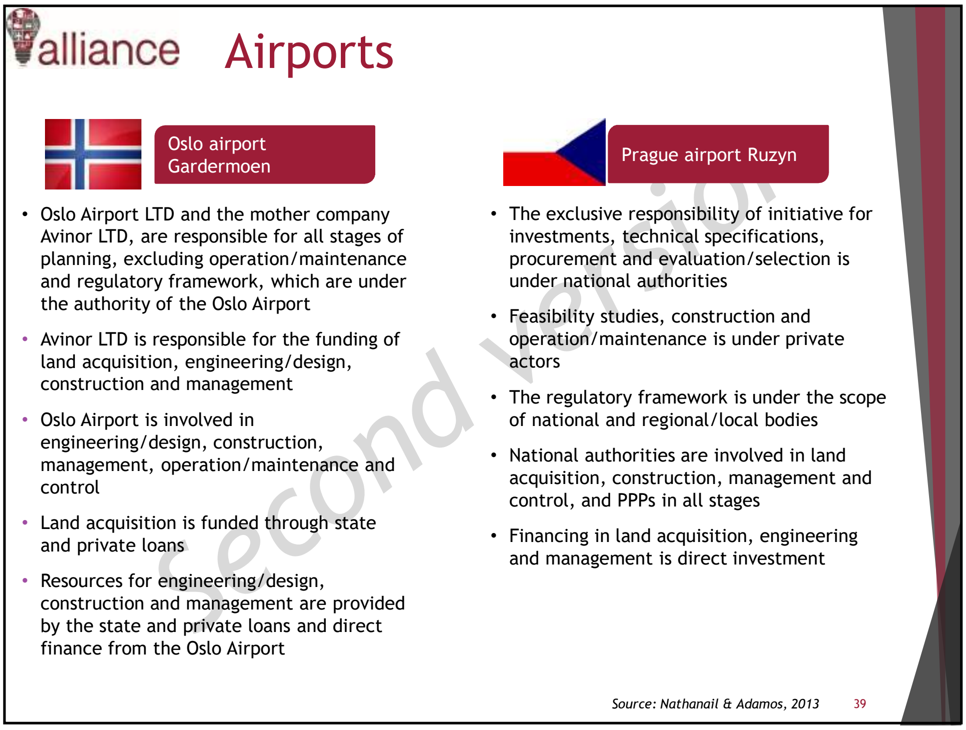
Thessaloniki Port Authority – ThPA S.A.

- The port works under a concession agreement between the state and the ThPA S.A.
- ThPA S.A. has the exclusive right to use and exploit land, buildings and facilities of the port, owned by the state
- All stages of the planning process are under the responsibility of the ThPA S.A., except from the regulatory framework, which is under the scope of the state
- The funding scheme is exclusively direct investment

Norwegian Coastal Administration

- The Norwegian Coastal Administration is the national agency for coastal management, maritime safety and communication in Norway
- The initiatives for investments, procurement and feasibility study are under the responsibility of national and regional/local authorities
- The technical specifications and the regulatory framework are under the responsibility of national authorities
- The state is involved in all stages, while regional and local authorities are responsible for engineering/design, construction, management, operation/maintenance and control
- The financing scheme is direct investments, and PPPs in the cases of engineering/design, construction and operation/maintenance

Source: Nathanail & Adamos, 2013



Airports

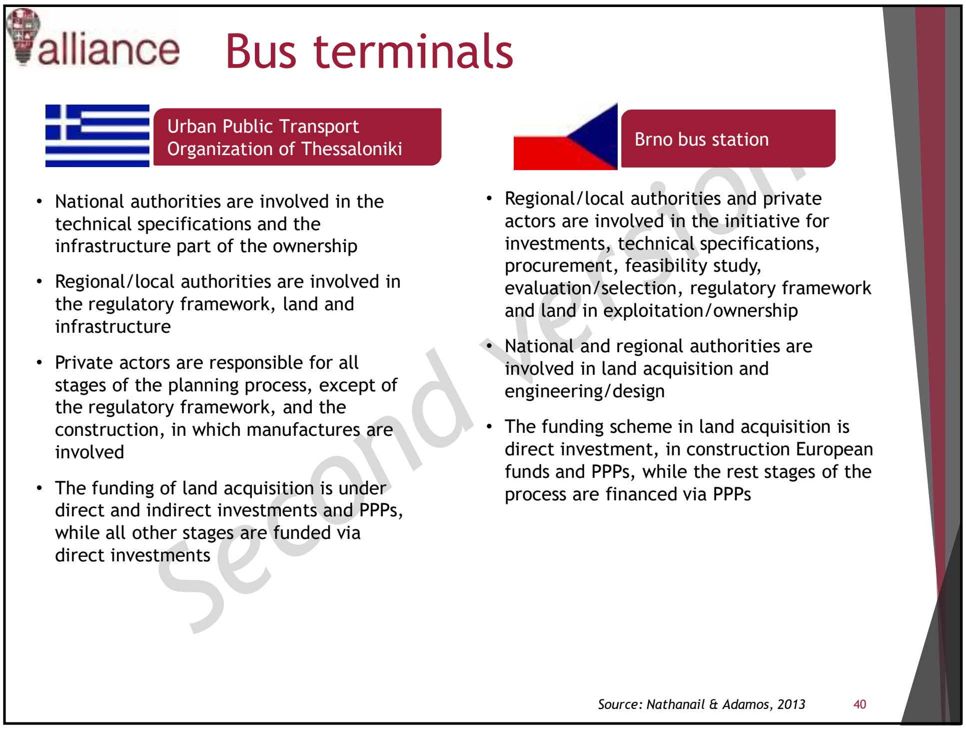
Oslo airport Gardermoen

- Oslo Airport LTD and the mother company Avinor LTD, are responsible for all stages of planning, excluding operation/maintenance and regulatory framework, which are under the authority of the Oslo Airport
- Avinor LTD is responsible for the funding of land acquisition, engineering/design, construction and management
- Oslo Airport is involved in engineering/design, construction, management, operation/maintenance and control
- Land acquisition is funded through state and private loans
- Resources for engineering/design, construction and management are provided by the state and private loans and direct finance from the Oslo Airport

Prague airport Ruzyn

- The exclusive responsibility of initiative for investments, technical specifications, procurement and evaluation/selection is under national authorities
- Feasibility studies, construction and operation/maintenance is under private actors
- The regulatory framework is under the scope of national and regional/local bodies
- National authorities are involved in land acquisition, construction, management and control, and PPPs in all stages
- Financing in land acquisition, engineering and management is direct investment

Source: Nathanail & Adamos, 2013



Bus terminals

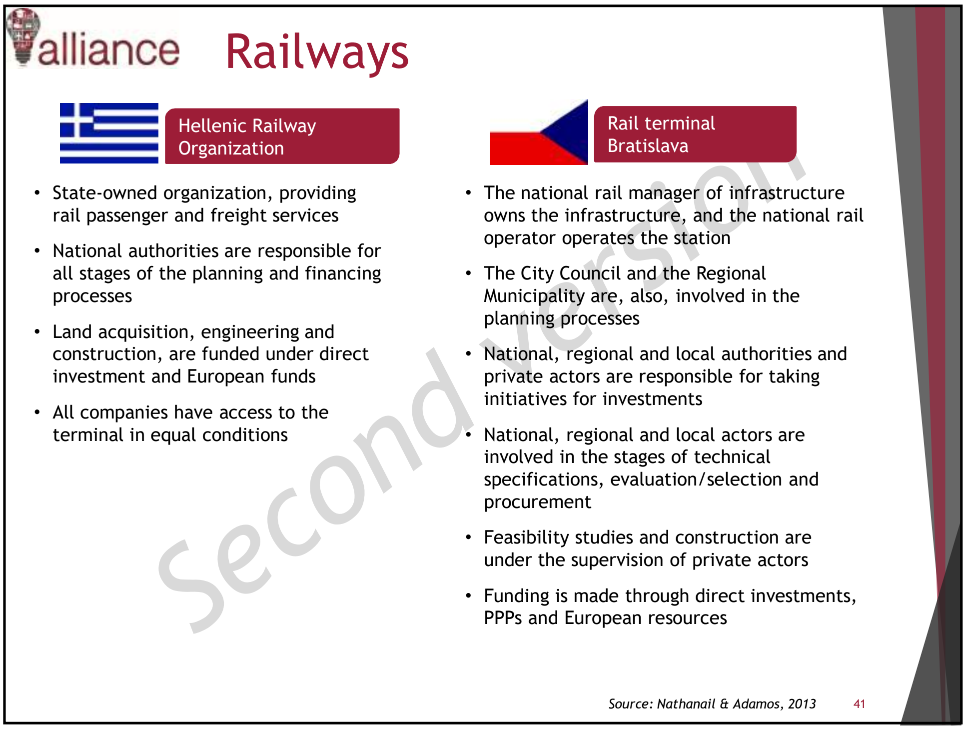
Urban Public Transport Organization of Thessaloniki

- National authorities are involved in the technical specifications and the infrastructure part of the ownership
- Regional/local authorities are involved in the regulatory framework, land and infrastructure
- Private actors are responsible for all stages of the planning process, except of the regulatory framework, and the construction, in which manufactures are involved
- The funding of land acquisition is under direct and indirect investments and PPPs, while all other stages are funded via direct investments

Brno bus station

- Regional/local authorities and private actors are involved in the initiative for investments, technical specifications, procurement, feasibility study, evaluation/selection, regulatory framework and land in exploitation/ownership
- National and regional authorities are involved in land acquisition and engineering/design
- The funding scheme in land acquisition is direct investment, in construction European funds and PPPs, while the rest stages of the process are financed via PPPs

Source: Nathanail & Adamos, 2013



Railways

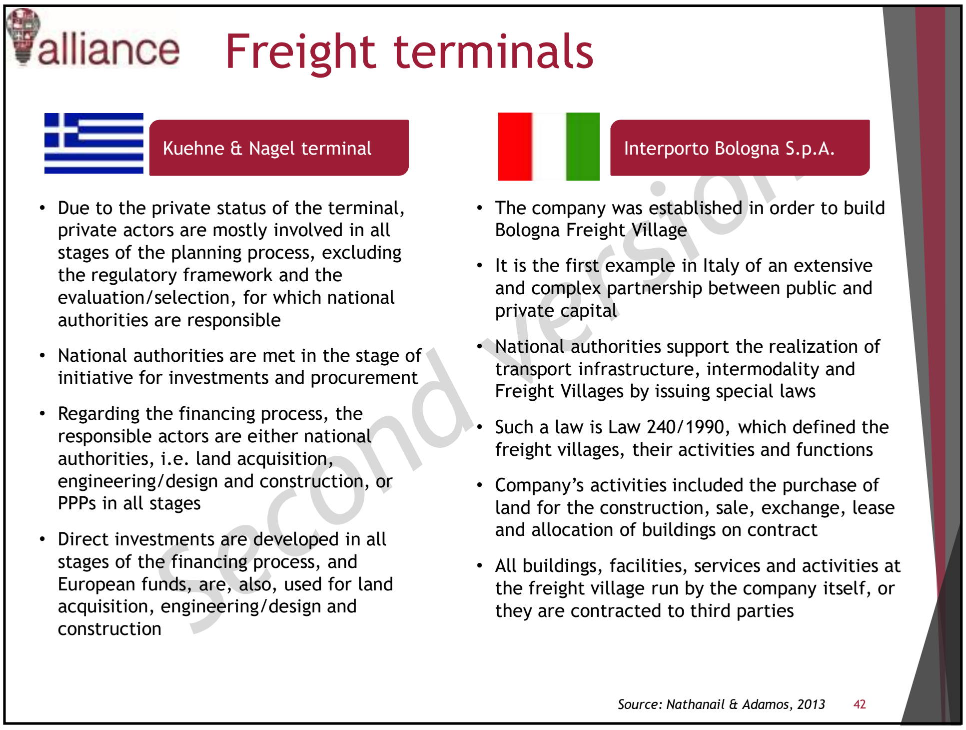
Hellenic Railway Organization

- State-owned organization, providing rail passenger and freight services
- National authorities are responsible for all stages of the planning and financing processes
- Land acquisition, engineering and construction, are funded under direct investment and European funds
- All companies have access to the terminal in equal conditions

Rail terminal Bratislava

- The national rail manager of infrastructure owns the infrastructure, and the national rail operator operates the station
- The City Council and the Regional Municipality are, also, involved in the planning processes
- National, regional and local authorities and private actors are responsible for taking initiatives for investments
- National, regional and local actors are involved in the stages of technical specifications, evaluation/selection and procurement
- Feasibility studies and construction are under the supervision of private actors
- Funding is made through direct investments, PPPs and European resources

Source: Nathanail & Adamos, 2013



Freight terminals

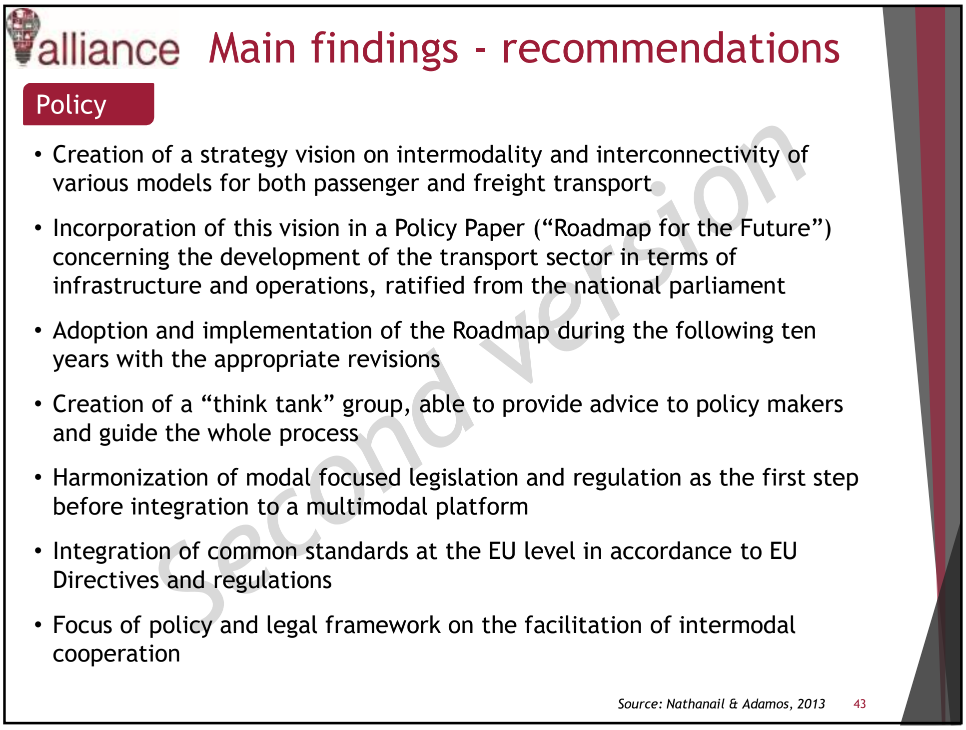
Kuehne & Nagel terminal

- Due to the private status of the terminal, private actors are mostly involved in all stages of the planning process, excluding the regulatory framework and the evaluation/selection, for which national authorities are responsible
- National authorities are met in the stage of initiative for investments and procurement
- Regarding the financing process, the responsible actors are either national authorities, i.e. land acquisition, engineering/design and construction, or PPPs in all stages
- Direct investments are developed in all stages of the financing process, and European funds, are, also, used for land acquisition, engineering/design and construction

Interporto Bologna S.p.A.

- The company was established in order to build Bologna Freight Village
- It is the first example in Italy of an extensive and complex partnership between public and private capital
- National authorities support the realization of transport infrastructure, intermodality and Freight Villages by issuing special laws
- Such a law is Law 240/1990, which defined the freight villages, their activities and functions
- Company's activities included the purchase of land for the construction, sale, exchange, lease and allocation of buildings on contract
- All buildings, facilities, services and activities at the freight village run by the company itself, or they are contracted to third parties

Source: Nathanail & Adamos, 2013

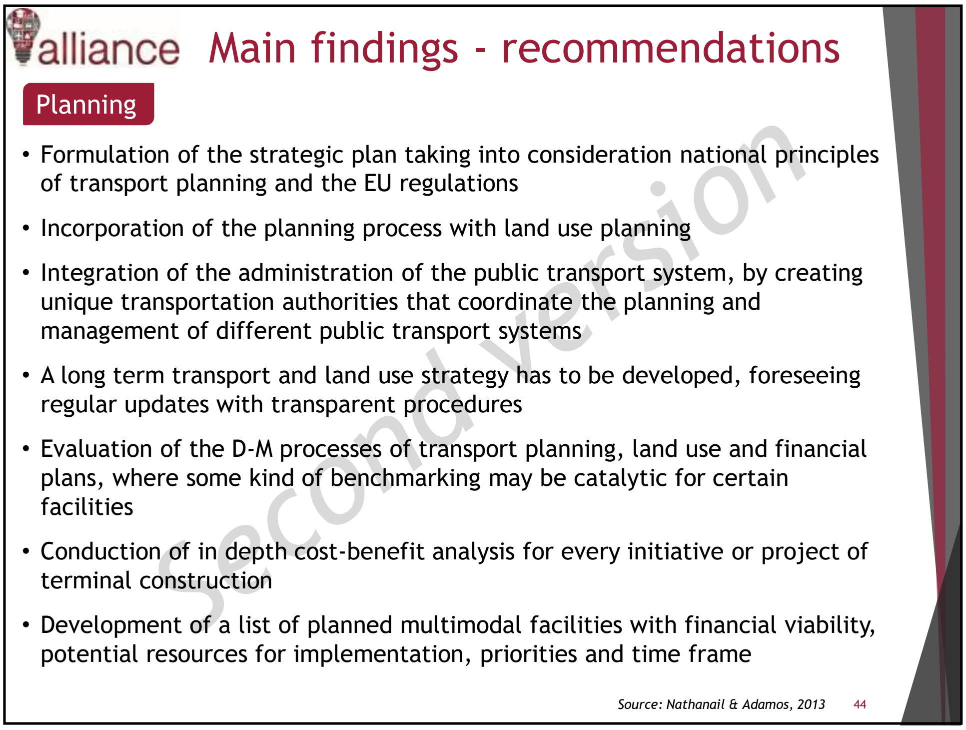


Main findings - recommendations

Policy

- Creation of a strategy vision on intermodality and interconnectivity of various models for both passenger and freight transport
- Incorporation of this vision in a Policy Paper (“Roadmap for the Future”) concerning the development of the transport sector in terms of infrastructure and operations, ratified from the national parliament
- Adoption and implementation of the Roadmap during the following ten years with the appropriate revisions
- Creation of a “think tank” group, able to provide advice to policy makers and guide the whole process
- Harmonization of modal focused legislation and regulation as the first step before integration to a multimodal platform
- Integration of common standards at the EU level in accordance to EU Directives and regulations
- Focus of policy and legal framework on the facilitation of intermodal cooperation

Source: Nathanail & Adamos, 2013

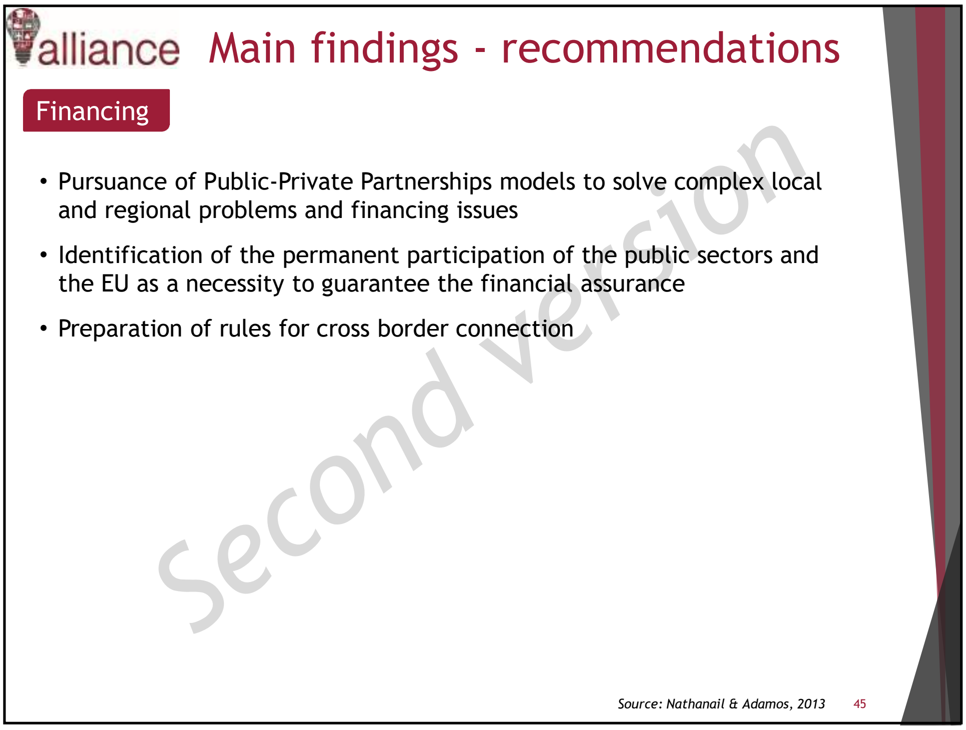


Main findings - recommendations

Planning

- Formulation of the strategic plan taking into consideration national principles of transport planning and the EU regulations
- Incorporation of the planning process with land use planning
- Integration of the administration of the public transport system, by creating unique transportation authorities that coordinate the planning and management of different public transport systems
- A long term transport and land use strategy has to be developed, foreseeing regular updates with transparent procedures
- Evaluation of the D-M processes of transport planning, land use and financial plans, where some kind of benchmarking may be catalytic for certain facilities
- Conduction of in depth cost-benefit analysis for every initiative or project of terminal construction
- Development of a list of planned multimodal facilities with financial viability, potential resources for implementation, priorities and time frame

Source: Nathanail & Adamos, 2013



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Main findings - recommendations

Financing

- Pursuance of Public-Private Partnerships models to solve complex local and regional problems and financing issues
- Identification of the permanent participation of the public sectors and the EU as a necessity to guarantee the financial assurance
- Preparation of rules for cross border connection

Source: Nathanail & Adamos, 2013

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Guidance to further knowledge acquisition

Suggested literature

- Adamos, G., Tsami, M. & Nathanail, E., 2015. “Urban interchanges: Moving towards a seamless transportation solution”. 5th International Conference on Environmental Management, Engineering, Planning and Economics (CEMEPE) and SECOTOX Conference. Mykonos Island, Greece, June 14-18, 2015.
- Adamos, G. & Nathanail, E., 2013. “Recommendations on the development and implementation of a coherent decision making process in the short-long transport interconnection”. 13th World Conference on Transport Research, Rio de Janeiro, Brazil, July 15-18, 2013.
- Adamos, G., Nathanail, E. & Zacharaki, E., 2012. “Developing a Decision-Making Framework for collaborative practices in long-short distance transport interconnection”. Procedia – Social and Behavioral Sciences, Volume 48, 2012, Pages 2849-2859.
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- European Commission, 2004: Towards passenger intermodality in the European Union. Brussels.
- European Commission, 2007. “GREEN PAPER - Towards a new culture for urban mobility”, Brussels, 25.9.2007 COM (2007) 551 final.
- European Commission, 2011. Roadmap to a Single European Transport Arena –Towards a competitive and resource efficient transport system. White Paper of the European Commission. COM (2011) 144 final.
- Nathanail E. & Adamos, G. 2013. “Planning and financing schemes linked to the decision-making for the interconnection of long-short distance transport”. Transport and Telecommunication. Volume 14, Issue 1, Pages 20-28, ISSN (Online) 1407-6179, ISSN (Print) 1407-6160, DOI: 10.2478/ttj-2013-000, February 2013.

List of indicative legislation

- Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions of 25 June 2008: “Single European Sky II: towards more sustainable and better performing aviation”.
- Communication from the Commission of 28 February 2013: EU Space industrial policy: Releasing the potential for economic growth in the space sector.
- Council Regulation (EC) No 12/98 of 11 December 1997, laying down the conditions under which non-resident carriers may operate national road passenger transport services within a Member State.
- Council Regulation (EEC) No 684.92 of 16 March 1992 on common rules for the internal carriage of passengers by coach.
- Council Directive 95/64/EC of 8 December 1995 on statistical returns in respect of carriage of goods and passengers by sea.
- Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system.
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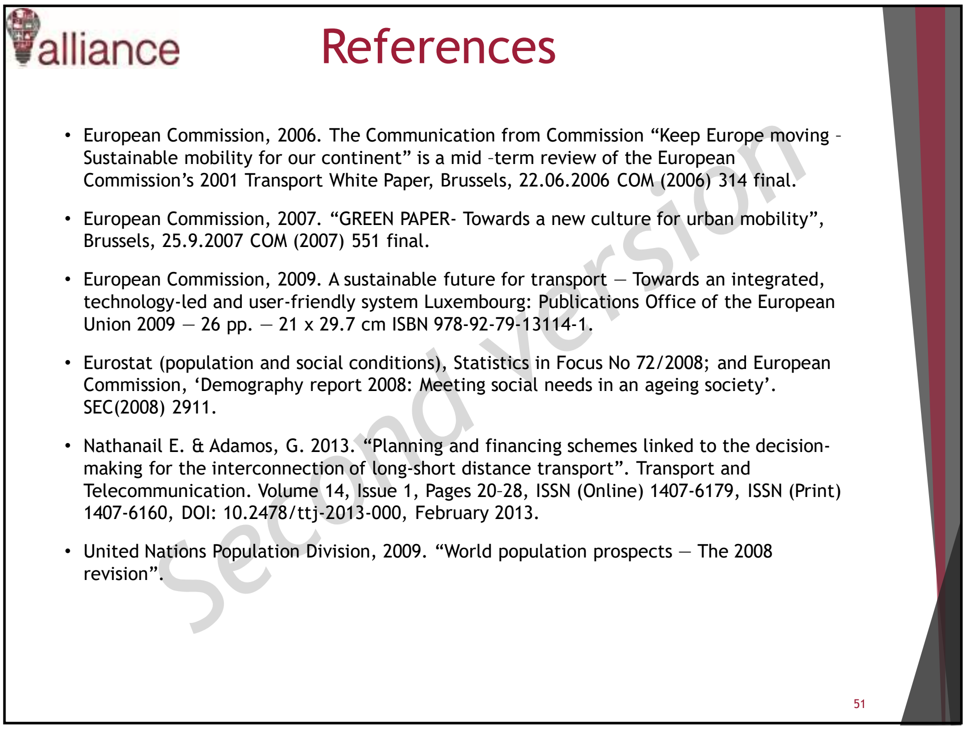

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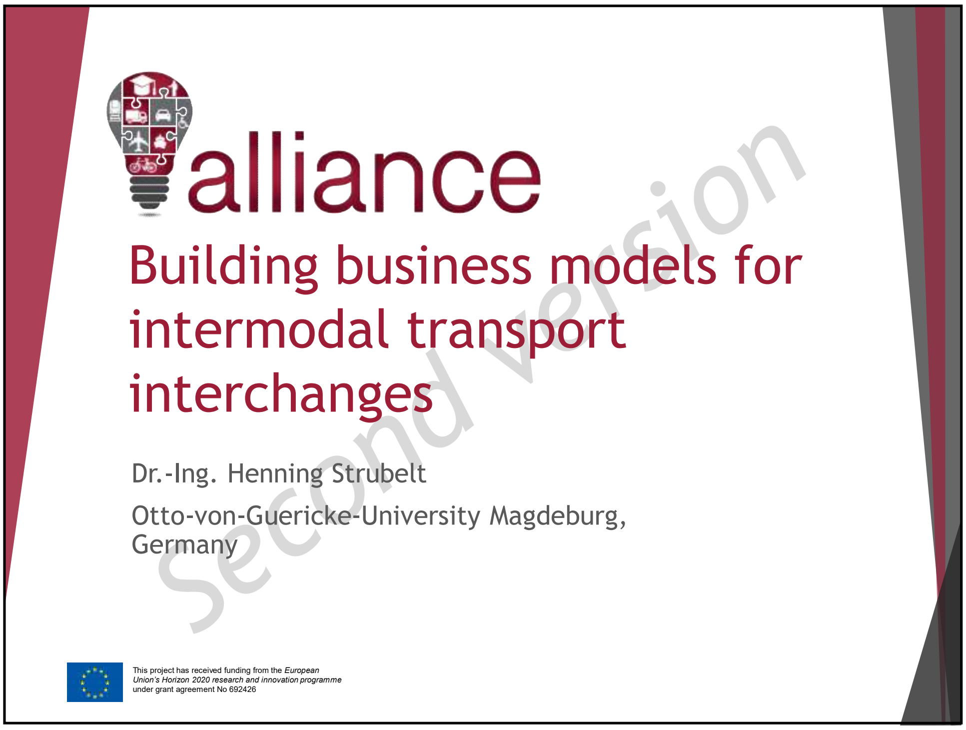

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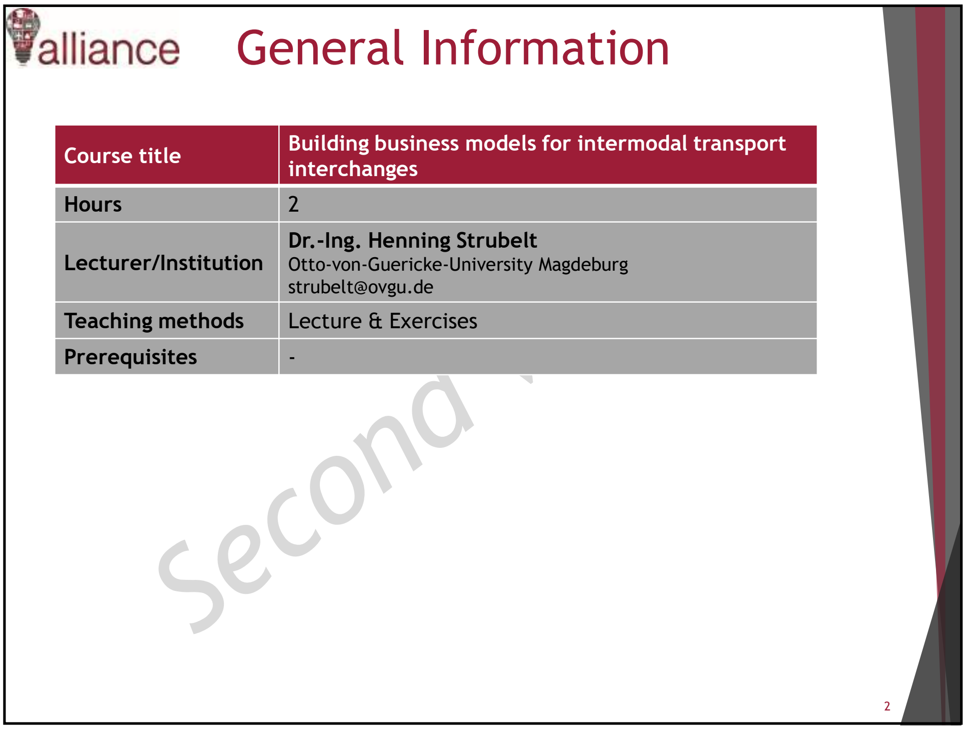
Building business models for intermodal transport interchanges

Dr.-Ing. Henning Strubelt

Otto-von-Guericke-University Magdeburg, Germany

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



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General Information

Course title	Building business models for intermodal transport interchanges
Hours	2
Lecturer/Institution	**Dr.-Ing. Henning Strubelt** Otto-von-Guericke-University Magdeburg strubelt@ovgu.de
Teaching methods	Lecture & Exercises
Prerequisites	-

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Aim and Learning Outcomes

- **Aim:**
  - Get introduced to business models and the development thereof
  - Get enabled to analyze the options for and limitations to logistics implementation concepts concerning intermodal transport aspects
  - Develop a thorough understanding of the physical and monetary aspects and processes of material flow technology in intermodal transport networks
  - Get enabled to evaluate business models for intermodal transport
- **Learning outcomes:**
  - Acquire basic knowledge of intermodal transport interchanges and business models
  - Acquire knowledge about the processual importance of intermodal transport interchanges in efficient supply chains
  - Develop skills for logistical evaluations required for the selection of intermodal transport concepts and to assess economic conditions of service and functionality
  - Enable the analysis and definition of complex intermodal transport networks

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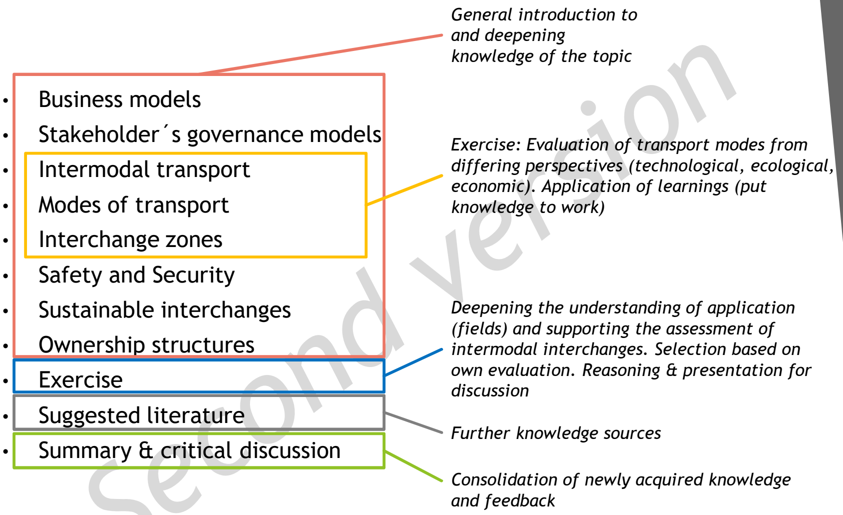
Content



- Business models
- Stakeholder´s governance models
- Intermodal transport
- Modes of transport
- Interchange zones
- Safety and Security
- Sustainable interchanges
- Ownership structures
- Exercise
- Suggested literature
- Summary & critical discussion

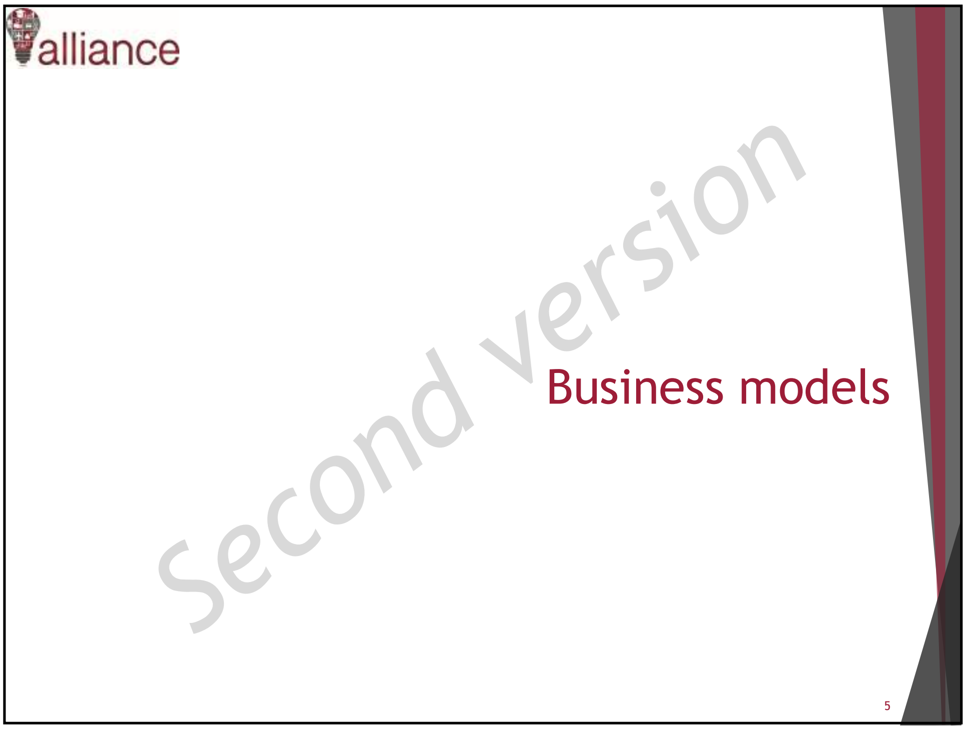
General introduction to and deepening knowledge of the topic

Exercise: Evaluation of transport modes from differing perspectives (technological, ecological, economic). Application of learnings (put knowledge to work)

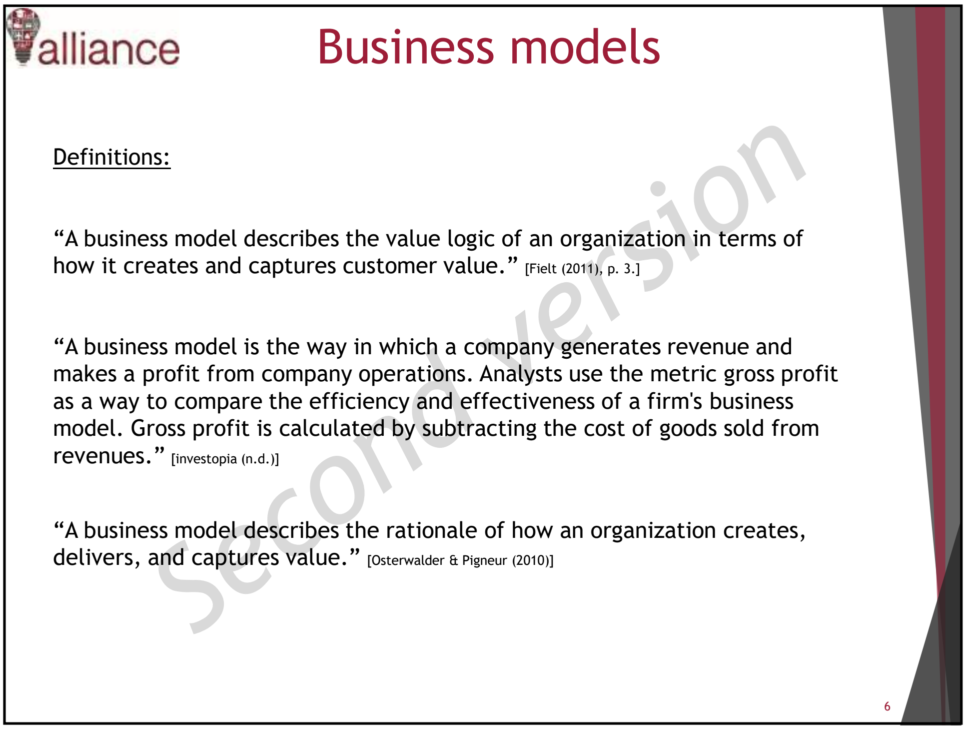
Deepening the understanding of application (fields) and supporting the assessment of intermodal interchanges. Selection based on own evaluation. Reasoning & presentation for discussion

Further knowledge sources

Consolidation of newly acquired knowledge and feedback



Business models



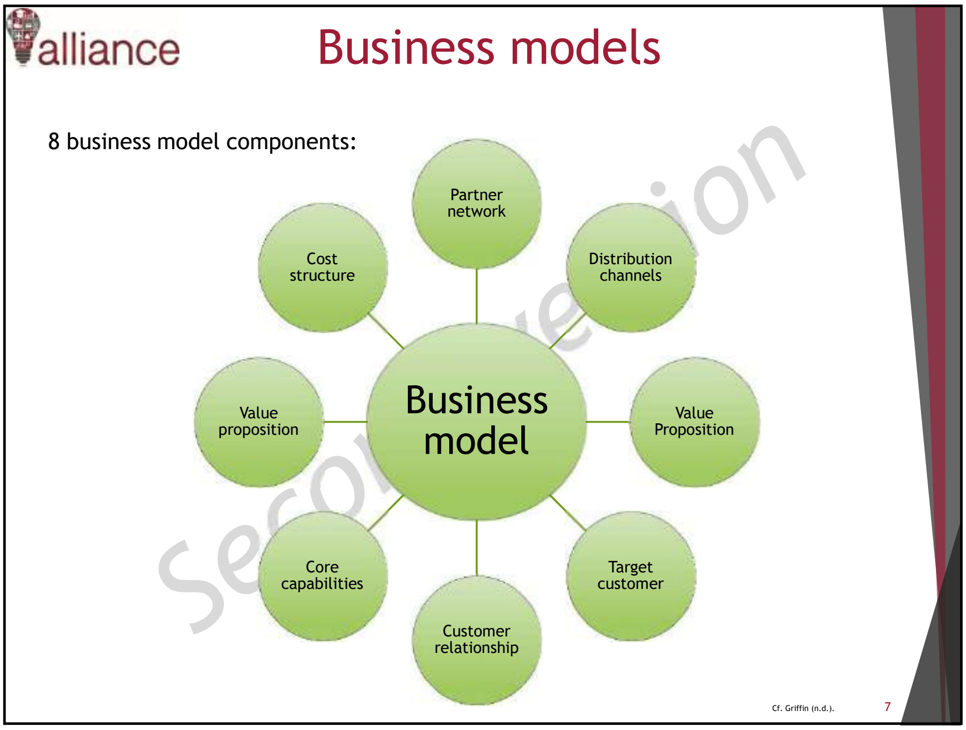
Business models

Definitions:

“A business model describes the value logic of an organization in terms of how it creates and captures customer value.” [Fielt (2011), p. 3.]

“A business model is the way in which a company generates revenue and makes a profit from company operations. Analysts use the metric gross profit as a way to compare the efficiency and effectiveness of a firm's business model. Gross profit is calculated by subtracting the cost of goods sold from revenues.” [investopia (n.d.)]

“A business model describes the rationale of how an organization creates, delivers, and captures value.” [Osterwalder & Pigneur (2010)]



Business models

8 business model components:

Business model

Partner network

Distribution channels

Value Proposition

Target customer

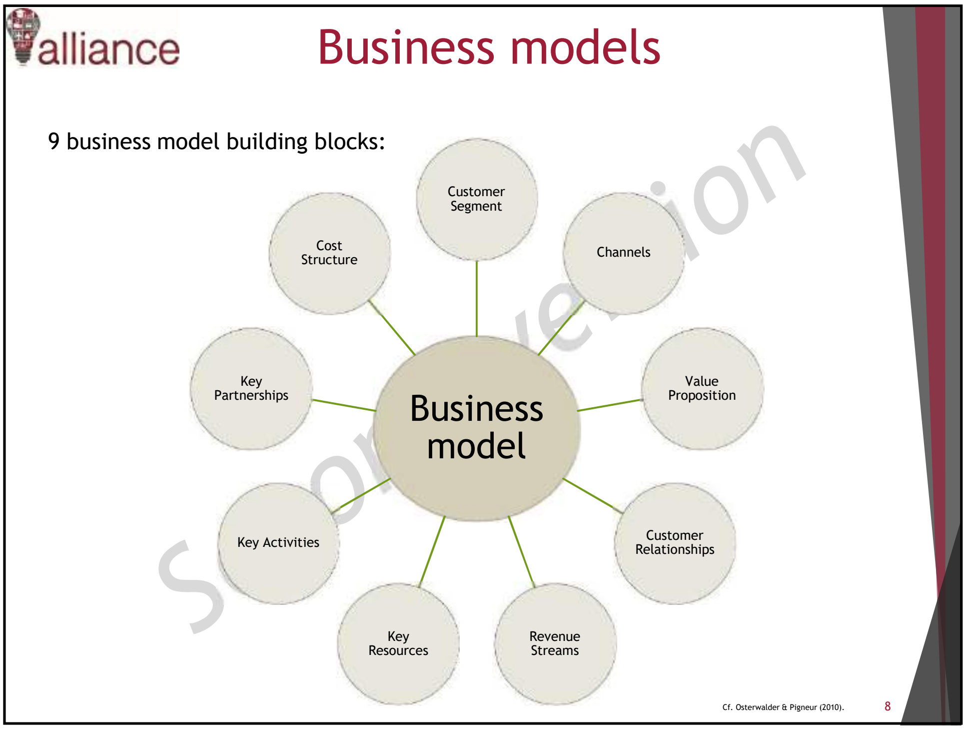
Customer relationship

Core capabilities

Value proposition

Cost structure

Cf. Griffin (n.d.).



Business models

9 business model building blocks:

Business model

Customer Segment

Channels

Value Proposition

Customer Relationships

Revenue Streams

Key Resources

Key Activities

Key Partnerships

Cost Structure

Cf. Osterwalder & Pigneur (2010).

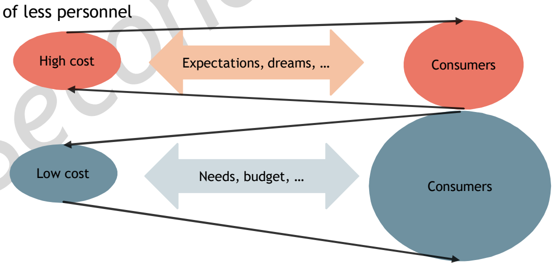
Business models

- Good business models are increasingly considered as a reason for profitable firm growth
- The two primary levers of a company's business model are pricing and costs
- Driven by the current environmental challenges, the profitability of established business models is decreasingly sustainable
  - Need for business model innovation
- Different types of business models:
  - Localized low-cost business model
  - Low-budget innovation business model
  - Community-funded business model
  - Sustainability-focused business model
  - Beyond advertising business model
  - Unlimited niches business model
  - In-crowd business model

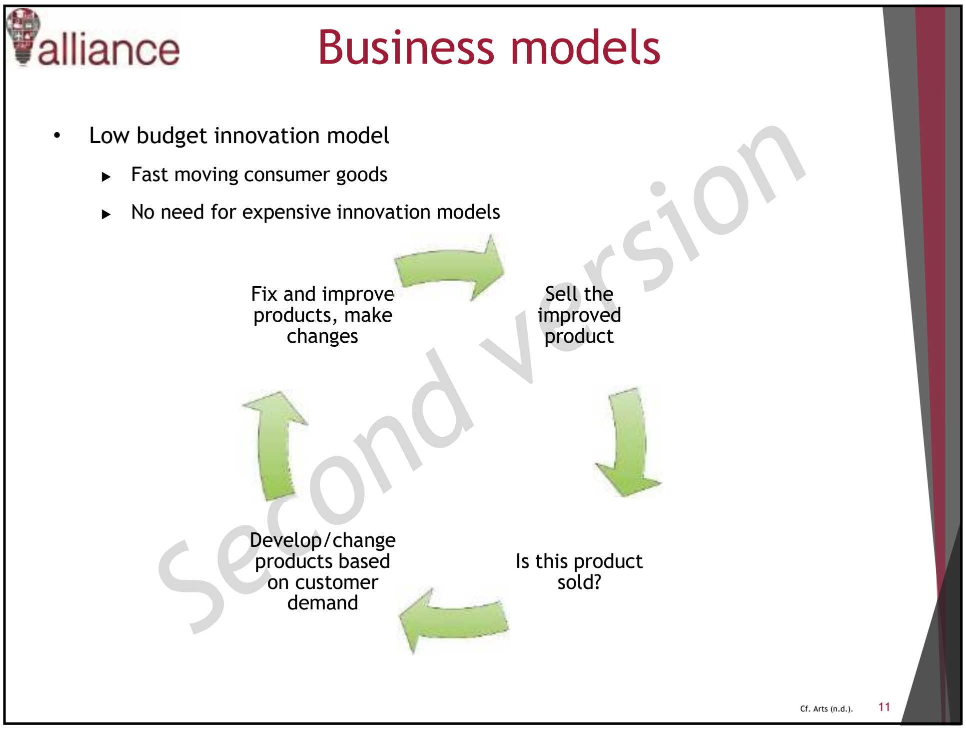
Cf. Trapp (2014), p.1, Osterwalder & Pigneur (2010) & Arts (n.d.).

Business models

- Localized low-cost business model
  - Buying services or products for less money
  - Point to point services
  - Quality aspects are more and more regulated by norms and standards
  - No need for expectations and dreams in the process, function is most important
  - Ways to reduce the price
    - Automation of the process
    - Eliminate unnecessary processes
    - Use of less personnel



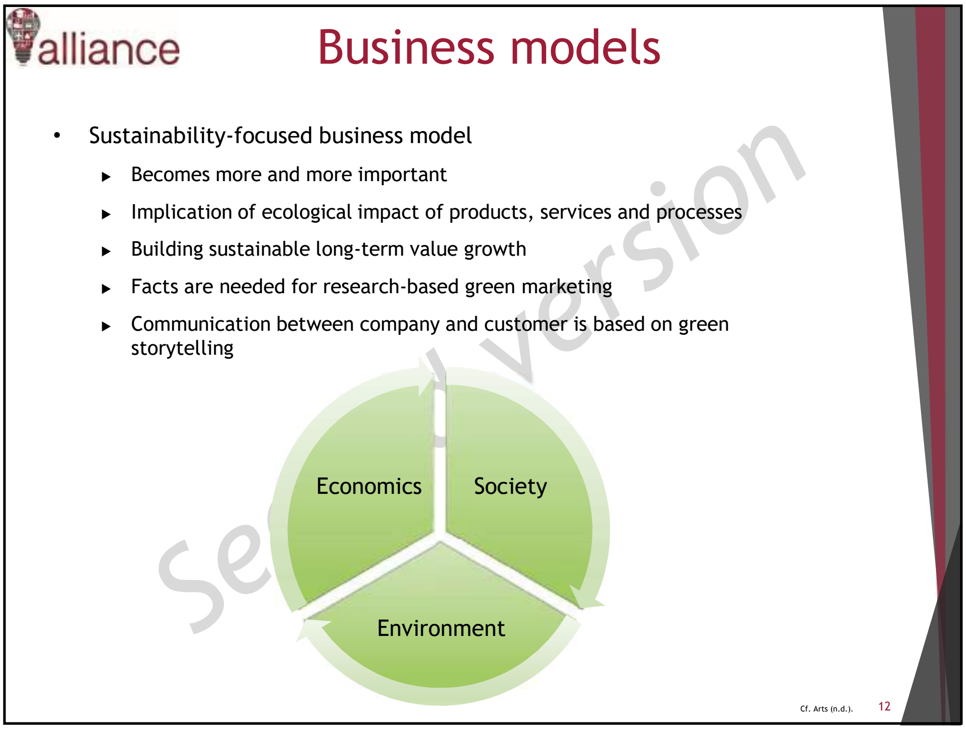
Cf. Arts (n.d.).



Business models

- Low budget innovation model
  - Fast moving consumer goods
  - No need for expensive innovation models

Cf. Arts (n.d.).



Business models

- Sustainability-focused business model
  - Becomes more and more important
  - Implication of ecological impact of products, services and processes
  - Building sustainable long-term value growth
  - Facts are needed for research-based green marketing
  - Communication between company and customer is based on green storytelling

Cf. Arts (n.d.).

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Business models

- **Discussion of other Business Models:**
  - Community-funded business model
  - Beyond advertising business model
  - Unlimited niches business model
  - In-crowd business model

Cf. Trapp (2014), p.1, Osterwalder & Pigneur (2010) & Arts (n.d.).

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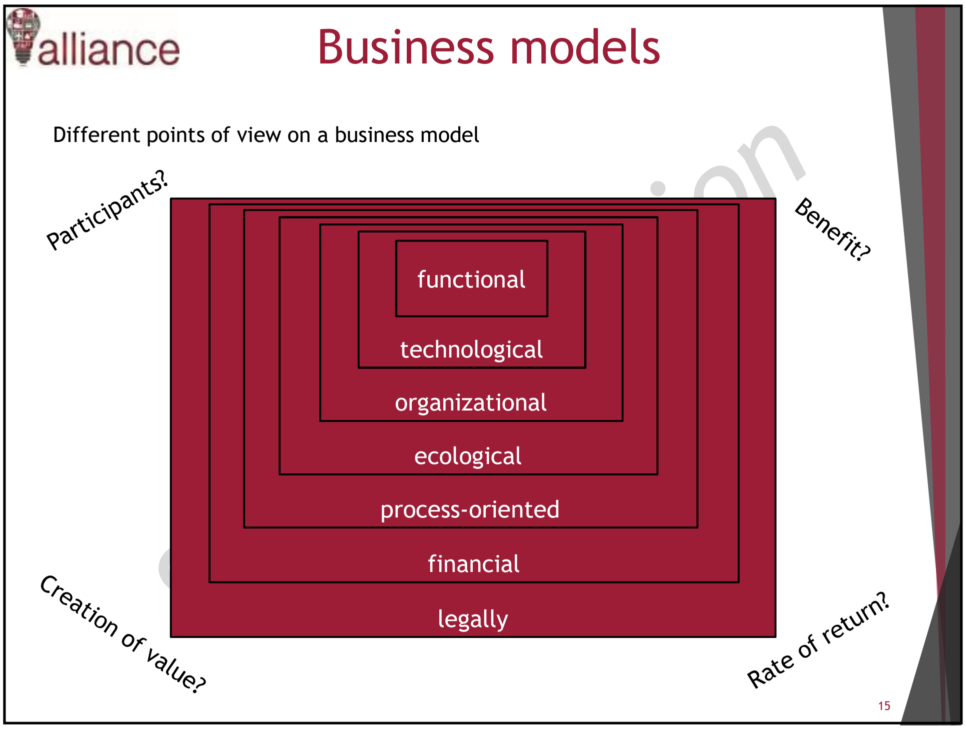
Business models

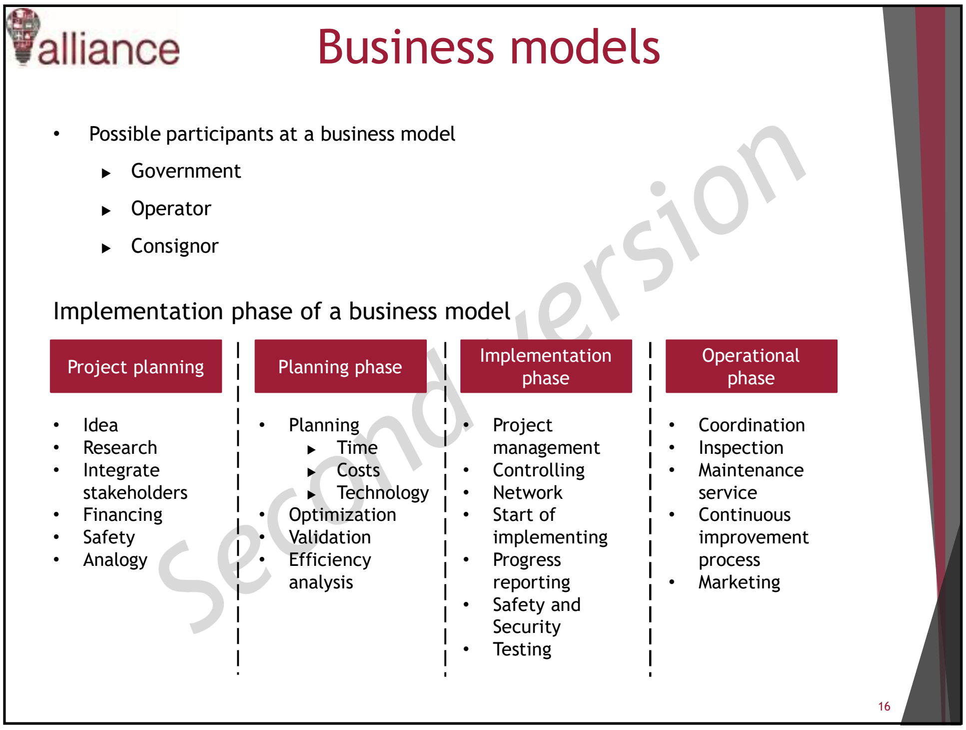
- **Steering & control - stakeholder governance**
  - **Stakeholders' governance models:**
    - **Coordinative model:**
      - Continuous efforts in coordination between various parts of the governing body
      - The framework is created by governing and governed bodies
      - The governing body is formed by actors who have the authority to decide
      - These actors:
        - ✓ Express the public interest
        - ✓ Determine the need for strategic planning
        - ✓ Select best policies and programs
    - **Governance through competition:**
      - Originates from political theory, market economy and the pluralist model of democracy
      - Considered as a competition between actors of different interests
    - **Communicative planning:**
      - Process of agreement between all involved stakeholders
      - Appropriate for the good management and operation of complex transport infrastructure, such as interchanges.

Cf.: Di Ciommo, F. (2004) & Martens, K. (2007).



Business models

Different points of view on a business model



Business models

- Possible participants at a business model
  - Government
  - Operator
  - Consignor

Implementation phase of a business model

Project planning	Planning phase	Implementation phase	Operational phase
• Idea • Research • Integrate stakeholders • Financing • Safety • Analogy	• Planning ▸ Time ▸ Costs ▸ Technology • Optimization • Validation • Efficiency analysis	• Project management • Controlling • Network • Start of implementing • Progress reporting • Safety and Security • Testing	• Coordination • Inspection • Maintenance service • Continuous improvement process • Marketing

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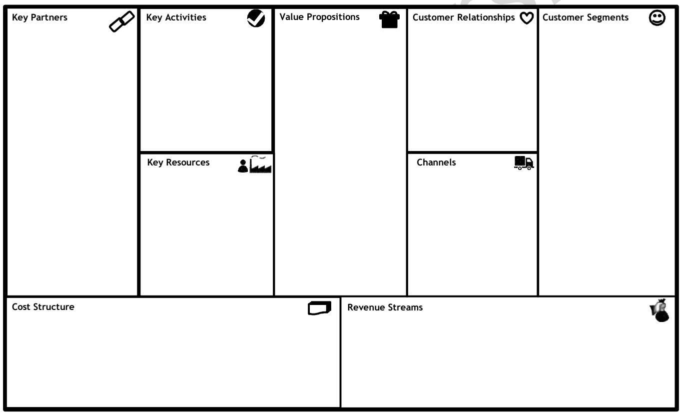
Business models

- **Development and evaluation of business models:**
  - **Business Model Canvas**
    - Develop and enhance a business model through the 9 building blocks
    - Creative process



Key Partners

Key Activities

Key Resources

Value Propositions

Customer Relationships

Channels

Customer Segments

Cost Structure

Revenue Streams

Cf. Strategyzer (2011) & Startplatz (n.d.).

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Business models

- **Development and evaluation of business models:**
  - **Business Plan**
    - Is a document with the strategy of how to realize the visions of the company
    - It also describes all important requirements, plans and measures to fulfil the strategy
    - Planning interval of three to five years
    - Evaluation through a financial plan with target-performance comparison

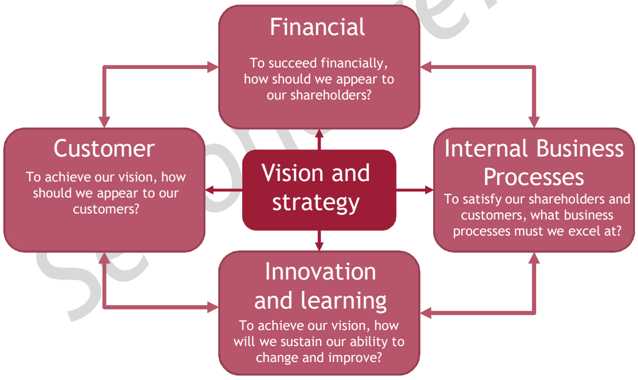
Pic.: Pixabay (2017)

Pic.: Flickr (2017)

Cf. Nagl (2015)

Business models

- **Development and evaluation of business models:**
  - **Balanced Score Card**
    - Performance Measurement System via characteristic factors
    - Link between strategy and implementation
    - Tool to enhance the business plan or business model
    - Balanced Scorecard Framework:



Financial
To succeed financially, how should we appear to our shareholders?

Customer
To achieve our vision, how should we appear to our customers?

Vision and strategy

Internal Business Processes
To satisfy our shareholders and customers, what business processes must we excel at?

Innovation and learning
To achieve our vision, how will we sustain our ability to change and improve?

Cf. Kaplan, Norton (1996)

Intermodal transport

Intermodal transport

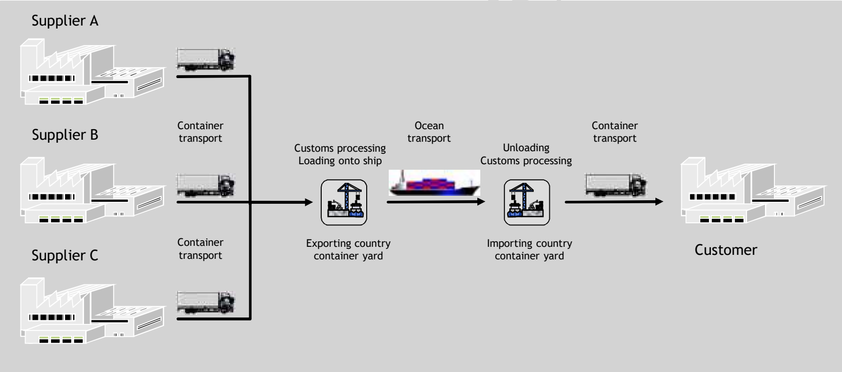
- Refers to the transportation of freight from their origin to their destination by a sequence of at least two different transportation modes
- Only a change of the transportation mode in the transport chain if it brings time or cost advantages (critical distance = 300km)
- The main role is to provide the space and equipment to load and unload vehicles of various modes for a seamless transfer of loads between different modes
- Aims at integrating various modes and services of transportation to improve the efficiency of the whole distribution process
- Some terminals (e.g. sea ports and airports) also provide the first line of customs, security, and immigration control for a country
- Avoiding unplanned delays and the formation of load or vehicle bottlenecks is one of the major goals in operating intermodal terminals
- Standardized containers are mostly used for the efficiency among transportation modes

Cf.: Peters, K. (2006).

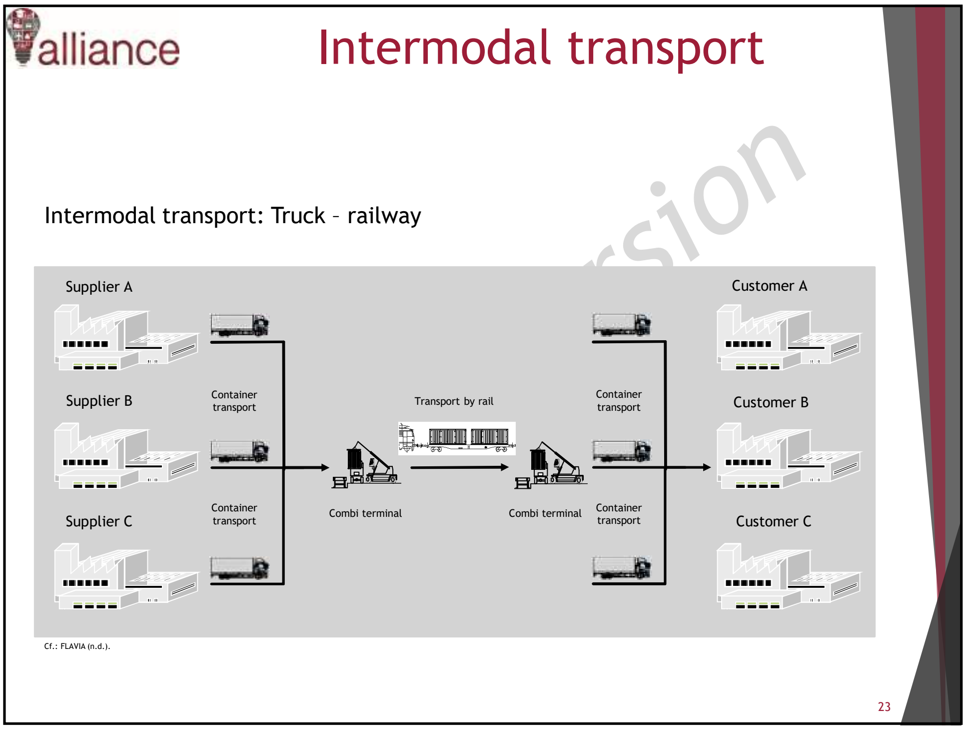
Intermodal transport

- Three types of intermodal transport
  - Non-self-sustaining discharge (container traffic)
  - Non-self-sustaining discharge (bimodal technics – Road Railer)
  - Self-sustaining discharge (piggyback traffic – Roll-on/Roll-off)

Intermodal transport: Truck – ship



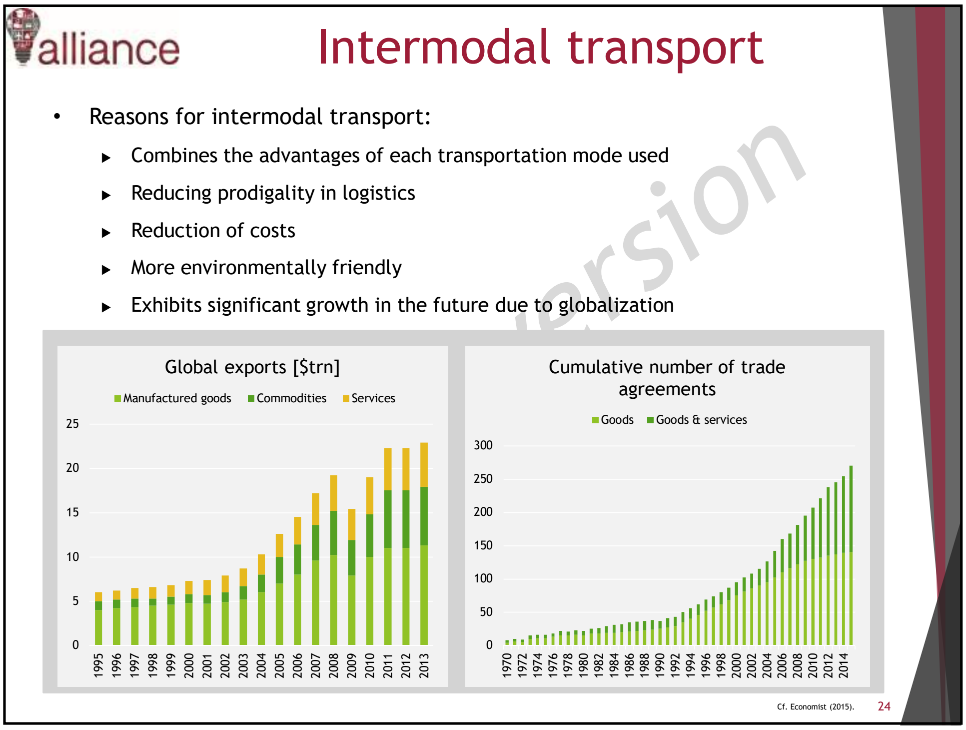
Cf.: Maruzen Showa (n.d.).



Intermodal transport

Intermodal transport: Truck – railway

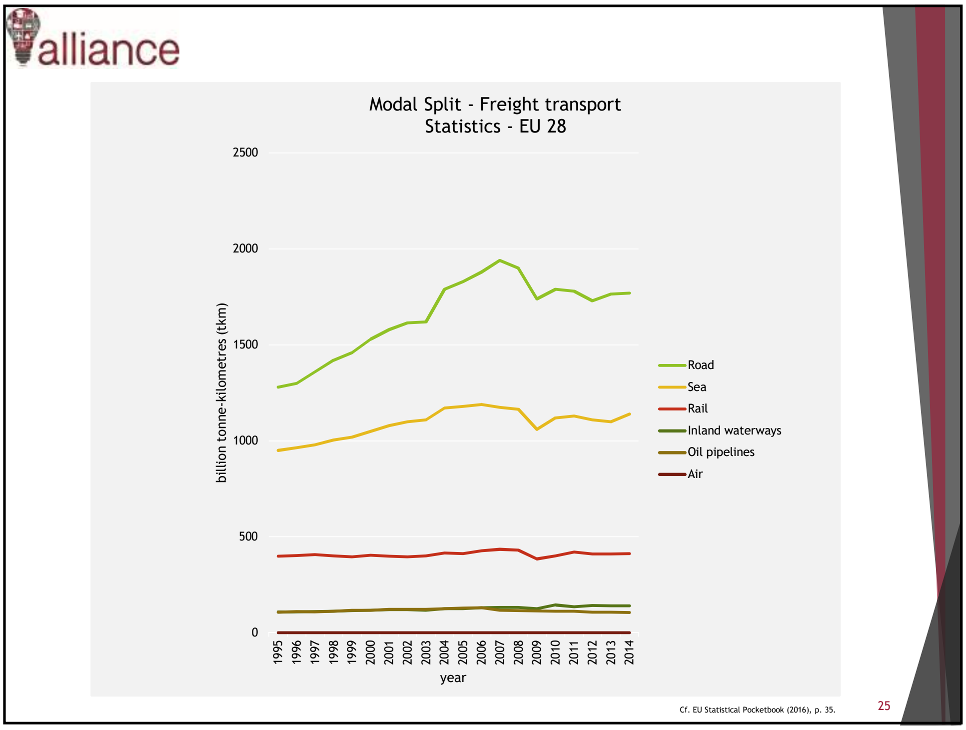
Cf.: FLAVIA (n.d.).



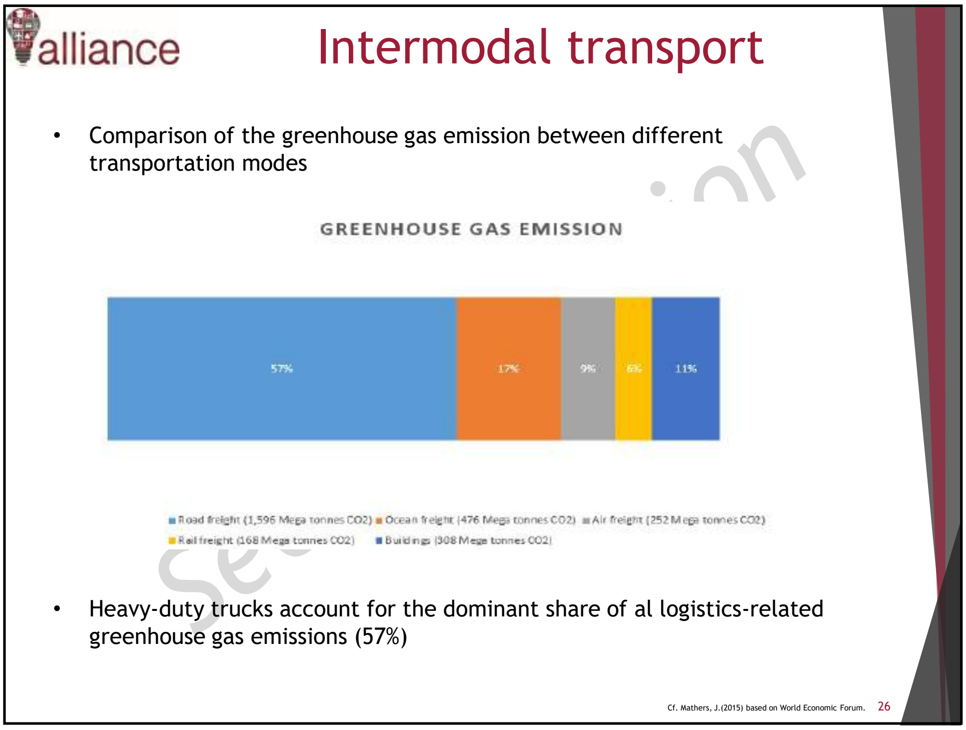
Intermodal transport

- Reasons for intermodal transport:
  - Combines the advantages of each transportation mode used
  - Reducing prodigality in logistics
  - Reduction of costs
  - More environmentally friendly
  - Exhibits significant growth in the future due to globalization

Cf. Economist (2015).



Cf. EU Statistical Pocketbook (2016), p. 35.



Intermodal transport

- Comparison of the greenhouse gas emission between different transportation modes

- Heavy-duty trucks account for the dominant share of al logistics-related greenhouse gas emissions (57%)

Cf. Mathers, J.(2015) based on World Economic Forum.

Intermodal transport

- Requirements:
  - Infrastructure
    - Airport, water, rails, roads
  - Standardized containers for more efficiency
    - Container reduces potential for damage and theft
    - Less transit time of the container
    - Ships, railcars and highway chassis are designed for the size of the container
    - Container is picked up by the spreader and their twistlocks at the corners

Pic: High-quality retractable twistlock (2008).

Intermodal transport

- Plane uses different containers (Unit Load Device – ULD)
  - Smaller than normal containers
  - More efficient utilization of the plane
  - Different sizes of the ULD

Container - AKE

Container - AMF

Pics: Lufthansa mediabase (n.d.).

Intermodal transport

- Different modes of transport:

Modes of transport

Truck

Advantages:
- Flexibility
- Infrastructure exists
- Speed

Disadvantages:
- Increasing traffic
- High costs

Ship

Advantages:
- High volume of cargo
- Low prices
- High transport safety
- Ecologically friendly

Disadvantages:
- Low speed
- Infrastructure (transport on rivers)

Plane

Advantages:
- International transport
- Flexibility & Reliability
- Speed

Disadvantages:
- Price for transport
- Cargo capacity
- Pollution

Railway

Advantages:
- Ecologically friendly
- High transport safety

Disadvantages:
- Poor infrastructure
- Priority of passenger transportation

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Exercise 1

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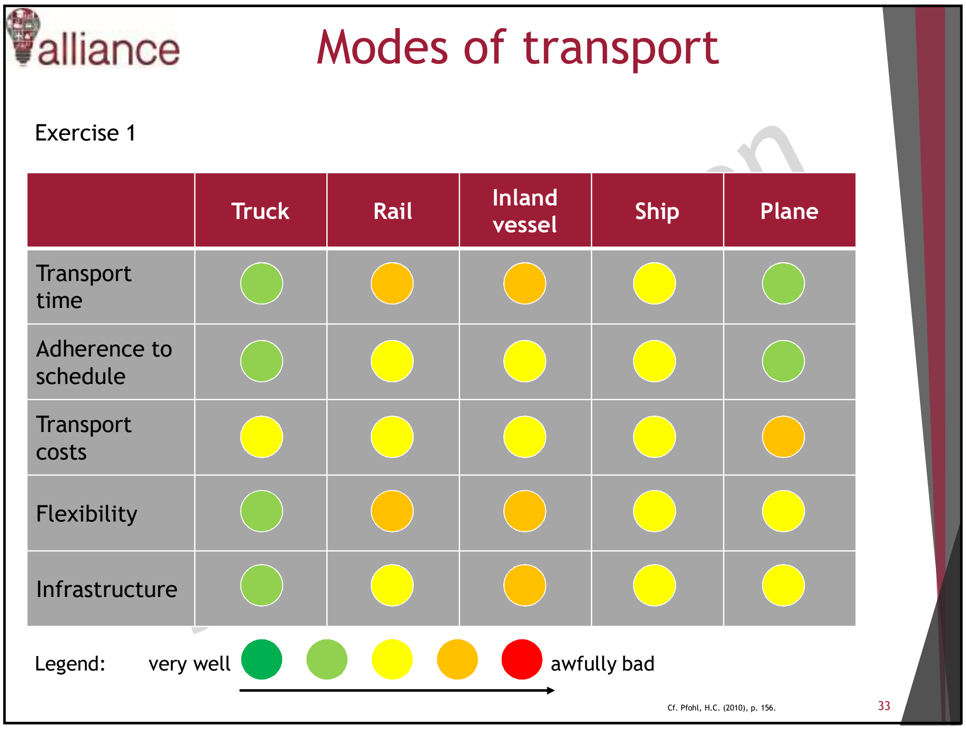
Modes of transport

Exercise 1

	Truck	Rail	Inland vessel	Ship	Plane
Transport time					
Adherence to schedule					
Transport costs					
Flexibility					
Infrastructure					

Legend: very well 🟢 🟢 🟡 🟠 🔴 awfully bad

Cf. Pfohl, H.C. (2010), p. 156.



Modes of transport

Exercise 1

	Truck	Rail	Inland vessel	Ship	Plane
Transport time	🟩	🟠	🟠	🟡	🟩
Adherence to schedule	🟩	🟡	🟡	🟡	🟩
Transport costs	🟡	🟡	🟡	🟡	🟠
Flexibility	🟩	🟠	🟠	🟡	🟡
Infrastructure	🟩	🟡	🟠	🟡	🟡

Legend: very well 🟢 🟩 🟡 🟠 🔴 awfully bad

Cf. Pfohl, H.C. (2010), p. 156.

Interchange zones

Interchange zones

- Interchanges play an essential role in a transport system
- Facilitate transportations between different routes and destinations
- An interchange is characterized by:
  - Its position in the transport network
  - The surrounding environment
  - The integration of different modes
  - The legislative framework that is in force
- Key interchange factors:
  - Process coordination and management
  - Accessibility for different transport systems
  - Safe technics
- The design of interchanges should ensure that the transport system is:
  - Smart
  - Clean
  - Seamless
  - Safe
  - Accessible to different transport systems

Interchange zones

- An interchange zone is a facility designed for the loading and unloading of containers and trailers from a transportation mode to another transportation mode
- It protects the function of interchanges by maximizing the capacity of the interchanges for safe movement from the mainline highway facility and provides safe and efficient operation between connecting roadways
- Most of the time only for two or three modes of transport – depends on the surrounding environment

- Goals at an interchange zone:
  - Reduce the waiting time for trucks, rails, planes and ships to a minimum
  - Container loading as fast as possible
  - Reduction of warehouse capacity

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Interchange zones

- Used vehicles for loading processes:

Reach Stacker

Pic: Kalmar industries (2010).

Straddle Carrier

Pic: Kalmar industries (2010).

Cargo & Container Loader

Pic: Lufthansa mediabase.

- Used cranes for loading processes:

Transtainer (RMG)

Pic: Kalmar industries (2010).

Container gantry crane

Pic: Kalmar industries (2010).

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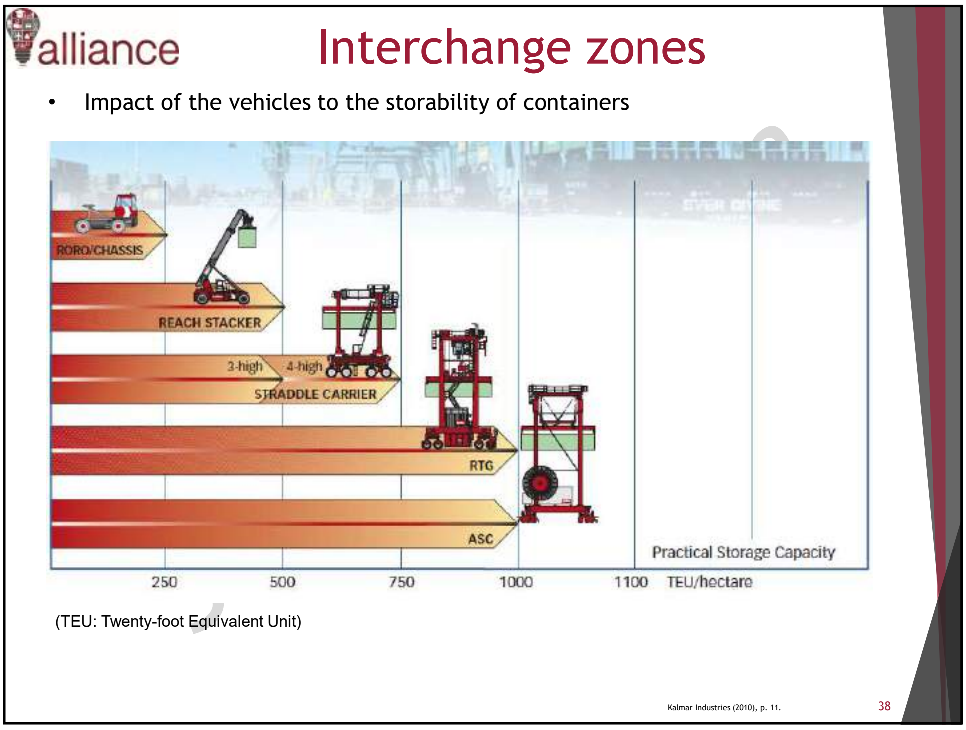

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Interchange zones

- Impact of the vehicles to the storability of containers

(TEU: Twenty-foot Equivalent Unit)

Kalmar Industries (2010), p. 11.

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Interchange zones

- Examples:

Truck – rail loading

Pic: ACTS-Loading, Priwo (2004).

Railrunner: Truck – rail loading

Pic: An ingenious type of roadrailer, Bryan Flint (2007).

Plane loading

Pic: AMC loading, U.S. Air Force (2005).

Interchange zones

- Examples: CargoBeamer

Truck – rail loading

Attachments for waggons

Pics: Automated parallel cranless loading, cargobeamer (n.d.).

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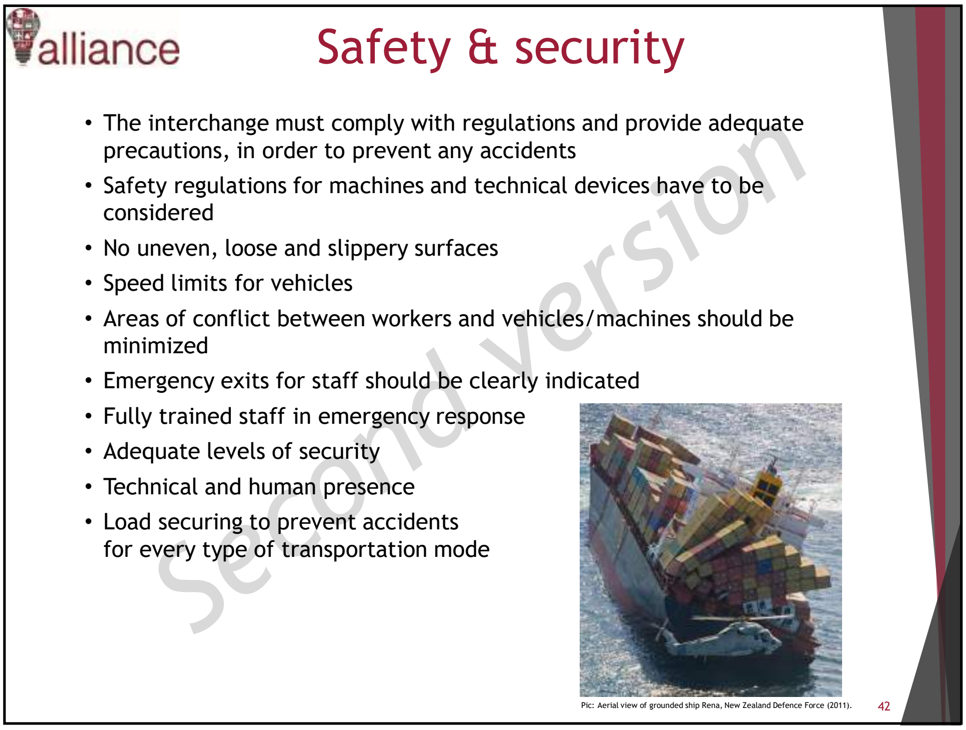
Safety and Security



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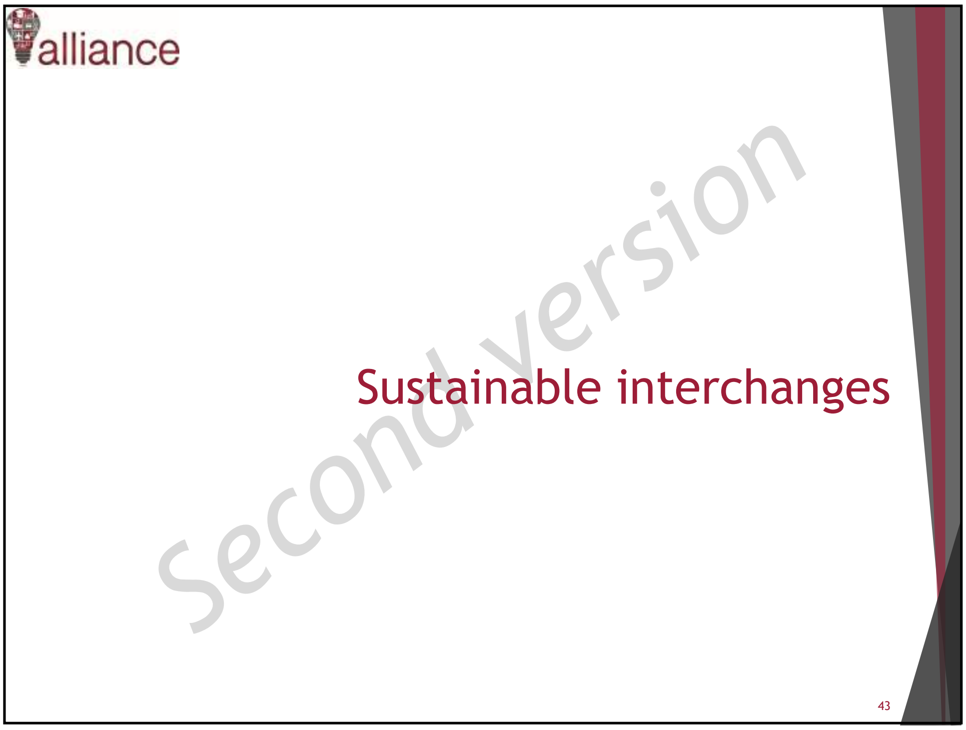
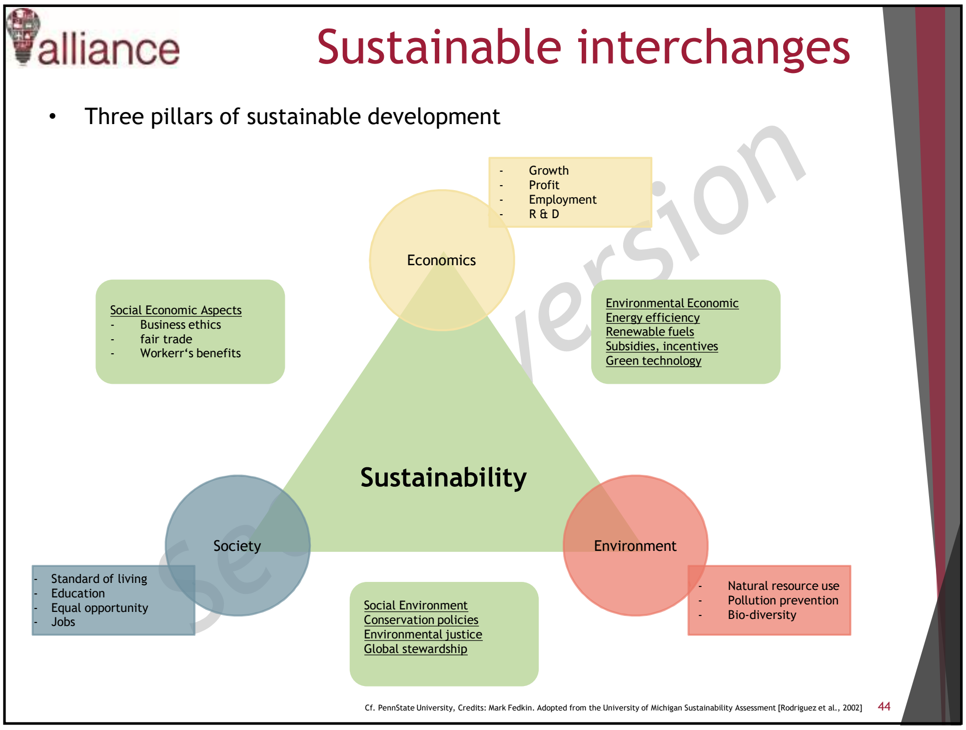
Safety & security

- The interchange must comply with regulations and provide adequate precautions, in order to prevent any accidents
- Safety regulations for machines and technical devices have to be considered
- No uneven, loose and slippery surfaces
- Speed limits for vehicles
- Areas of conflict between workers and vehicles/machines should be minimized
- Emergency exits for staff should be clearly indicated
- Fully trained staff in emergency response
- Adequate levels of security
- Technical and human presence
- Load securing to prevent accidents for every type of transportation mode

Pic: Aerial view of grounded ship Rena, New Zealand Defence Force (2011).



Sustainable interchanges



Sustainable interchanges

- Three pillars of sustainable development

Economics
- Growth
- Profit
- Employment
- R & D

Social Economic Aspects
- Business ethics
- fair trade
- Workerr's benefits

Environmental Economic
Energy efficiency
Renewable fuels
Subsidies, incentives
Green technology

Sustainability

Society
- Standard of living
- Education
- Equal opportunity
- Jobs

Social Environment
Conservation policies
Environmental justice
Global stewardship

Environment
- Natural resource use
- Pollution prevention
- Bio-diversity

Cf. PennState University, Credits: Mark Fedkin. Adopted from the University of Michigan Sustainability Assessment [Rodriguez et al., 2002]

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Sustainable interchanges

Possibilities to reach this goals:

- Isolation of buildings
- Ergonomic workplaces
- Lean Management
- Improvement of storage space utilization
- Reduction of packaging
- **Efficient loading of containers on ship, truck, plane, rail**
- Use of renewable energies (cranes, vehicles)
- Reduction of rolling friction and motor resistance
- **Reduction of air pollution**
- Reduction of noise (machine, vehicle)
- Usage of Gigaliners instead of normal trucks
- **Pooling of transports**
- Common quality standards

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Ownership structures

Ownership structures

- Ownership at interchanges is directly associated with the financing scheme and the arrangements of the initial investments and operations
- Common ownership structures:
  - Publicly owned and maintained interchanges
  - Privately owned and maintained interchanges
  - Public-private partnerships
- Concession agreements with private companies can generate the required management efficiency
- The sell-off of assets by public sector actors can generate one-time revenues, but they are not an answer to ongoing maintenance and operating cost recovery in the long run.

Cf. City-HUB (2013).

Main principles for ownership structures

- Closer interaction between the public and private sectors is needed, since there are opportunities for commercially successful utilization of the available space in the interchanges for services provided by the private sector.
- Partnerships with the private sector could introduce business models, which can complement the skills of the public sector.
- There is a variety of different business models that can be used to operate and manage the facility, and this is guided by local/national regulations, but there are also opportunities for an international knowledge and experience transfer.

Cf. City-HUB (2013).

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Exercise 2

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Exercise 2

Intermodal transport:

For the transport of 30t clothes from Rotterdam to (a) Vienna, (b) Bonn, there is a company offering a door to door service.
10 containers each with a weight of 3t can be transported on the road, water, rail or in the air. At the logistics center in Rotterdam, the containers can be loaded directly onto a truck or ship. The truck, which can always carry 2 containers at the same time, can go through to (a) Vienna (b) Bonn without any transshipment.
After the transport by ship (a) upriver Rhine and Main, Main-Danube canal and downriver Danube to Vienna the containers have to be loaded back onto a truck for the last 50km to Vienna (b) upriver Rhine the containers have to be loaded back onto a truck for the last 50km to Bonn.
For the transport by rail, first the containers have to be transported to an interchange zone which is 50km east of Rotterdam. For using the airplane the containers have to be transported to the airport, which is located 20 km east of Rotterdam. The train can travel the remaining route without another transshipment. From the airport in (a) Vienna (b) Cologne-Bonn the containers have to be loaded again onto a truck for the last 20km to the destination in (a) Vienna (b) Bonn.

Only the way of transportation with full containers from Rotterdam to (a) Vienna (b) Bonn should be considered!

Further data for exact distances and the CO2-emissions for the different transportation modes can be found in the following tables:

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Exercise 2

Exercise a)

Volume of cargo [t]	a+b
Volume of cargo [t]	30
filling quantity [t/container]	3
Number of containers	10
Number of containers on a truck	2

Costs/transshipment [€/container]	a+b
Supplier/Truck	200
Supplier/Ship	220
Truck/Rail	400
Truck/ship	300
Truck/Plane	600
Truck/Customer	200
Rail/Customer	240

Distance to customer [km]	a		
Truck (direct)	1200		
Rail (transshipment)	1250	50	Truck
		1200	Rail
Ship (transshipment)	1150	630	Ship upriver
		170	Ship canal
		300	Ship downriver
		50	Truck
Plane (transshipment)	940	20	Truck
		900	Plane
		20	Truck

Costs of transport [€/container]	a
Truck	4000
Rail	3500
Ship	3700
Plane	6000

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Exercise 2

	Carbon dioxide emission [g/tkm]*	a+b	
Truck		Fuel equivalents diesel [kgCO₂e/L]	Fuel consumption [l/100km]
(40t truck)	full container	2,665	32,8
	empty container	2,665	22,2
Rail		[Wh/tkm] or [g diesel/tkm]	co2 faktor [g/WH] or [g/tkm] (Germany)
(medium size)	middle hilly (Holland, Germany, Austria)	42,7	0,527
Ship		[Wh/tkm] or [g diesel/tkm]	co2 faktor [g/WH] or [g/tkm]
(motor vessel)	upriver	3,772	7,5
	downriver	3,772	3,9
	canal	3,772	4,6
Plane		co2 faktor [g/tkm]	Fuel consumption [g/tkm]
(Airbus 330)	for 463km	3,201	304,1
(freighter)	for 926km	3,201	223,4
	*Source: VerkehrsRUNDSCHAU (51-52, 2010), (01-04, 2011): So ermitteln Sie den CO2 Fußabdruck		

Exercise b)

Distance to customer [km]	b		
Truck (direct)	300		
Rail (transshipment)	350	50	Truck
		300	Rail
Ship (transshipment)	320	300	Ship upriver
		0	Ship canal
		0	Ship downriver
		20	Truck
Plane (transshipment)	280	20	Truck
		240	Plane
		20	Truck

Costs of transport [€/container]	b
Truck	3000
Rail	2500
Ship	2700
Plane	5000

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Exercise 2

Exercise:

Design a transportation system with the given numbers in this exercise.

First of all draw all kinds of transport chains with different transportation modes in strict accordance to the used technical vehicles/machine at the loading processes between the transportation modes.

Furthermore, the aspect of sustainability and the costs of the interchange zone should be considered:

Therefor calculate the costs of the transport (without wages, abrasion, insurance etc.) and the CO2-emission/container of all transport possibilities for both transport routes from Rotterdam to (a) Vienna and (b) Bonn.

Which additional costs normally have to be considered?

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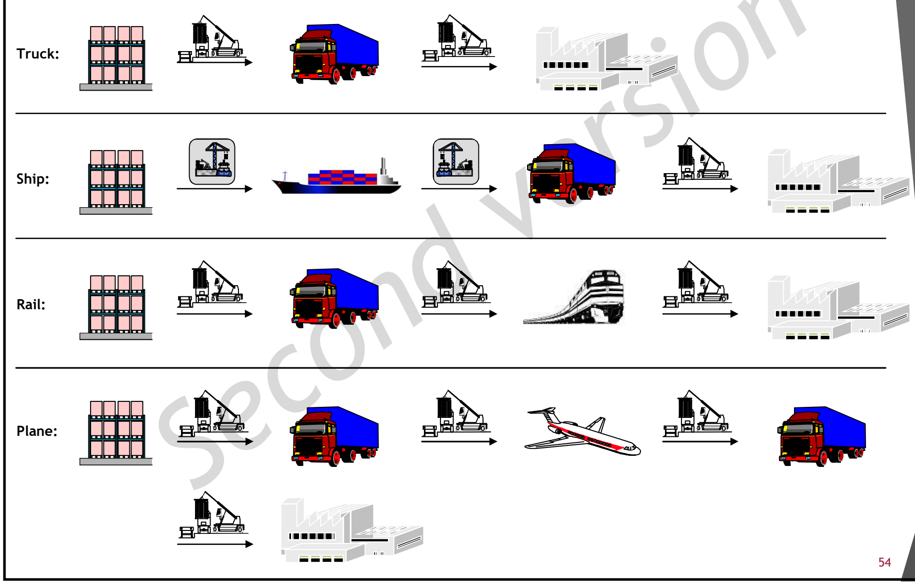
Exercise 2

Transport chains:

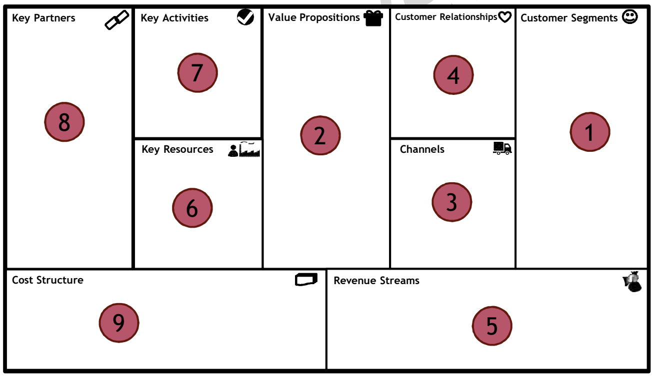


Exercise 3

Exercise 3

Business Model for intermodal transport

- The Business Model Canvas helps to transfer all important elements (the 9 building blocks) of a successful business model into a scalable system
- It helps also to discuss, design and improve the business model
- For each block essential questions can be answered but it is a creative process at the beginning → there is no “right” or “wrong”



Cf. Strategyzer (2011) & Startplatz (n.d.).

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Exercise 3

Some example of a Business Model Canvas

Key Partners
- Air Port XY
- Harbor YZ
- Leasing company
- Etc.

Key Activities
- Transport
- Transshipping
- Etc.

Key Resources
- Ship
- Plane
- Train
- Truck
- Staff
- Etc.

Value Propositions
- Deliver just in time/ sequence
- Deliver within 24 hours
- Etc.

Customer Relationships
- Sales and distribution
- Marketing
- Etc.

Channels
- Website
- Stores
- Shops
- Service Center
- Etc.

Customer Segments
- Industry national/ international
- Regional shops
- Customers
- Etc.

Cost Structure
- Staff
- Website/ IT
- Marketing
- Leasing Trucks
- Office rent
- Service Center
- Etc.

Revenue Streams
- Transportation revenues
- Packaging sales
- Etc.

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Exercise 3

Exercise:

Develop a Business Model Canvas with the knowledge and results from exercise 1 and 2. The following questions and order can guideline you through the development:

Key Partners ⑧
- Who are our keyparteners?
- Who are our key suppliers?
- Which key resources are we aquiring from our partners?
- Which key activities do partners perform?

Key Activities ⑦
- What key activities do our value propositions require?

Key Resources ⑥
- What key resources do our value propositions require?

Value Propositions ②
- How do we get, keep and grow customers?
- How costly are they?
- How are they integrated?

Customer Relationships ④
- How do we get, keep and grow customers?
- How costly are they?
- How are they integrated?

Channels ③
- Through which channels do our customers wnt to be reached?
- Which ones are the best and most cost-efficient?

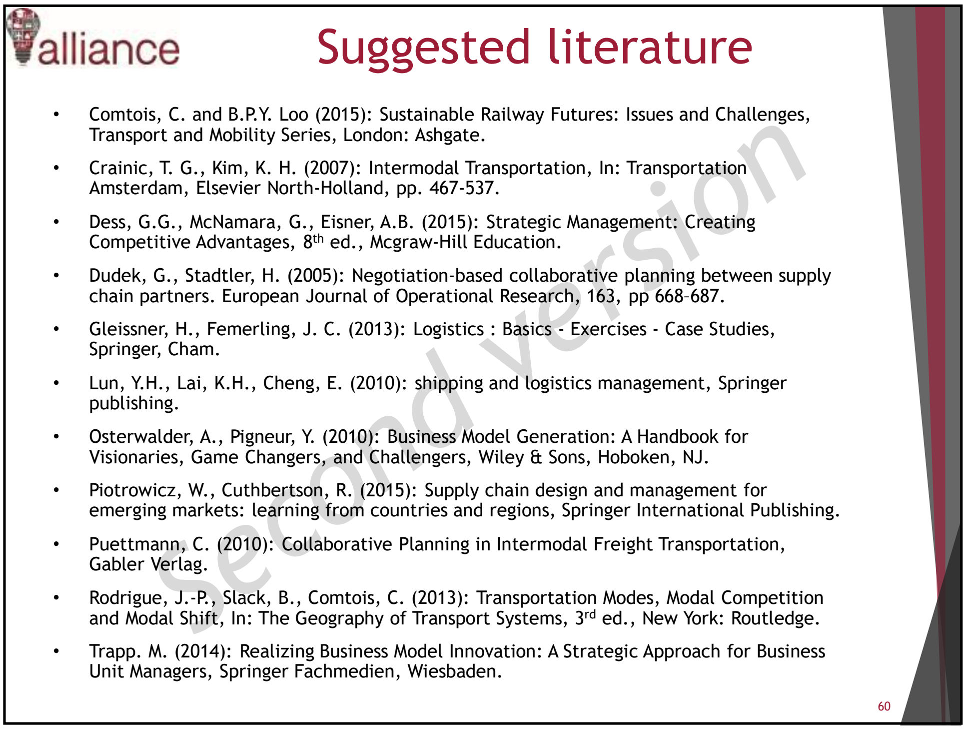
Customer Segments ①
- For whom are we creating value?
- Who are our most important customers?
- What are the customers archetypes?

Cost Structure ⑨
- What are the most important costs inherent to our business model?
- Which key resources are most expensive?
- Which key activities are most expensive?

Revenue Streams ⑤
- For what value are our customer willing to pay?
- For what do they currently pay?
- What are the pricing tactics?

Cf. Strategyzer (2011) & Osterwalder & Pigneur (2010).

Suggested literature



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Sustainable development and transportation planning

University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426

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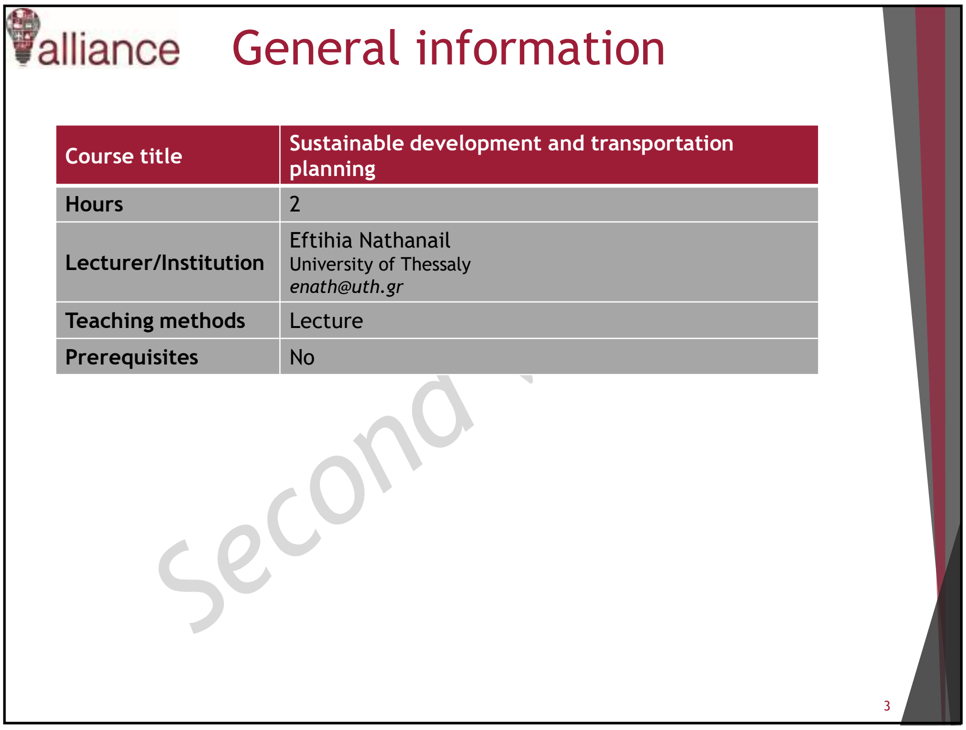
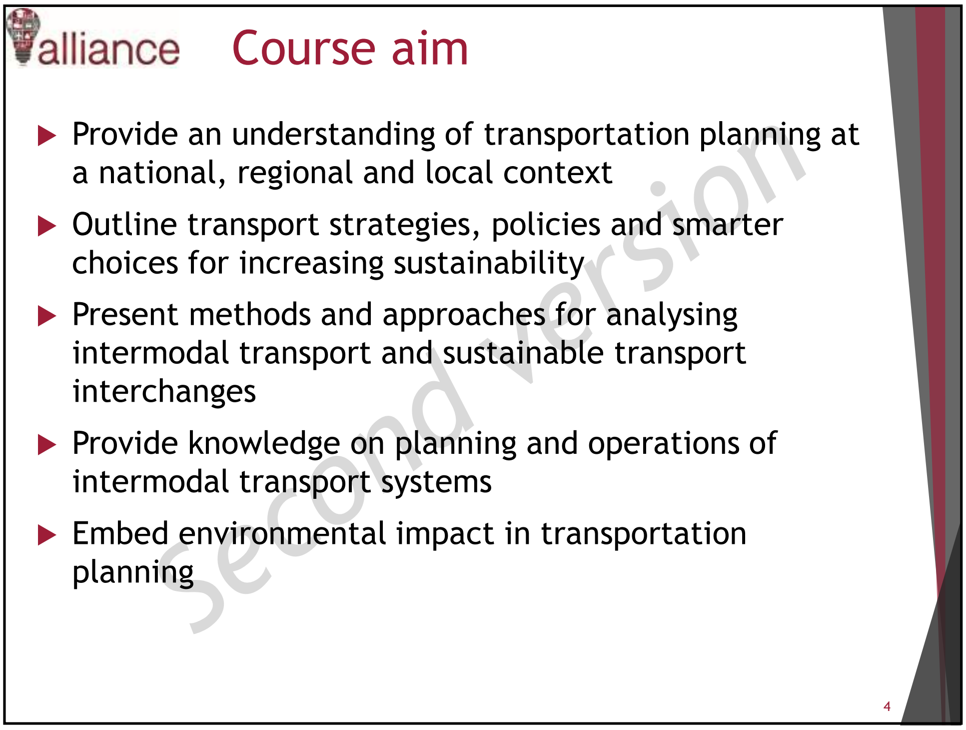
Content

1. Sustainable transport
2. Smart solutions in sustainable transportation planning
3. Sustainable urban development and mobility plans
4. Transportation planning principles
5. Modelling freight transport
6. Transport impacts
7. Environmental impact assessment
8. Safety impact assessment
9. Suggested literature



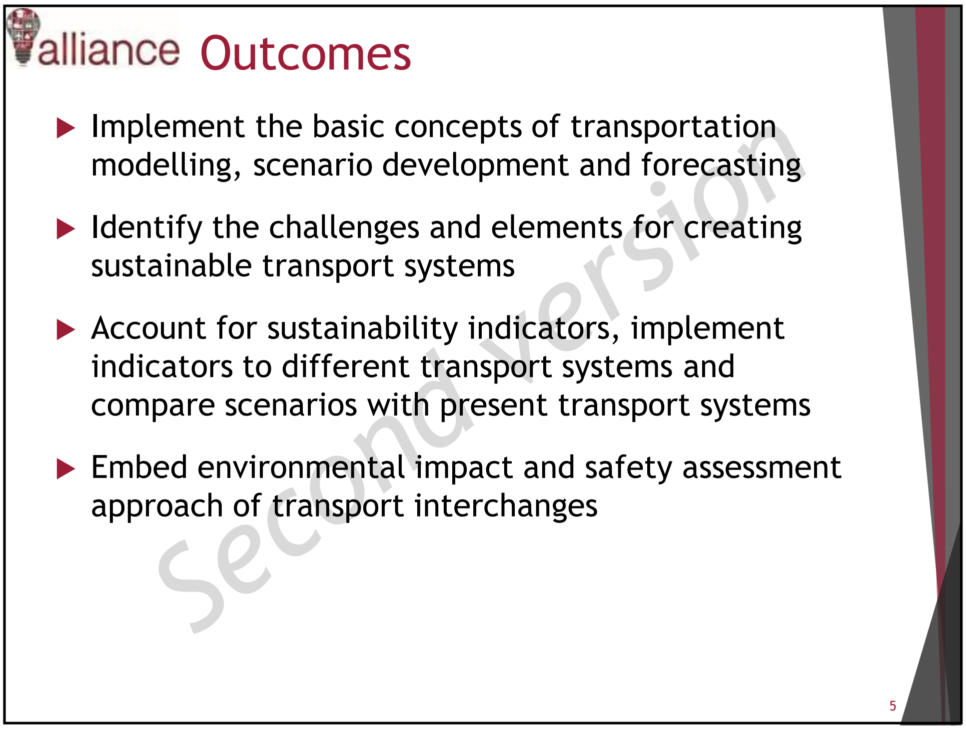
General information

Course title	Sustainable development and transportation planning
Hours	2
Lecturer/Institution	Eftihia Nathanail University of Thessaly *enath@uth.gr*
Teaching methods	Lecture
Prerequisites	No



Course aim

- Provide an understanding of transportation planning at a national, regional and local context
- Outline transport strategies, policies and smarter choices for increasing sustainability
- Present methods and approaches for analysing intermodal transport and sustainable transport interchanges
- Provide knowledge on planning and operations of intermodal transport systems
- Embed environmental impact in transportation planning



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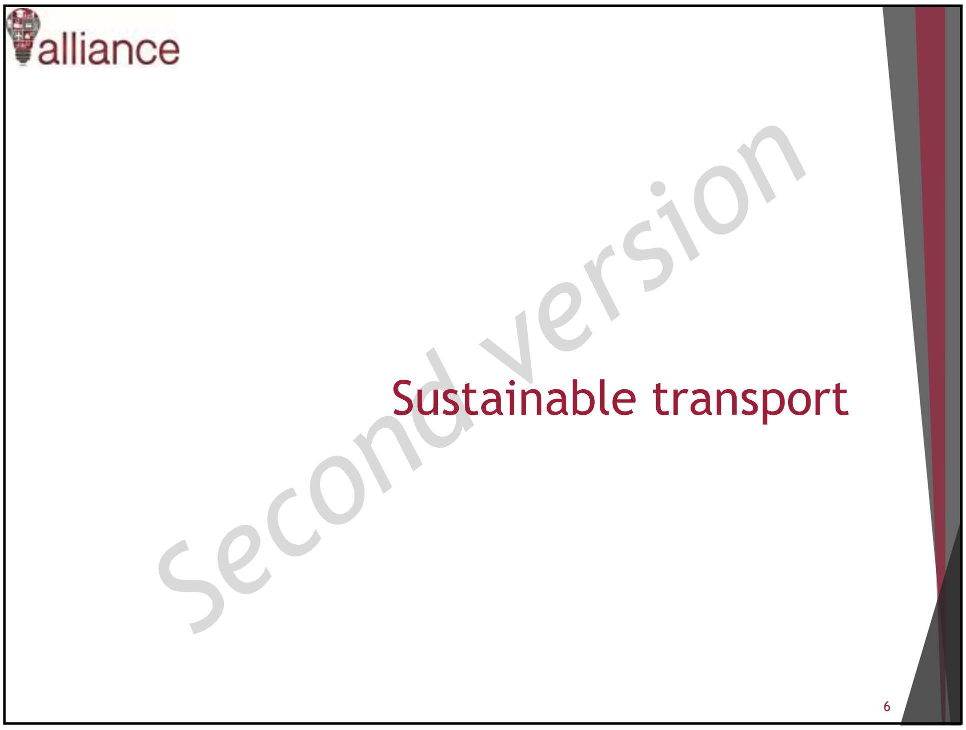
Outcomes

- Implement the basic concepts of transportation modelling, scenario development and forecasting
- Identify the challenges and elements for creating sustainable transport systems
- Account for sustainability indicators, implement indicators to different transport systems and compare scenarios with present transport systems
- Embed environmental impact and safety assessment approach of transport interchanges



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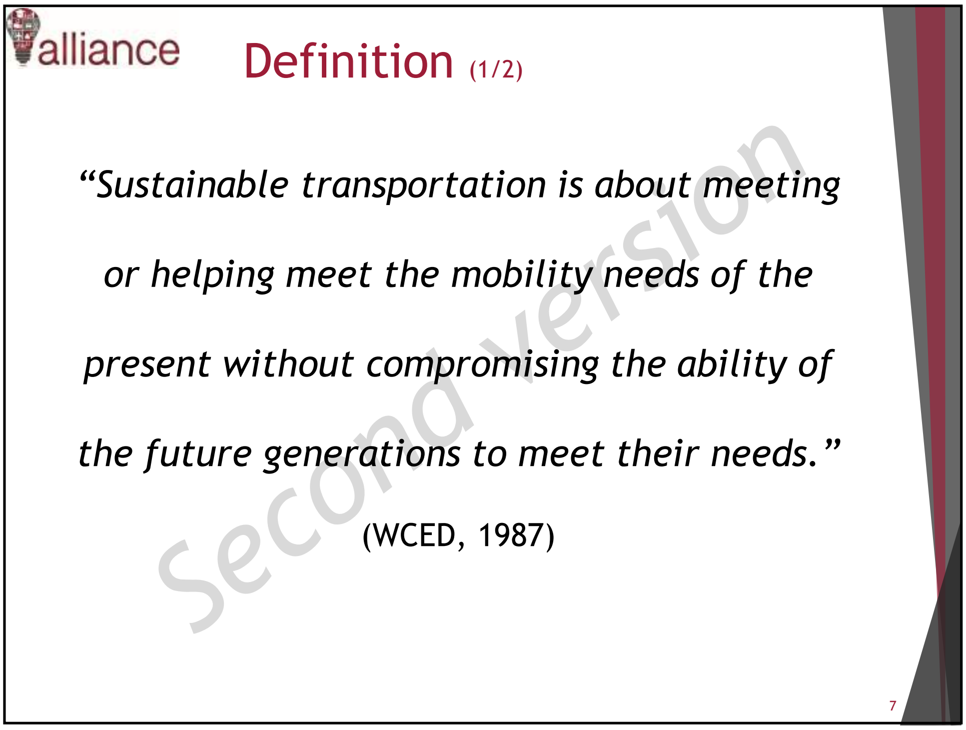
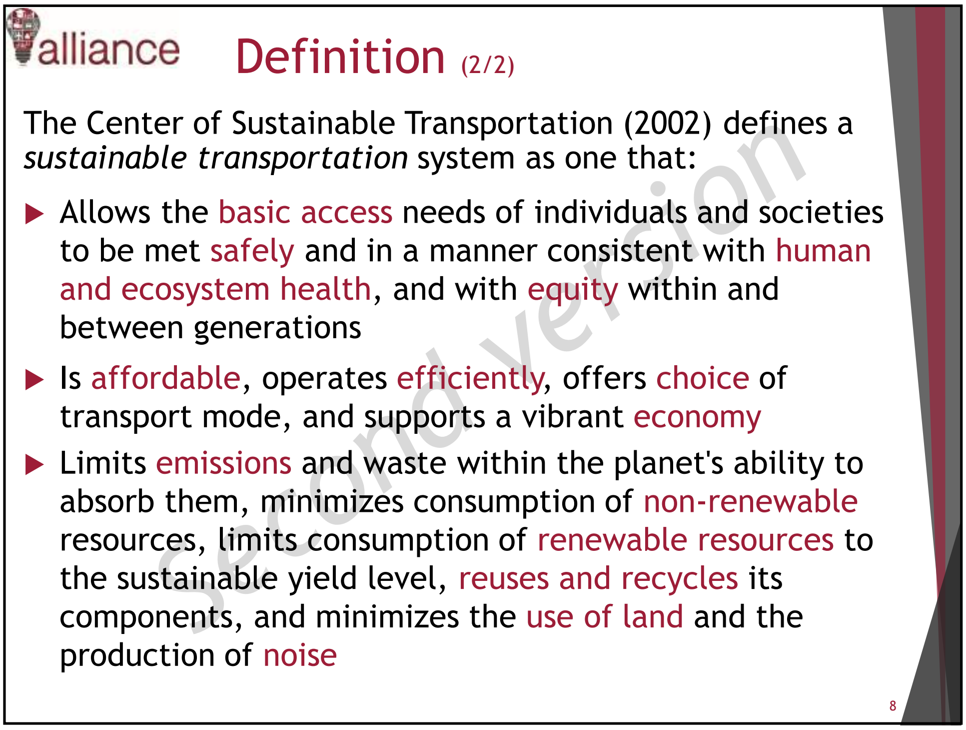
Sustainable transport



Definition (1/2)

“Sustainable transportation is about meeting or helping meet the mobility needs of the present without compromising the ability of the future generations to meet their needs.”

(WCED, 1987)



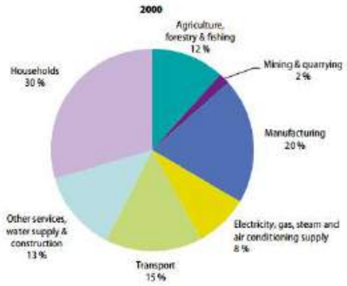
Definition (2/2)

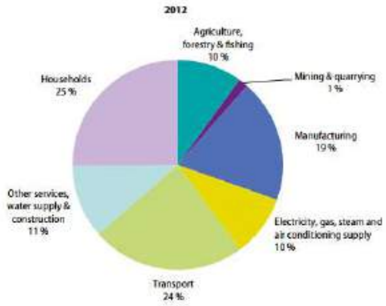
The Center of Sustainable Transportation (2002) defines a *sustainable transportation* system as one that:

- Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise

Why sustainable transport? (1/2)

Ozone formation potential emissions





Reference: EUROSTAT 2015

Why sustainable transport? (2/2)

Transport – environmental concerns in EU

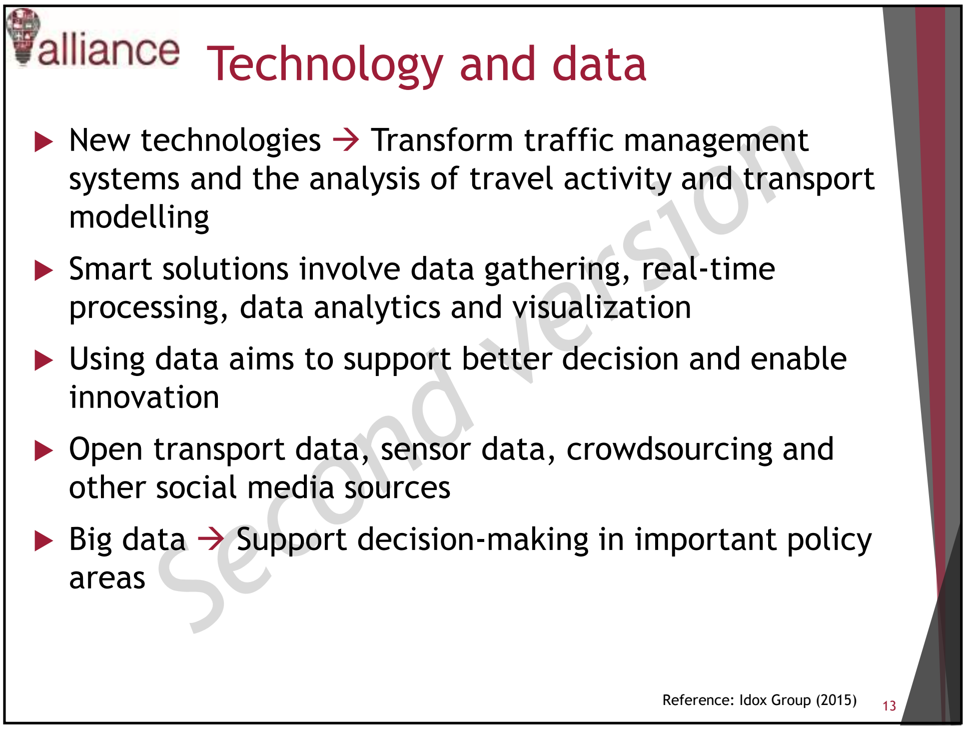
- Trucks represent less than 5% of all vehicles on the road in Europe
- Trucks, buses and coaches produce about 30% of CO_2 emissions from road transport in the EU
- CO_2 emissions from Heavy Duty Vehicles (HDV) rose by 36% between 1990 and 2010, mainly due to increasing road freight traffic

Reference: EC 2017

Smart solutions in sustainable transport planning

Smart transport

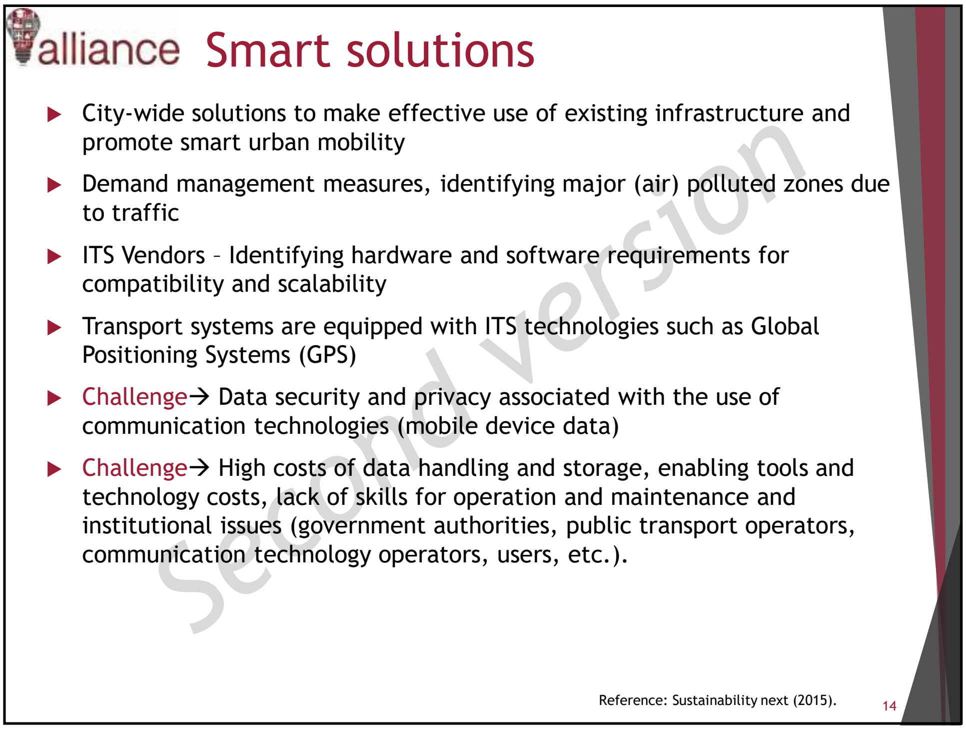
Smart transportation planning deals with the sustainable evaluation, assessment and design of movement of people and goods through transport networks.



Technology and data

- New technologies → Transform traffic management systems and the analysis of travel activity and transport modelling
- Smart solutions involve data gathering, real-time processing, data analytics and visualization
- Using data aims to support better decision and enable innovation
- Open transport data, sensor data, crowdsourcing and other social media sources
- Big data → Support decision-making in important policy areas

Reference: Idox Group (2015)



Smart solutions

- City-wide solutions to make effective use of existing infrastructure and promote smart urban mobility
- Demand management measures, identifying major (air) polluted zones due to traffic
- ITS Vendors – Identifying hardware and software requirements for compatibility and scalability
- Transport systems are equipped with ITS technologies such as Global Positioning Systems (GPS)
- Challenge→ Data security and privacy associated with the use of communication technologies (mobile device data)
- Challenge→ High costs of data handling and storage, enabling tools and technology costs, lack of skills for operation and maintenance and institutional issues (government authorities, public transport operators, communication technology operators, users, etc.).

Reference: Sustainability next (2015).

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Short-term action (1/2)

- Little change in future with no action
- Without policy action, total HDV emissions would be close to current levels in 2030 and 2050
- HDV strategy, adopted in May 2014, is the EU’s first initiative to tackle such emissions from trucks, buses and coaches
- Measure and report → The European Commision developed a computer simulation tool, VECTO, to measure CO_2 emissions from new HDV

↓

- Propose legislation which would require CO_2 emissions from new HDVs to be certified, reported and monitored

Reference: EC 2017

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Short-term action (2/2)

- Fifteen EU countries have tolling systems in place where trucks pay per kilometer driven
- Charging per kilometer encourages drivers to take the most efficient route and discourages empty trips while reducing congestion and pollution
- Tolls will be calculated based on the carbon emissions of trucks while zero-emission vehicles will be given a 75% toll discount
- Truckmakers → information on key vehicle parameters, including weight, aerodynamics performance and engine efficiency → VECTO
- VECTO → Reference CO_2 emission
- On-road fuel consumption testing → VECTO
- Researchers, fleet managers, transport companies and NGOs → Access to VECTO raw data

Long-term action

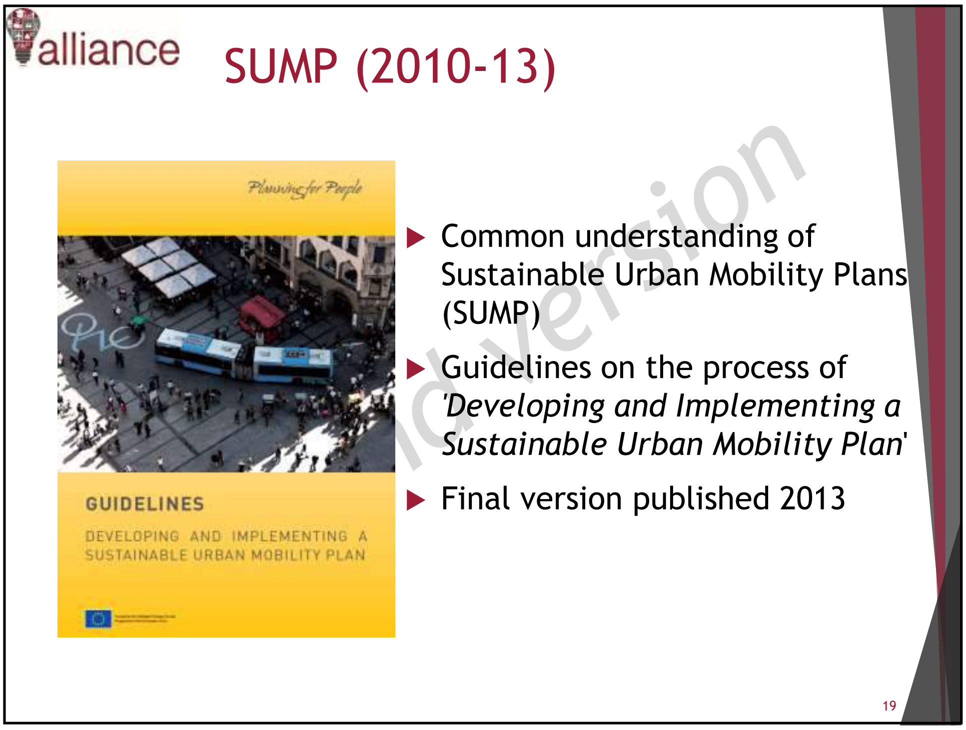
- Set mandatory limits on average CO_2 emissions from newly-registered HDVs
- Develop modern infrastructure supporting alternative fuels for HDVs, smarter pricing on infrastructure usage, effective and coherent use of vehicle taxation by Member States and other market-based mechanisms

⬇

- State-of-the art technologies can achieve cost-effective reductions of at least 30% in CO_2 emissions from new HDVs

Reference: EC 2017

Sustainable urban development and mobility plan



SUMP (2010-13)

- Common understanding of Sustainable Urban Mobility Plans (SUMP)
- Guidelines on the process of *'Developing and Implementing a Sustainable Urban Mobility Plan'*
- Final version published 2013

Challenges in urban logistics

- 40% of air emissions and noise are attributed to urban logistics fleets (CO_2 25%, PM 30-50%)
- Contribute to 15% of total traffic volume
- Consume 20% of total energy consumption in urban areas
- Low loading factors for delivery trucks (38% in London)
- Frequent deliveries, e-commerce, food delivery, market shrinkage etc.
- High cost – last mile distribution represent 28% of total cost in a supply chain

Reference: Papoutsis & Nathanail (2016)

Freight distribution in small and medium (historic) towns

More complex due to:

- City environment old road infrastructure, narrow streets, etc.
  - More strict access regulations
  - Presence of heritage and historic assets
  - Higher risks for pedestrian safety

Sustainable Urban Logistics Plan (SULP)

Strategic plan that:

- Serves the commercial needs of citizens and businesses in cities
- A better standard of living
- Protects the environment

One of the key components of SUMP that integrates

- Strategies
- Services
- Regulations

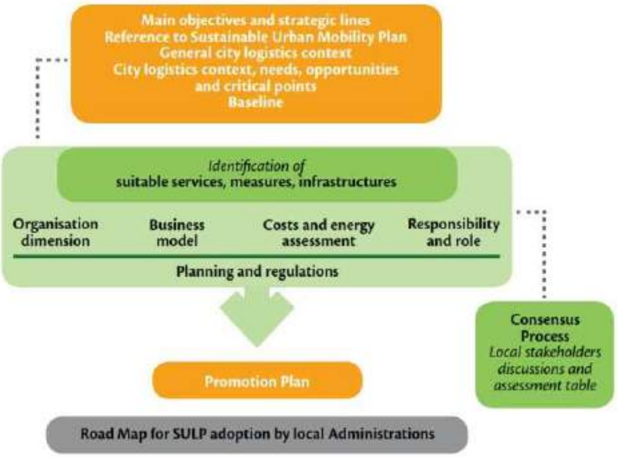
For urban freight transport in the generic strategies and solutions for sustainable urban mobility

SULP methodology

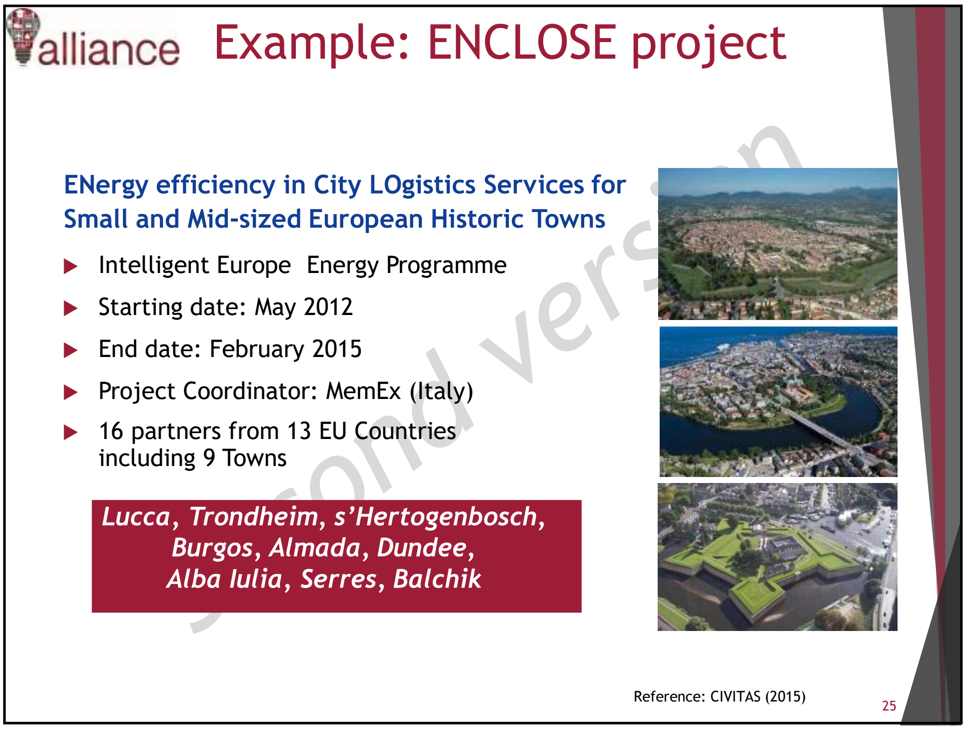
1. Setting the objective and target
2. Urban mobility scenario and priorities
3. Analyze the logistics context and processes
4. Setting requirements and logistics baseline
5. Suitable measures and services vs. requirements
6. Design of Identified solutions
7. Business model, actor role and responsibility
8. Services/Solutions assessment and impacts
9. Responsibilities, implementing plan
10. Promotion and communication plan
11. Roadmap to adopt the SULP

Reference: Ambrosino et al. (2015)

SULP methodology structure



Reference: Ambrosino et al. (2015)



Example: ENCLOSE project

ENergy efficiency in City LOgistics Services for Small and Mid-sized European Historic Towns

- Intelligent Europe Energy Programme
- Starting date: May 2012
- End date: February 2015
- Project Coordinator: MemEx (Italy)
- 16 partners from 13 EU Countries including 9 Towns

Lucca, Trondheim, s'Hertogenbosch,
Burgos, Almada, Dundee,
Alba Iulia, Serres, Balchik

Reference: CIVITAS (2015)

ENCLOSE

Exchange knowledge about feasible solutions for:

- A large number of European small and medium-sized towns with historic or shopping centers
- Exploring the possibility of transferring solutions
- Dissemination and future adoption of energy-efficient and sustainable city-logistics in as many European cities as possible with the above characteristics
- Development of SULPs in 9 European cities of small and medium size having historic or business centers

Reference: CIVITAS (2015)

The City of Almada (Portugal)

- ~1500 freight vehicles/day (~500 heavy and ~1000 light) circulating in the reference area
- 2,300 shops in the reference area
- 2,020 total deliveries/day (non optimized vans) 60 tons/day of delivered freight
- Specific normative for commercial vehicles (i.e. time windows, Enforcement scheme and control activities - L/U areas, etc.)

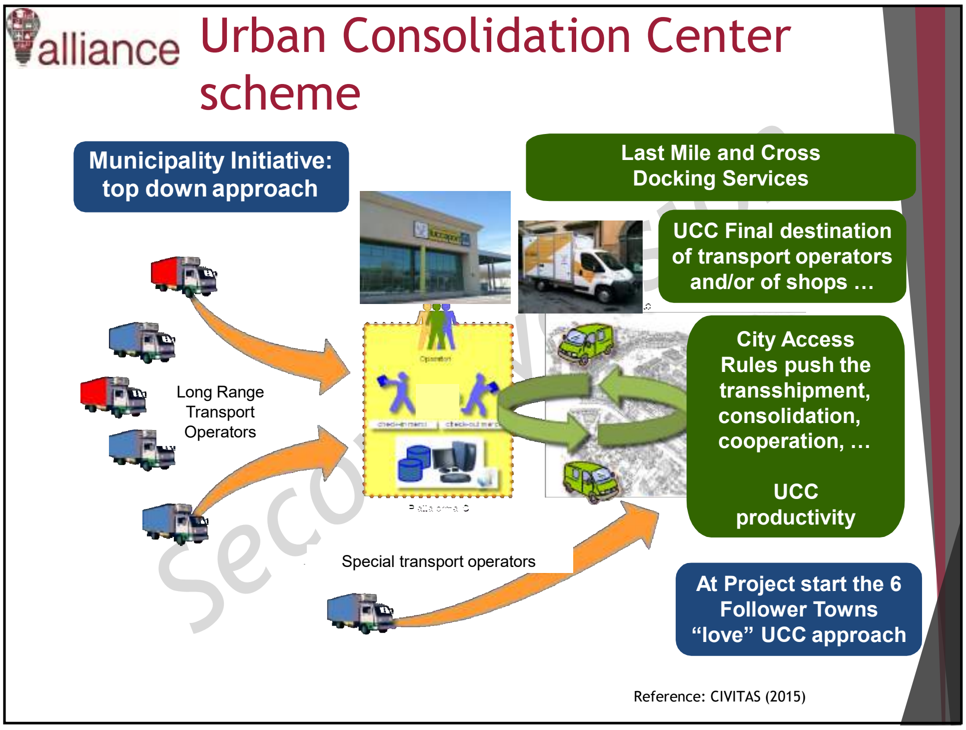
- CO_2eq emission from city logistics processes = 1,289 tons/year
- Energy consumption = 361 tons of oil equivalent TOE/year

Reference: CIVITAS (2015)

Candidate measures Almada

- Pick-up point (packstation approach) utilizing existing structure (FLEXIBUS depot)
- Reorganization of Almada's market area with parking the market shopkeeper vans into a nearby garage during market opening time (Micro Consolidation Center – short term)
- Extension of new parking rules/regulations for commercial vehicles to all the town (only for Cacilhas district, at the moment)
- UCC (long term)

Reference: CIVITAS (2015)



Urban Consolidation Center scheme

Municipality Initiative: top down approach

Last Mile and Cross Docking Services

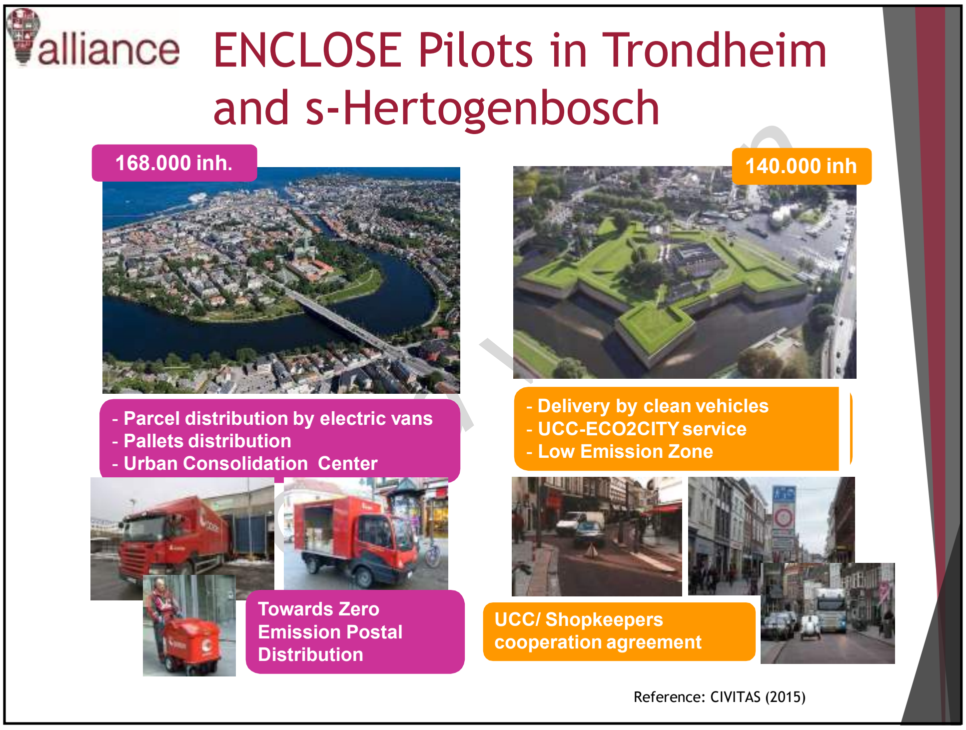
UCC Final destination of transport operators and/or of shops …

City Access Rules push the transshipment, consolidation, cooperation, …

UCC productivity

At Project start the 6 Follower Towns "love" UCC approach

Reference: CIVITAS (2015)



ENCLOSE Pilots in Trondheim and s-Hertogenbosch

168.000 inh.

- **Parcel distribution by electric vans**
- **Pallets distribution**
- **Urban Consolidation Center**

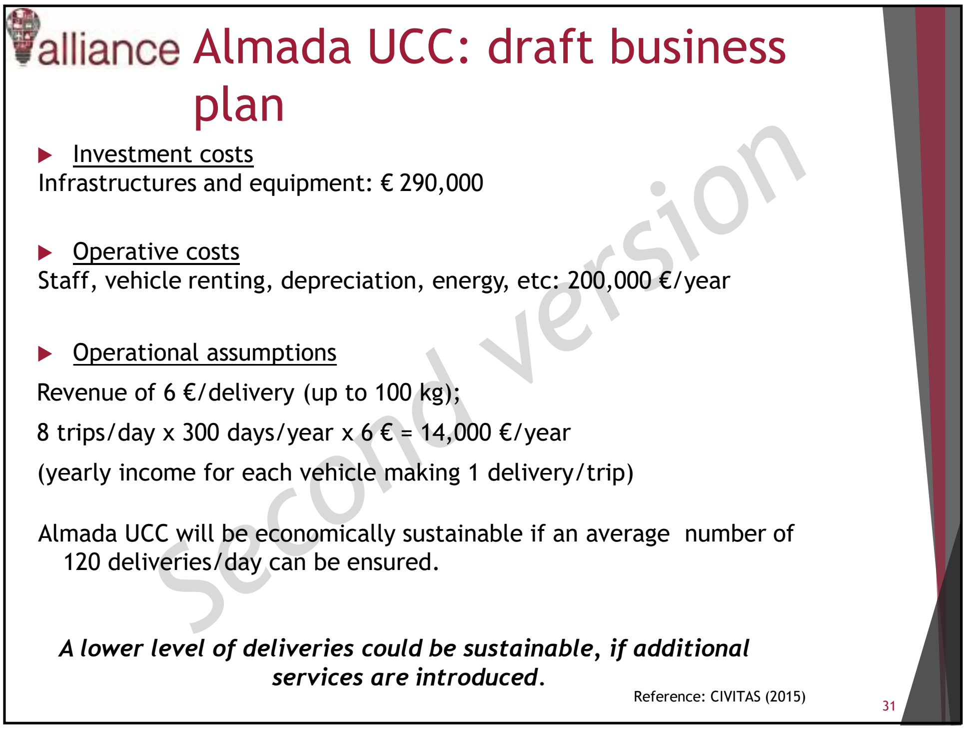
Towards Zero Emission Postal Distribution

140.000 inh

- **Delivery by clean vehicles**
- **UCC-ECO2CITY service**
- **Low Emission Zone**

UCC/ Shopkeepers cooperation agreement

Reference: CIVITAS (2015)



Almada UCC: draft business plan

- Investment costs

Infrastructures and equipment: € 290,000

- Operative costs

Staff, vehicle renting, depreciation, energy, etc: 200,000 €/year

- Operational assumptions

Revenue of 6 €/delivery (up to 100 kg);

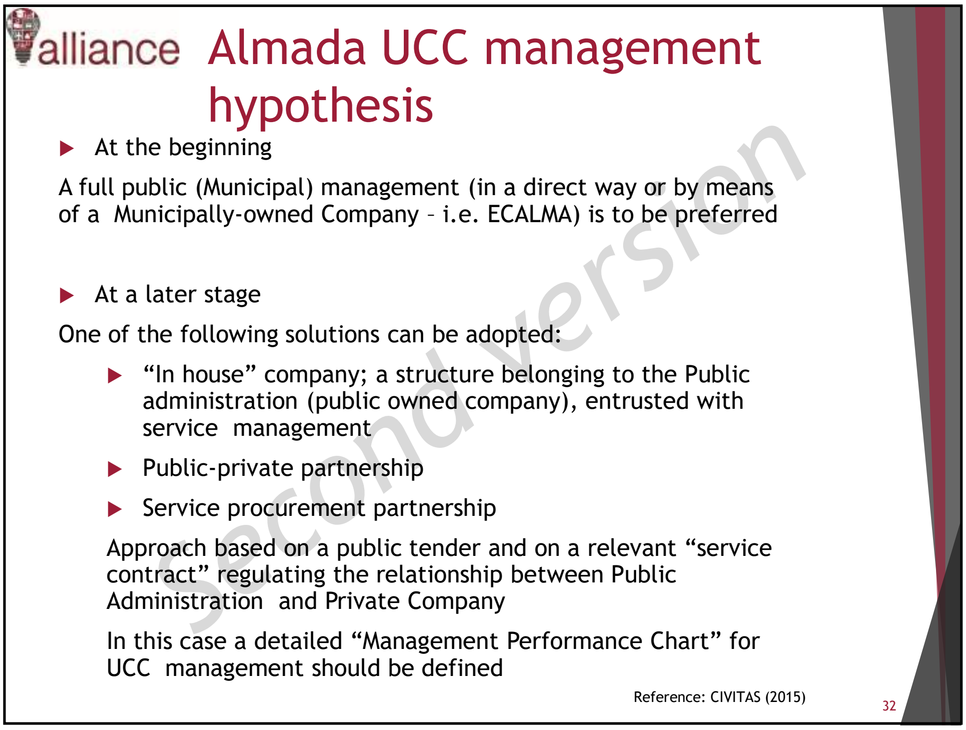
8 trips/day x 300 days/year x 6 € = 14,000 €/year

(yearly income for each vehicle making 1 delivery/trip)

Almada UCC will be economically sustainable if an average number of 120 deliveries/day can be ensured.

A lower level of deliveries could be sustainable, if additional services are introduced.

Reference: CIVITAS (2015)



Almada UCC management hypothesis

- At the beginning

A full public (Municipal) management (in a direct way or by means of a Municipally-owned Company – i.e. ECALMA) is to be preferred

- At a later stage

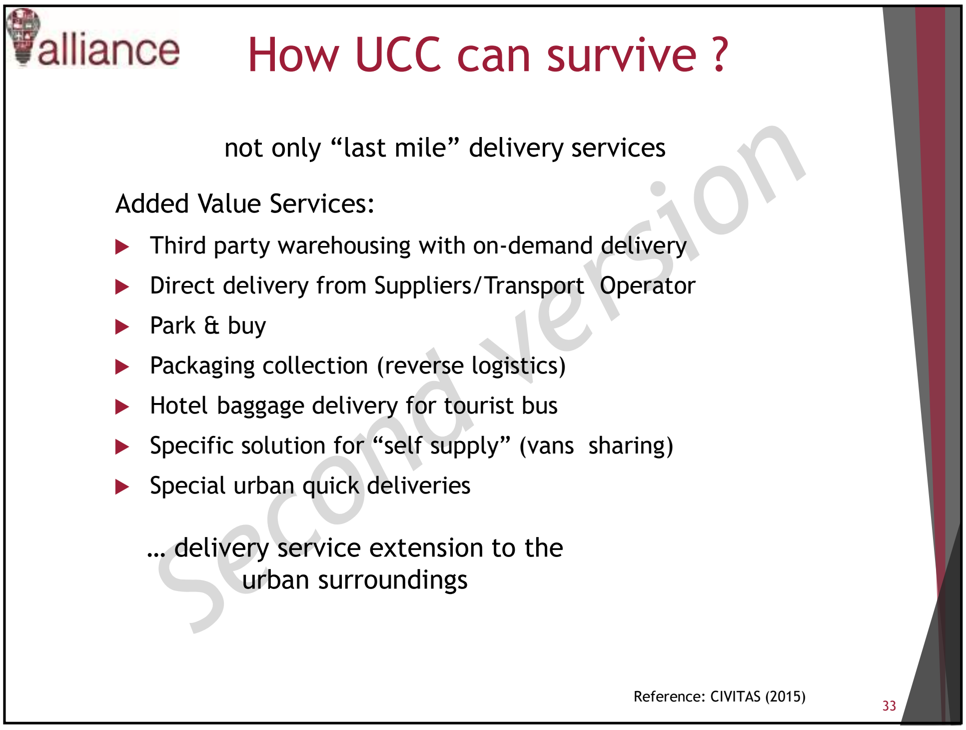
One of the following solutions can be adopted:

  - “In house” company; a structure belonging to the Public administration (public owned company), entrusted with service management
  - Public-private partnership
  - Service procurement partnership

Approach based on a public tender and on a relevant “service contract” regulating the relationship between Public Administration and Private Company

In this case a detailed “Management Performance Chart” for UCC management should be defined

Reference: CIVITAS (2015)



How UCC can survive ?

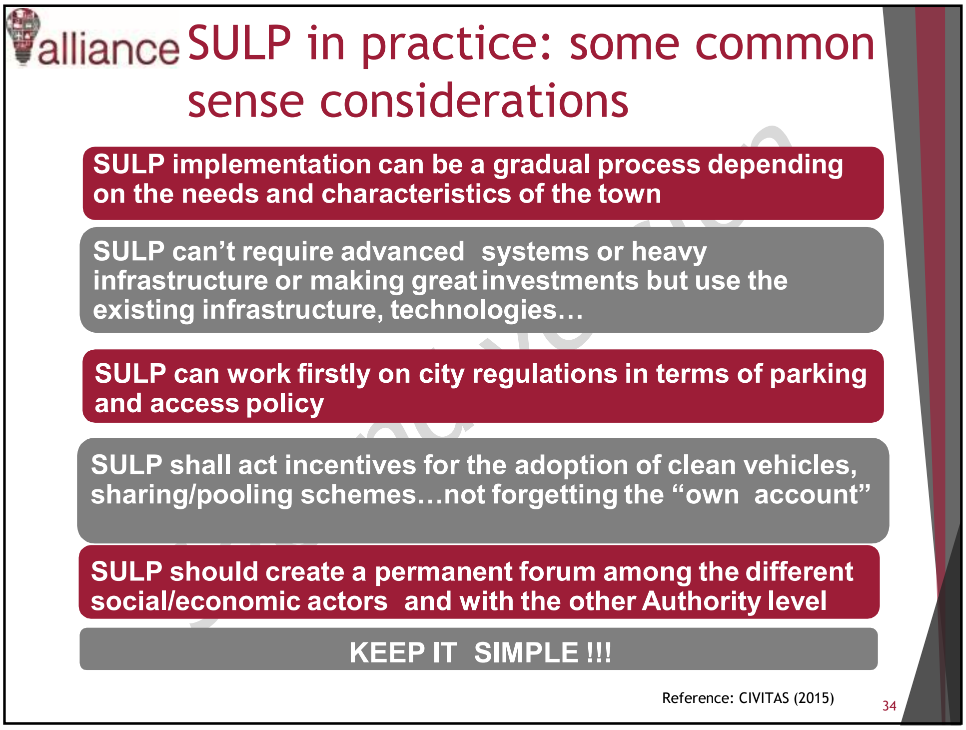
not only "last mile" delivery services

Added Value Services:

- Third party warehousing with on-demand delivery
- Direct delivery from Suppliers/Transport Operator
- Park & buy
- Packaging collection (reverse logistics)
- Hotel baggage delivery for tourist bus
- Specific solution for "self supply" (vans sharing)
- Special urban quick deliveries

… delivery service extension to the urban surroundings

Reference: CIVITAS (2015)



SULP in practice: some common sense considerations

SULP implementation can be a gradual process depending on the needs and characteristics of the town

SULP can't require advanced systems or heavy infrastructure or making great investments but use the existing infrastructure, technologies…

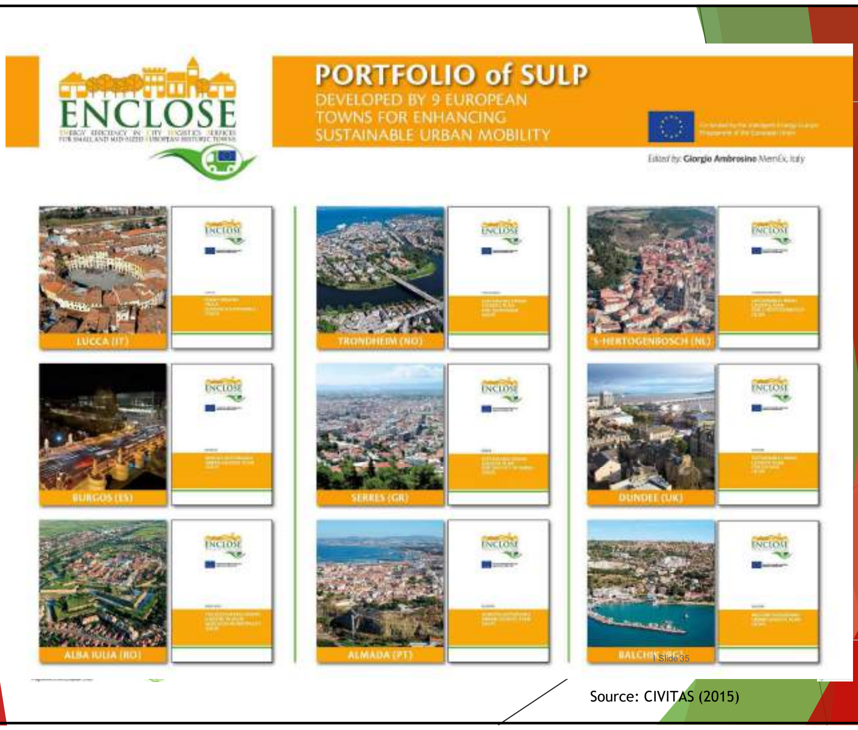
SULP can work firstly on city regulations in terms of parking and access policy

SULP shall act incentives for the adoption of clean vehicles, sharing/pooling schemes…not forgetting the "own account"

SULP should create a permanent forum among the different social/economic actors and with the other Authority level

KEEP IT SIMPLE !!!

Reference: CIVITAS (2015)



PORTFOLIO of SULP

DEVELOPED BY 9 EUROPEAN TOWNS FOR ENHANCING SUSTAINABLE URBAN MOBILITY

Edited by: Giorgio Ambrosino MemEx, Italy

Source: CIVITAS (2015)

SULP and SUMP

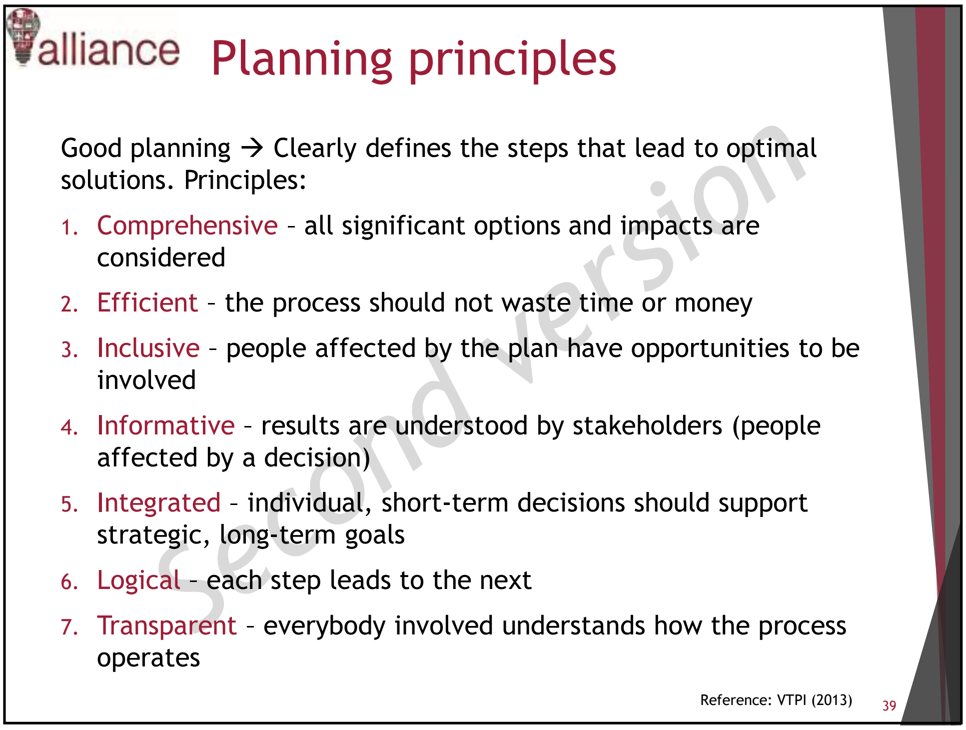
- One supports the other
- Common high-level goals
- Common participatory approach
- Common framework definition
- Common need for training courses and practical experience
- Common need to understand the related obstacles
- Shared analysis tools database
- Sharing infrastructure, ITS, devices

Transport planning principles

Background

- Planning → Process of deciding what to do and how to do it
- Planning at many levels → Community land use and transport planning
- Planners → Professionals who facilitate decision-making
- Planners → Support decision-makers (managers, public officials, citizens) by coordinating information and activities
- Role → Create a logical, systematic decision-making process that results in the best actions

Reference: VTPI (2013)

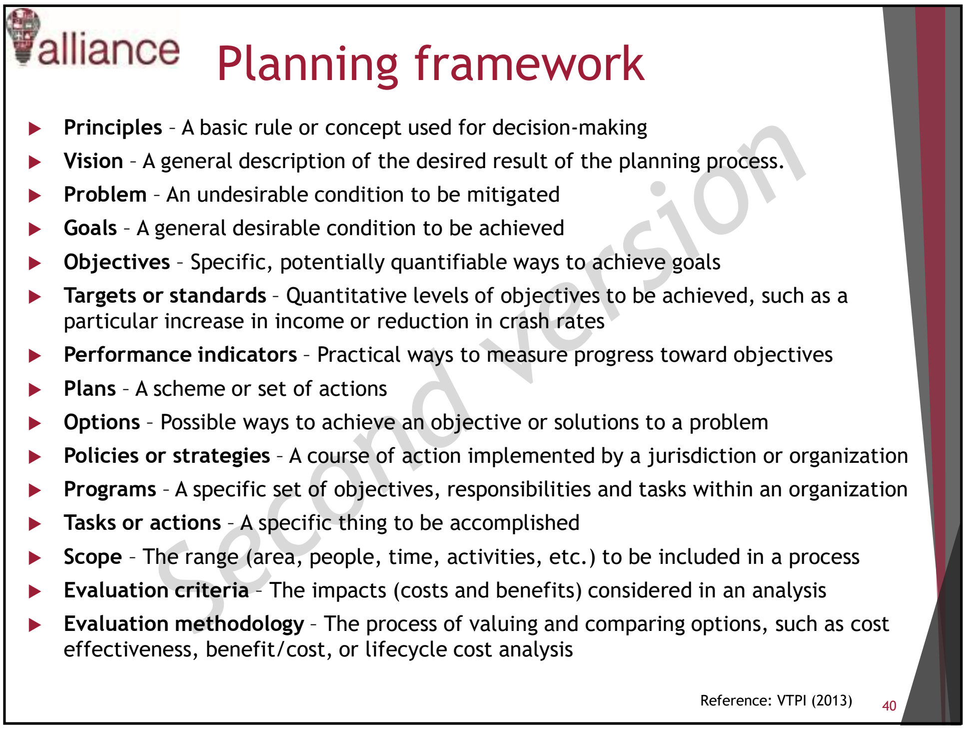


Planning principles

Good planning → Clearly defines the steps that lead to optimal solutions. Principles:

1. Comprehensive – all significant options and impacts are considered
2. Efficient – the process should not waste time or money
3. Inclusive – people affected by the plan have opportunities to be involved
4. Informative – results are understood by stakeholders (people affected by a decision)
5. Integrated – individual, short-term decisions should support strategic, long-term goals
6. Logical – each step leads to the next
7. Transparent – everybody involved understands how the process operates

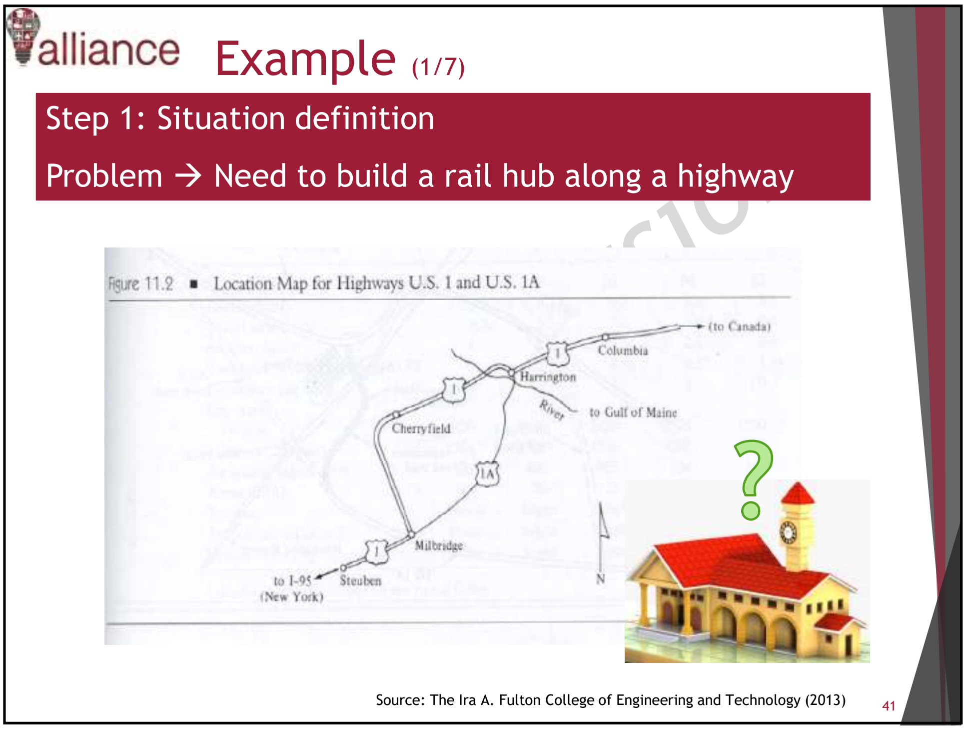
Reference: VTPI (2013)



Planning framework

- **Principles** - A basic rule or concept used for decision-making
- **Vision** - A general description of the desired result of the planning process.
- **Problem** - An undesirable condition to be mitigated
- **Goals** - A general desirable condition to be achieved
- **Objectives** - Specific, potentially quantifiable ways to achieve goals
- **Targets or standards** - Quantitative levels of objectives to be achieved, such as a particular increase in income or reduction in crash rates
- **Performance indicators** - Practical ways to measure progress toward objectives
- **Plans** - A scheme or set of actions
- **Options** - Possible ways to achieve an objective or solutions to a problem
- **Policies or strategies** - A course of action implemented by a jurisdiction or organization
- **Programs** - A specific set of objectives, responsibilities and tasks within an organization
- **Tasks or actions** - A specific thing to be accomplished
- **Scope** - The range (area, people, time, activities, etc.) to be included in a process
- **Evaluation criteria** - The impacts (costs and benefits) considered in an analysis
- **Evaluation methodology** - The process of valuing and comparing options, such as cost effectiveness, benefit/cost, or lifecycle cost analysis

Reference: VTPI (2013)



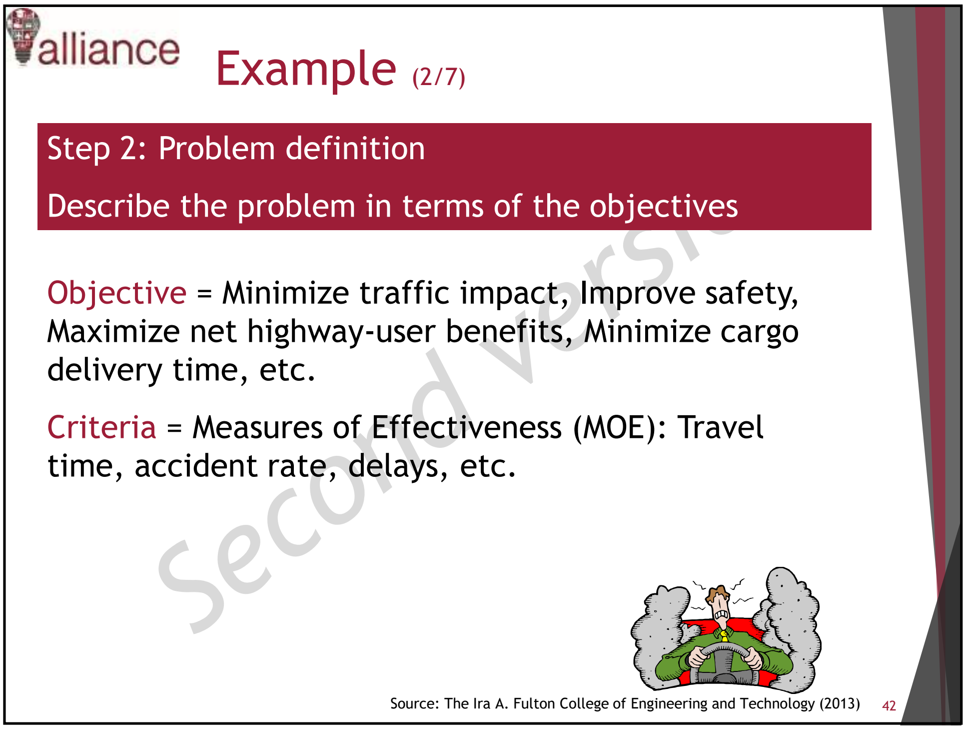
Example (1/7)

Step 1: Situation definition

Problem → Need to build a rail hub along a highway

Figure 11.2 ■ Location Map for Highways U.S. 1 and U.S. 1A

Source: The Ira A. Fulton College of Engineering and Technology (2013)



Example (2/7)

Step 2: Problem definition

Describe the problem in terms of the objectives

Objective = Minimize traffic impact, Improve safety, Maximize net highway-user benefits, Minimize cargo delivery time, etc.

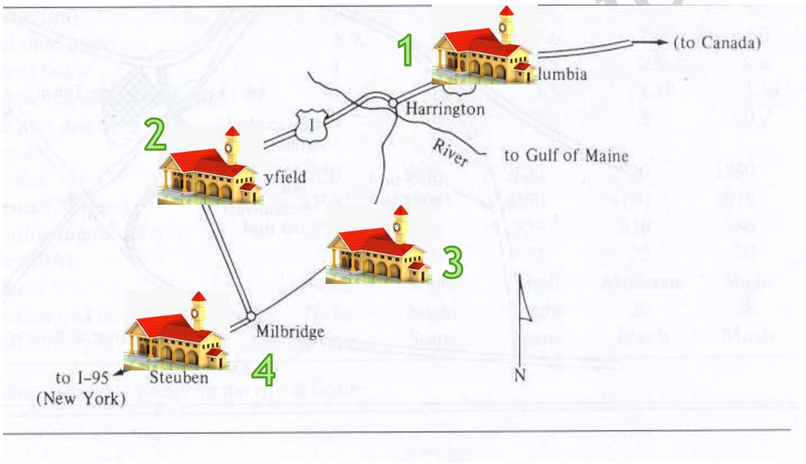
Criteria = Measures of Effectiveness (MOE): Travel time, accident rate, delays, etc.

Source: The Ira A. Fulton College of Engineering and Technology (2013)

Example (3/7)

Step 3: Search for solutions

Options at this stage.



Source: The Ira A. Fulton College of Engineering and Technology (2013)

Example (4/7)

Step 4: Analysis of performance

Quantify MOE for the proposed alternatives for present and future conditions.

	Alternatives				
Criteria	0	1	2	3	4
Speed (mph)	25	55	30	30	55
Distance (mi)	3.7	3.2	3.8	3.8	3.7
Travel time (min)	8.9	3.5	7.6	7.6	4.0
Accident factor*	4	1.2	3.5	2.5	0.6
Construction cost (million €)	0	1.50	1.58	1.18	1.54
Residences displaced	0	0	7	3	0
Present	2620	1400	2620	2520	1250
Future (20 years)	4350	2325	4350	4180	2075
Trees removed (acres)	none	slight	slight	25	28

*Relative to country average for this type of facility

Example (5/7)

Step 5: Ranking of alternatives (in terms of MOE)

	Alternatives				
Criteria	0	1	2	3	4
Travel time	1	3	2	2	3
Travel time (min)	4	3	3	3	2
Accident factor*	5	2	4	3	1
Construction cost (million €)	1	3	5	2	4
Residences displaced	1	1	3	2	1
Present	4	2	4	3	1
Future (20 years)	4	2	4	3	1
Trees removed (acres)	1	2	2	3	4

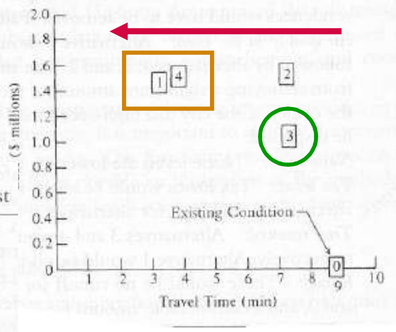
*Note: 1 = highest; 5=lowest

Example (6/7)

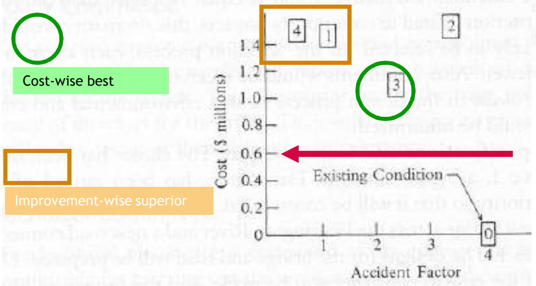
Step 6: Evaluation

Estimate criteria and compare alternatives

Travel Time Between West Harrington and U.S. 1 Versus Cost



Accident Factor (relative to statewide average) Versus Cost



Multi-objective evaluation problem.

Source: The Ira A. Fulton College of Engineering and Technology (2013)

Example (7/7)

Step 7: Choose alternative

Step 8: Specification and construction

Transportation planning models

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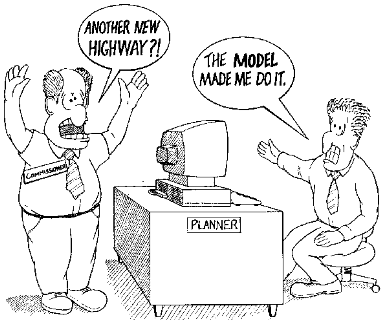
Model

- Represent human behavior making decisions → choices
- Assumptions + data ➔ models

A model is defined as a simplified representation of a part of the real world-the system of interest-which concentrates on certain elements considered important for its analysis from a particular point of view



Reference: Ortuzar and Willumsen (pp.2, 2011)
Source: Beimborn, E Kennedy, R. (1996)

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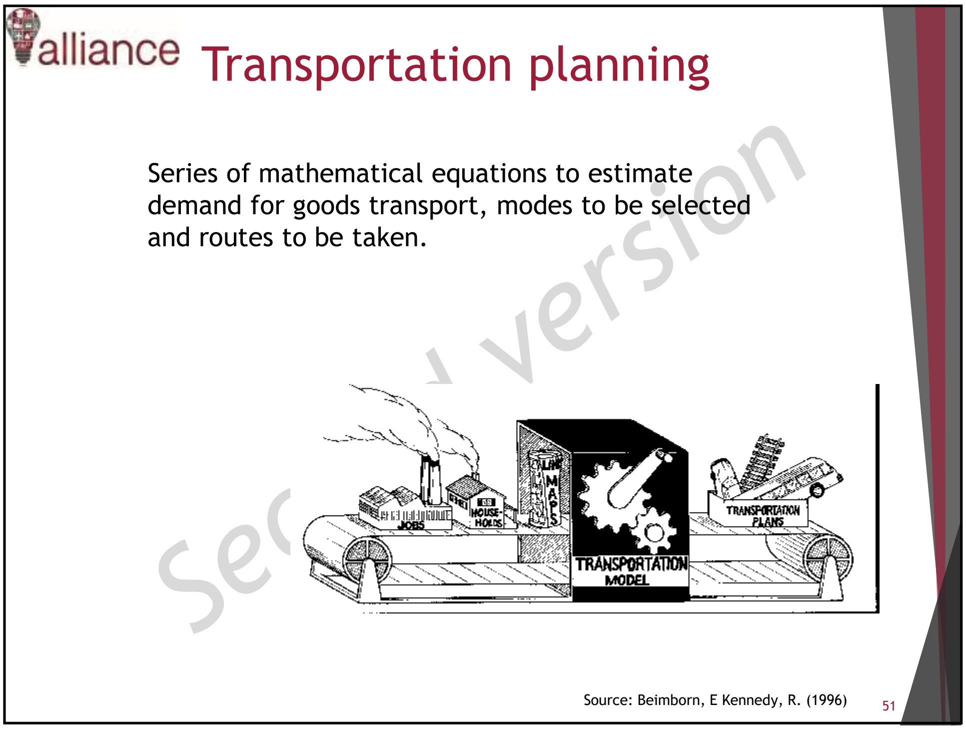
Forecasting models

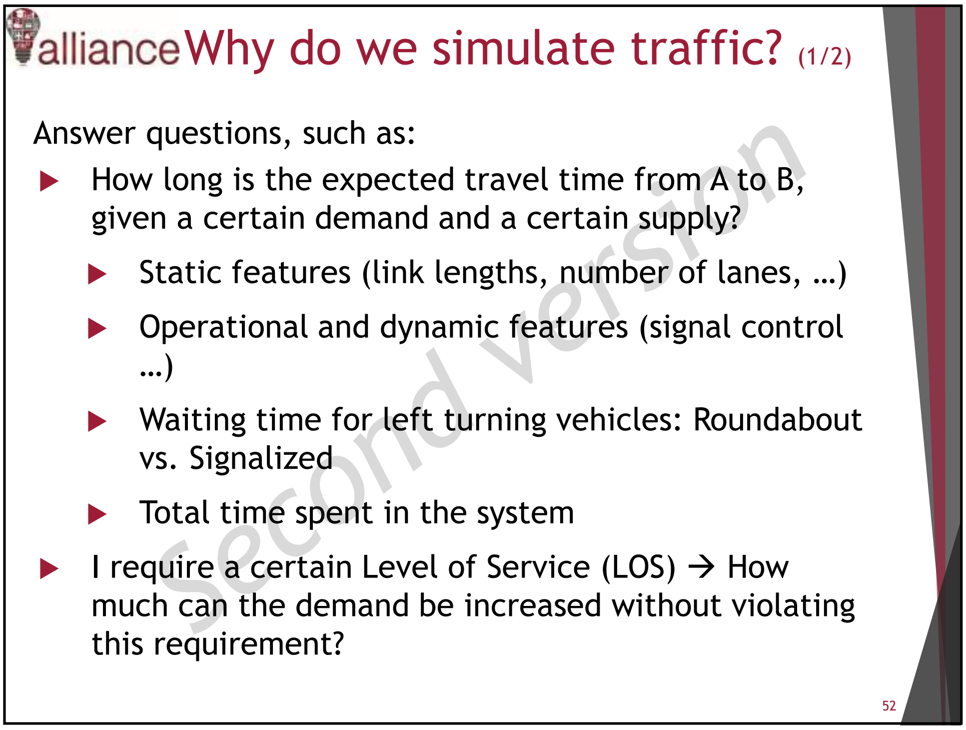
- Population → Birth/death rates, population growth, life expectancy
- Economic forecasts → GDP, inflation, unemployment, fiscal deficit, retail sales, inflation
- Land use → Where people will live, work, shop (household activity), land development
- Transportation planning → Estimate tonnage to be transported from one point to another



Transportation planning

Series of mathematical equations to estimate demand for goods transport, modes to be selected and routes to be taken.

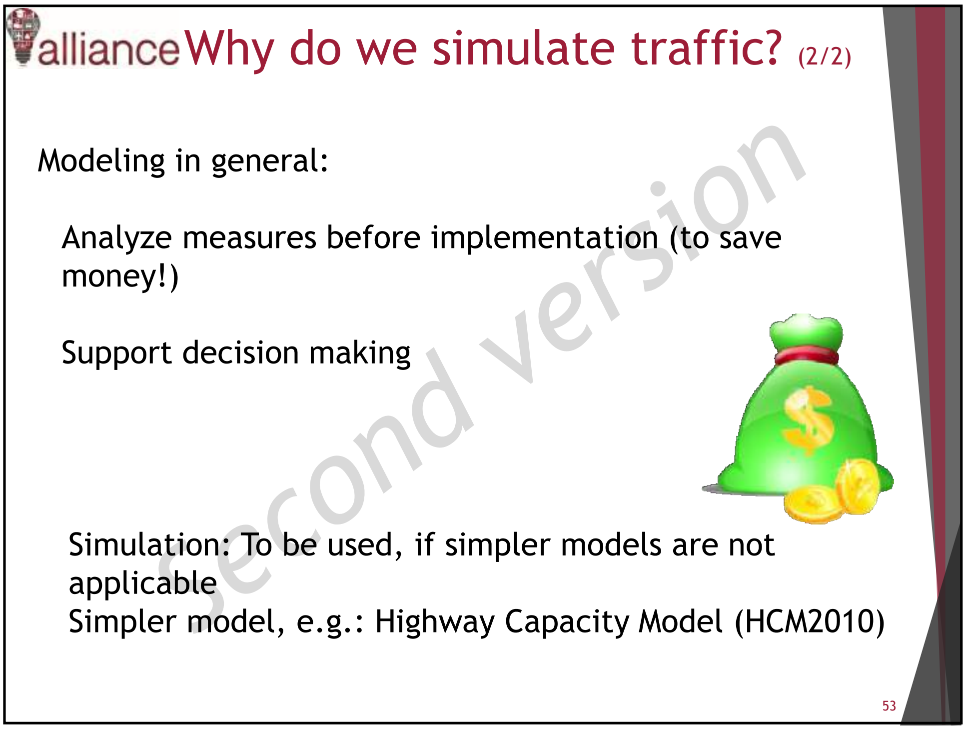
Source: Beimborn, E Kennedy, R. (1996)



Why do we simulate traffic? (1/2)

Answer questions, such as:

- How long is the expected travel time from A to B, given a certain demand and a certain supply?
  - Static features (link lengths, number of lanes, …)
  - Operational and dynamic features (signal control …)
  - Waiting time for left turning vehicles: Roundabout vs. Signalized
  - Total time spent in the system
- I require a certain Level of Service (LOS) → How much can the demand be increased without violating this requirement?



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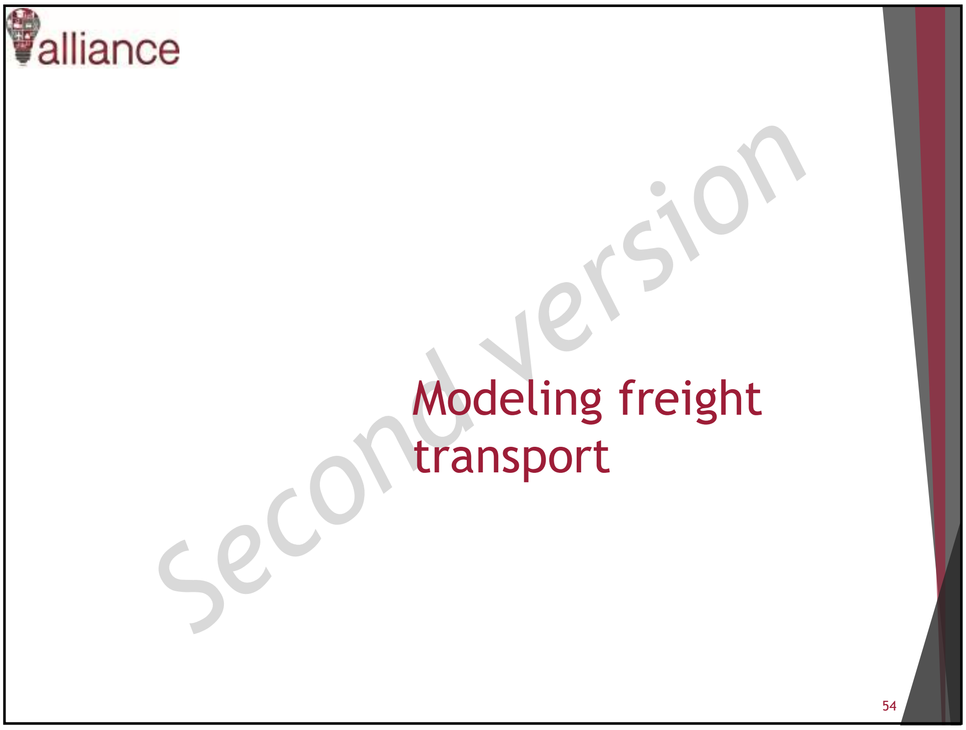
Why do we simulate traffic? (2/2)

Modeling in general:

Analyze measures before implementation (to save money!)

Support decision making

Simulation: To be used, if simpler models are not applicable
Simpler model, e.g.: Highway Capacity Model (HCM2010)



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Modeling freight transport

System characteristics

- Various stakeholders
- Type of commodity (agricultural), type of cargo (bulk) and type of loading (tank)
- Type of vehicle (truck)
- Shipment characteristics (city center or bypass)
- Loading type (FTL: full truck load, LTL: less than truck load)

Challenges

- Problems due to low flexibility and high volume of vehicles, pollutants and noise, high risk of goods (accidents) and special traffic regime (frequent stops for loading and unloading etc.)
- Difficult modeling of freight and especially in intermodal transport, given the complexity that rises from the high number of stakeholders with conflicting interests, the complexity of the routes and the processes followed and the frequent change of transport modes
- No attention was given to modeling for freight planning in coordinating the overall production process, managing inventories and controlling the commercial, industrial and economic development of a region at local, regional, national and international level

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Influence factors

- Local (origins of resources, industries and processing centers, point of sale & promotion of goods to consumers - final beneficiaries)
- Demand (size, number and type of commodities preferred by consumers)
- Physical (mode of transport / type of cargo)
- Operational (transport company policy)
- Geographical (population distribution)
- Dynamics (seasonal demand variation)
- Financial (transactions, deals, agreements and negotiations with governance)

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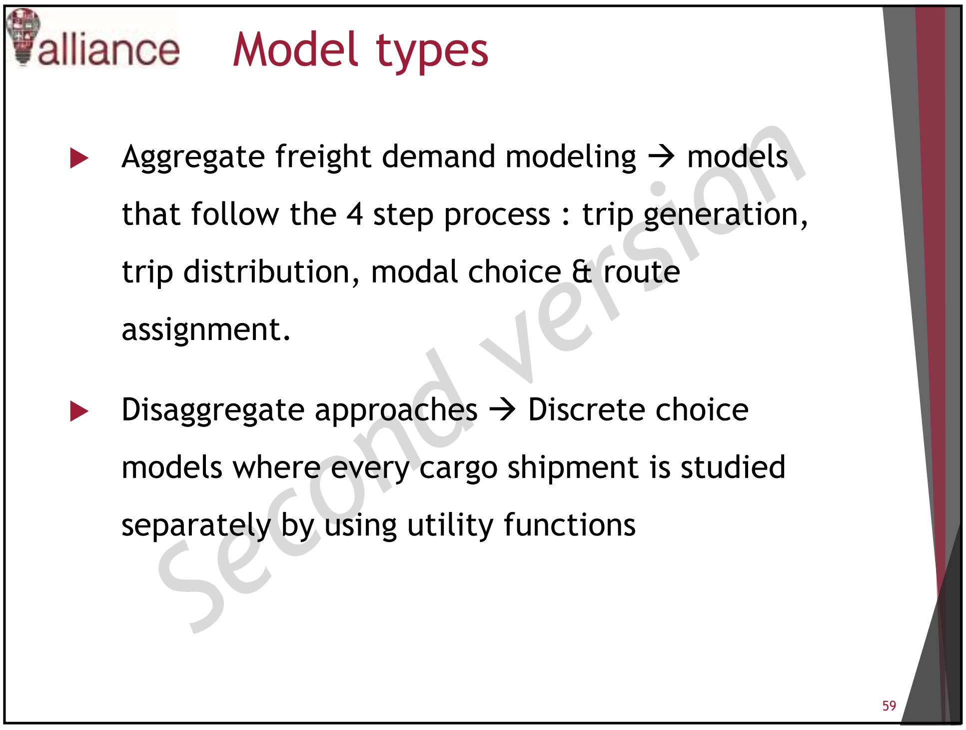
Model parameters

Independent variables:

- Population or population growth rate
- Labor force index
- Location and number of production and business units
- Private consumption
- Per capita income
- Gross Domestic Product or its time series
- Gross added value of industrial production
- Rate of change in import - export volumes

Dependent variable: Freight flows → traffic volume



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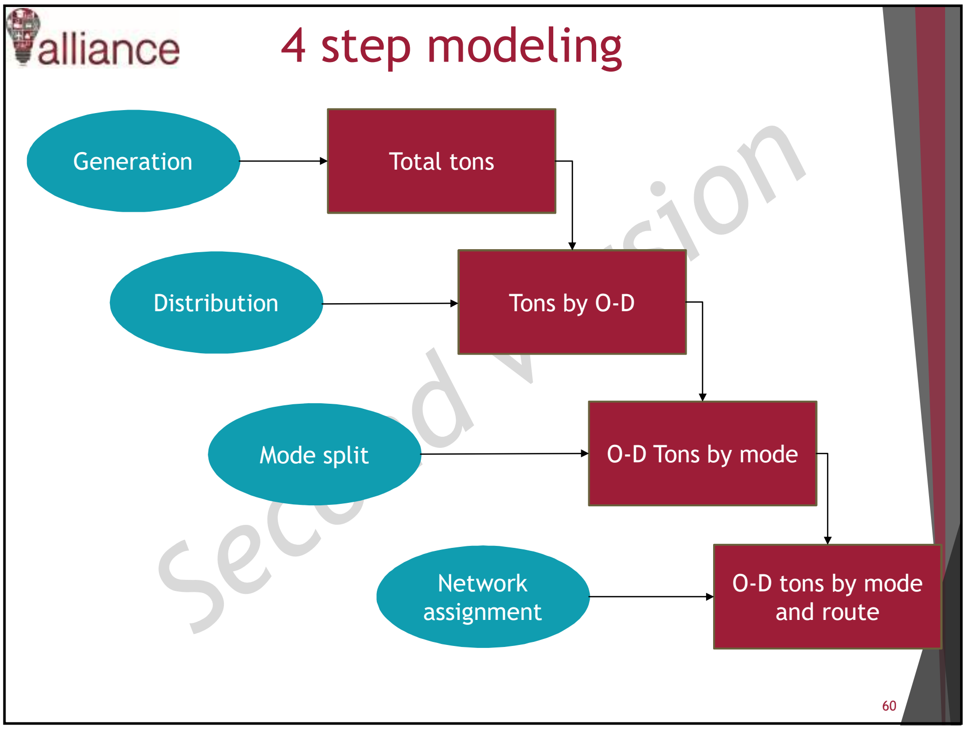
Model types

- Aggregate freight demand modeling → models that follow the 4 step process : trip generation, trip distribution, modal choice & route assignment.
- Disaggregate approaches → Discrete choice models where every cargo shipment is studied separately by using utility functions



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4 step modeling

Generation → Total tons

Distribution → Tons by O-D

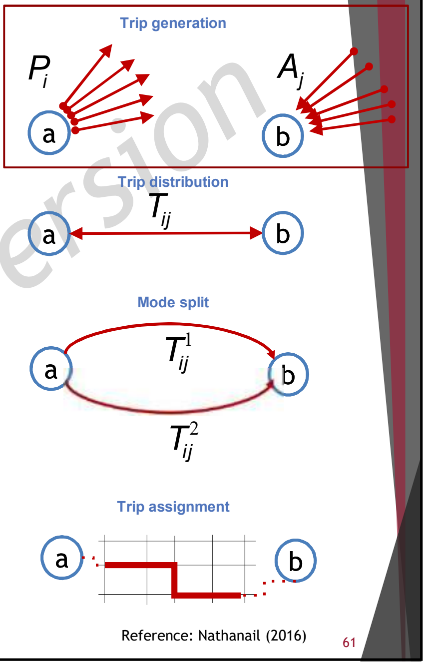
Mode split → O-D Tons by mode

Network assignment → O-D tons by mode and route

Generation

Estimating goods per O-D by:

- Research (direct demand - supply surveys) for homogenized goods (π.x. fuel, fossil, cement)
- Macro-economic models at local level
- Using growth factors
- Multiple linear regression
- Demand correlation with warehouse or shopping center capacity per zone (in urban areas)



Reference: Nathanail (2016)

Example

Forecasting model for transporting food and beverages by using linear regression

$$\log_e YP = 2.62 + 0.33\log_e[private\_trucks]$$

$$R^2 = 0.656$$

$$YA = 2.24 + 0.10[male\_manufacturing] + 0.39[private\_trucks]$$
$$R^2 = 0.715$$

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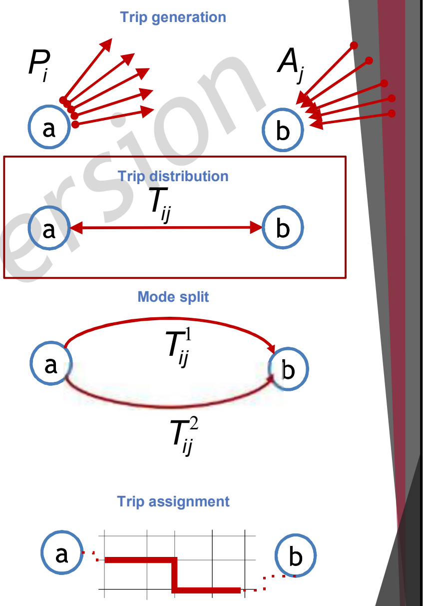
Distribution

- The form of freight flows is represented by the Origin - Destination table (O-D)
- Lines and columns represent the zones in which the study area is separated
- The cells of each line contain values that represent the cargo volume that is transported between specific origin and destination
- Diagonal cells represent cargo that is transported within the same zone



Reference: Nathanail (2016)

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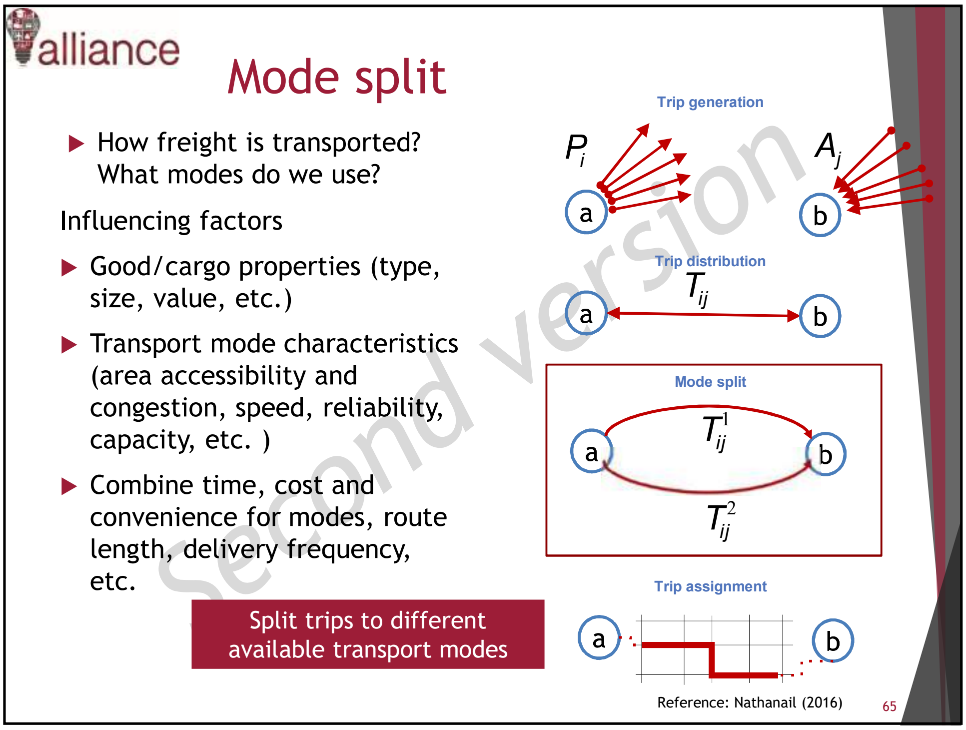
O - D Matrix Example

Destinations

Origins	1	2	3	4	5	6	Sum
1	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}	T_{16}	O_1
2	T_{21}	T_{22}	T_{23}	T_{24}	T_{25}	T_{26}	O_2
3	T_{31}	T_{32}	T_{33}	T_{34}	T_{35}	T_{36}	O_3
4	T_{41}	T_{42}	T_{43}	T_{44}	T_{45}	T_{46}	O_4
5	T_{51}	T_{52}	T_{53}	T_{54}	T_{55}	T_{56}	O_5
6	T_{61}	T_{62}	T_{63}	T_{64}	T_{65}	T_{66}	O_6
Sum	D_1	D_2	D_3	D_4	D_5	D_6	



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Mode split

- How freight is transported? What modes do we use?

Influencing factors

- Good/cargo properties (type, size, value, etc.)
- Transport mode characteristics (area accessibility and congestion, speed, reliability, capacity, etc.)
- Combine time, cost and convenience for modes, route length, delivery frequency, etc.

Split trips to different available transport modes

Reference: Nathanail (2016)

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Market segmentation mode split

Demand characteristics (price, income and cross elasticities, sensitivity to time, comfort for passengers, growth rates) and transport costs (type of service demanded) will vary for different segments of the market

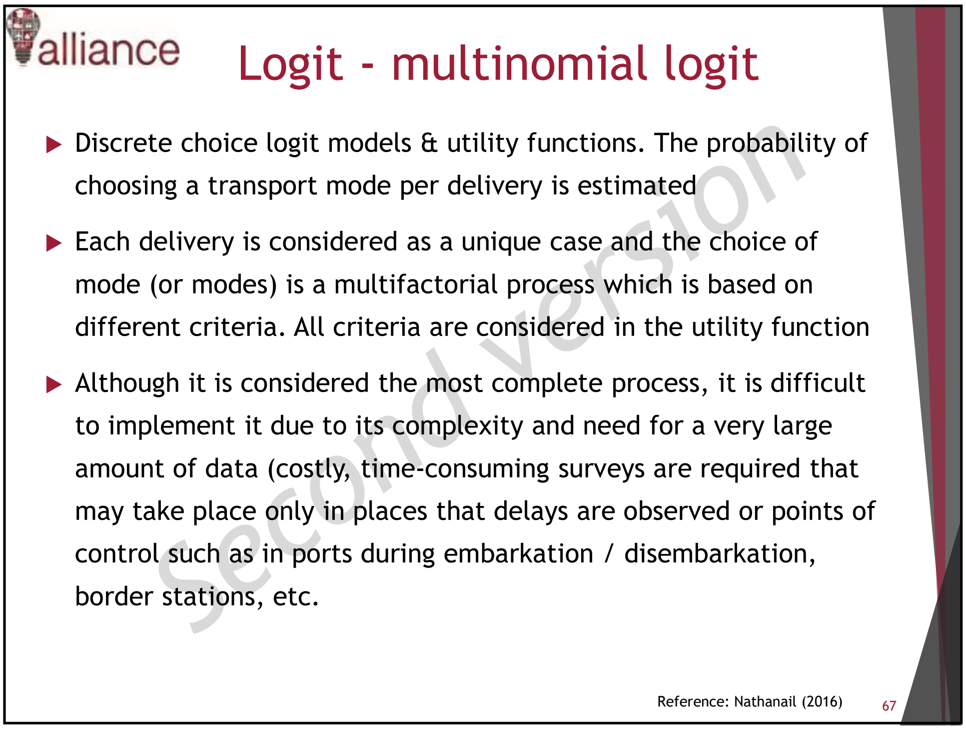
Benefits:

- Simple approach to implement
- Easy process of collection of required data

Disadvantages:

- Changes at strategic level are not modeled (e.g. projects that potentially affect the average distribution of flows)
- It assumes that all transport parameters do not vary

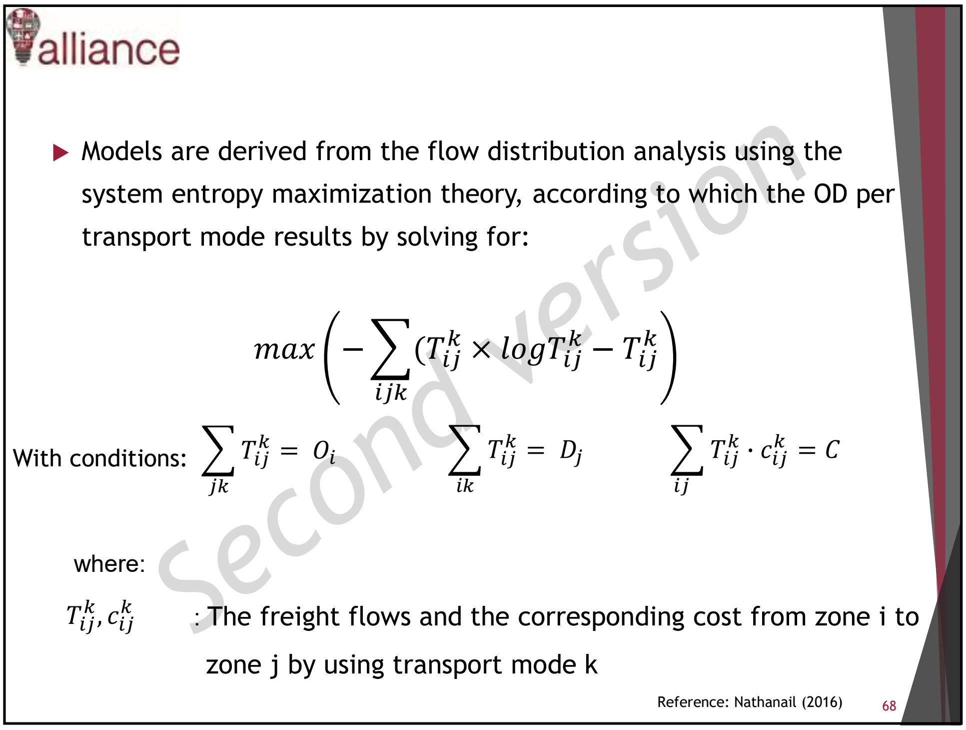
Reference: Nathanail (2016)



Logit - multinomial logit

- Discrete choice logit models & utility functions. The probability of choosing a transport mode per delivery is estimated
- Each delivery is considered as a unique case and the choice of mode (or modes) is a multifactorial process which is based on different criteria. All criteria are considered in the utility function
- Although it is considered the most complete process, it is difficult to implement it due to its complexity and need for a very large amount of data (costly, time-consuming surveys are required that may take place only in places that delays are observed or points of control such as in ports during embarkation / disembarkation, border stations, etc.

Reference: Nathanail (2016)



- Models are derived from the flow distribution analysis using the system entropy maximization theory, according to which the OD per transport mode results by solving for:

$$max\left(-\sum_{ijk}(T_{ij}^{k} \times logT_{ij}^{k} - T_{ij}^{k}\right)$$

With conditions: $\sum_{jk} T_{ij}^{k} = O_i$ $\quad \sum_{ik} T_{ij}^{k} = D_j$ $\quad \sum_{ij} T_{ij}^{k} \cdot c_{ij}^{k} = C$

where:

T_{ij}^{k}, c_{ij}^{k} : The freight flows and the corresponding cost from zone i to zone j by using transport mode k

Reference: Nathanail (2016)

- The probability of choosing a transport mode is given by the following sigmoid or “S shape” logistic function:

$$f(x) = \frac{1}{1 + \exp(\lambda \cdot x)}$$

Reference: Nathanail (2016)

- General choice model by using logistic function

$$P_{ij}^{m} = \frac{\exp(-\lambda \cdot C_{ij}^{m})}{\sum_{\kappa} \exp(-\lambda \cdot C_{ij}^{k})}$$

- It expresses the probability of using mode m as a function of generalized cost C_{ij}^{m} of mode m and the corresponding generalized cost C_{ij}^{k} of all alternative modes k

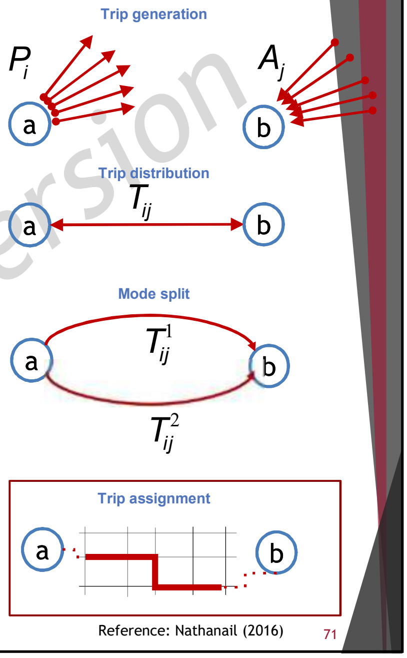
Reference: Nathanail (2016)

Network assignment

- Optimum routing based on Wardrop principles:

a) Shippers will strive to find the shortest (least resistance) path from origin to destination

b) Every shipper minimizes the total travel effort in the network



Reference: Nathanail (2016)

Algorithms for network assignment

- Fixed path assignment – easy to approach but not flexible in changes
- Dynamic path assignment – routes are estimated and chosen based on real conditions/needs:
  1. All or nothing or preload assignment
  2. Multi – class or simultaneous assignment
  3. Stochastic or random assignment
  4. User equilibrium assignment

Reference: Nathanail (2016)

- **All or nothing or Preload assignment:** Capacity limitations are not taken into account; route time and cost are not re-estimated (recommended) for long-distance journeys, i.e. there are no time variations given different loading
- **Multi - class or Simultaneous assignment:** Taking into account the passenger traffic, since total congestion affects transport time and cost. In order to calculate the network traffic loading and the environmental nuisance due to heavy vehicles traffic, conversion factors - PCEs are used

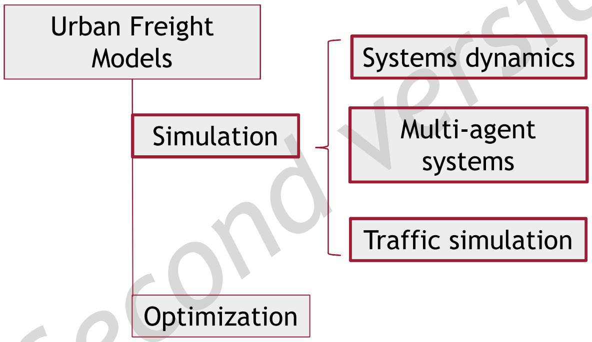
Reference: Nathanail (2016)

- **User equilibrium assignment:** Estimated travel times for alternative routes are recalculated (iterative process) given the delays which result after the initial allocation of flows to the network, so that all alternative routes having equal travel times time (suitable for urban environments and congested networks)
- **Stochastic assignment:** The user may have partial knowledge of how far the proposed solution is from the optimum solution (shortest path), while routes with equal estimated time or/and cost will receive an equal percentage/share of total freight flows which correspond to a specific O-D pair

Reference: Nathanail (2016)

Transport impacts

Introduction- Simulation models



Reference: Taniguchi et al. (2012)

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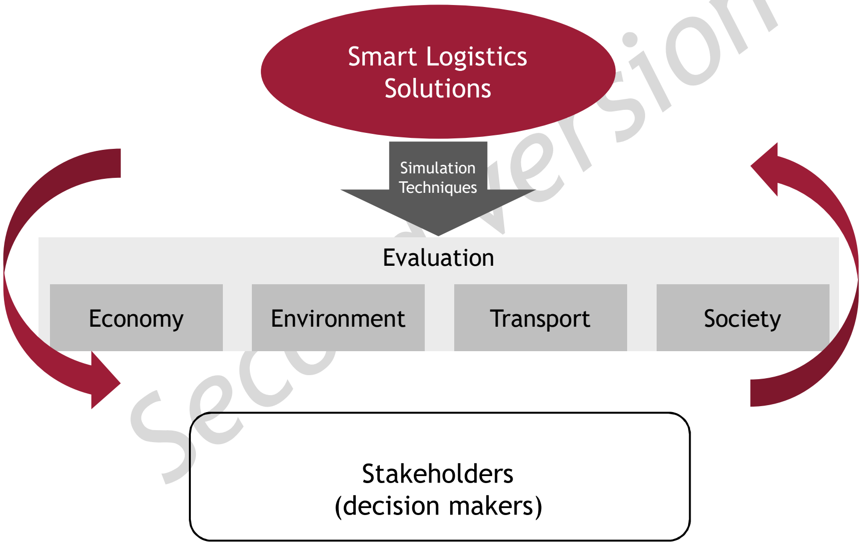
Evaluation



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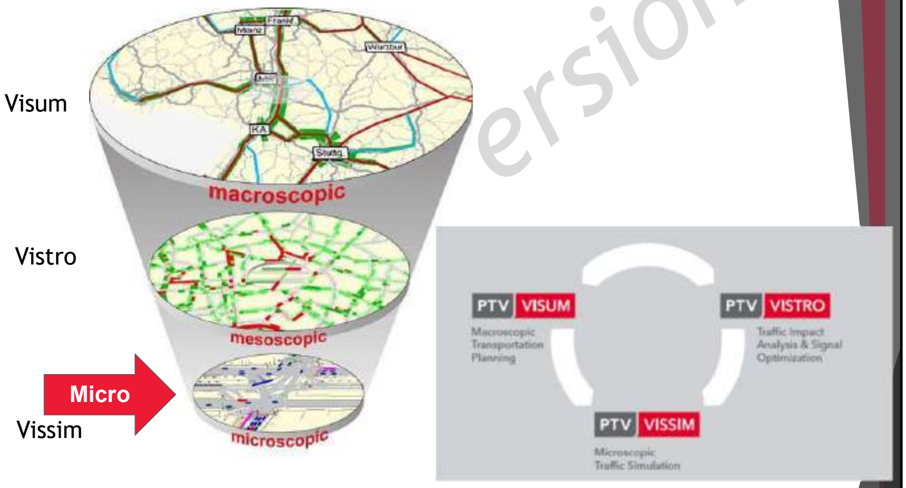
Modeling Levels



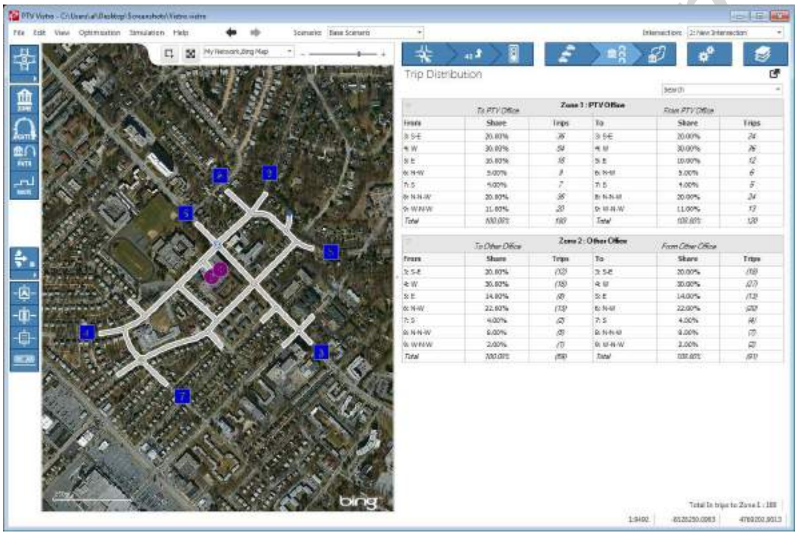
Macroscopic models

- Consider transportation network attributes such as capacity, speed limit, flow and density
- Simulate large scale facilities (highways, regions etc.)
- No need to track individual vehicles (aggregate theory)
- No detailed information about road design and signal plans are required
- CUBE, TRIPS and VISUM, TransModeler

Reference: Papaioannou et al. (2009)

Mesoscopic – Vistro (1/2)

Traffic Impact Analysis



Trip Distribution

Zone 1 : PTV Office

To PTV Office			From PTV Office		
From	Share	Trips	To	Share	Trips
3: S-E	20.00%	36	3: S-E	20.00%	24
4: W	30.00%	54	4: W	30.00%	36
5: E	10.00%	18	5: E	10.00%	12
6: N-W	5.00%	9	6: N-W	5.00%	6
7: S	4.00%	7	7: S	4.00%	5
8: N-N-W	20.00%	36	8: N-N-W	20.00%	24
9: W-N-W	11.00%	20	9: W-N-W	11.00%	13
Total	100.00%	180	Total	100.00%	120

Zone 2 : Other Office

To Other Office			From Other Office		
From	Share	Trips	To	Share	Trips
3: S-E	20.00%	(12)	3: S-E	20.00%	(18)
4: W	30.00%	(18)	4: W	30.00%	(27)
5: E	14.00%	(8)	5: E	14.00%	(12)
6: N-W	22.00%	(13)	6: N-W	22.00%	(20)
7: S	4.00%	(2)	7: S	4.00%	(4)
8: N-N-W	8.00%	(5)	8: N-N-W	8.00%	(7)
9: W-N-W	2.00%	(1)	9: W-N-W	2.00%	(2)
Total	100.00%	(60)	Total	100.00%	(90)

Reference: PTV Group. (2016)

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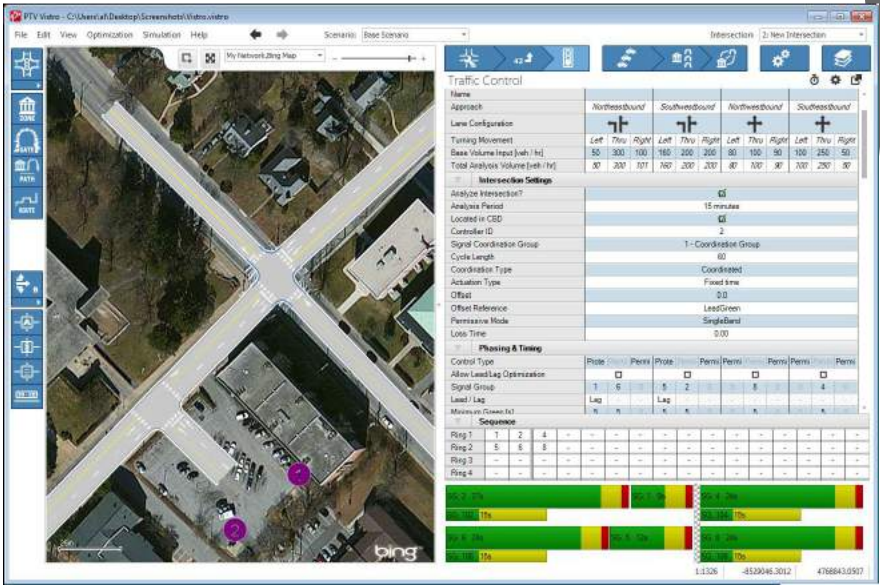
Mesoscopic – Vistro (2/2)

Signal optimization



Traffic Control

Name												
Approach	Northeastbound			Southwestbound			Northwestbound			Southeastbound		
Turning Movement	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right	Left	Thru	Right
Base Volume Input [veh / hr]	50	300	100	160	200	200	80	100	90	100	250	50
Total Analysis Volume [veh / hr]	50	300	101	160	200	200	80	100	90	100	250	50
Intersection Settings												
Analyze Intersection?	☑											
Analysis Period	15 minutes											
Located in CBD	☑											
Controller ID	2											
Signal Coordination Group	1 - Coordination Group											
Cycle Length	60											
Coordination Type	Coordinated											
Actuation Type	Fixed time											
Offset	0.0											
Offset Reference	LeadGreen											
Permissive Mode	SingleBand											
Loss Time	0.00											
Phasing & Timing												
Control Type	Prote		Permi	Prote		Permi	Permi		Permi	Permi		Permi
Allow Lead/Lag Optimization		☐			☐			☐			☐	
Signal Group	1	6		5	2			8			4	
Lead / Lag	Lag			Lag								

Sequence																
Ring 1	1	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	5	6	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Reference: PTV Group. (2016) 81

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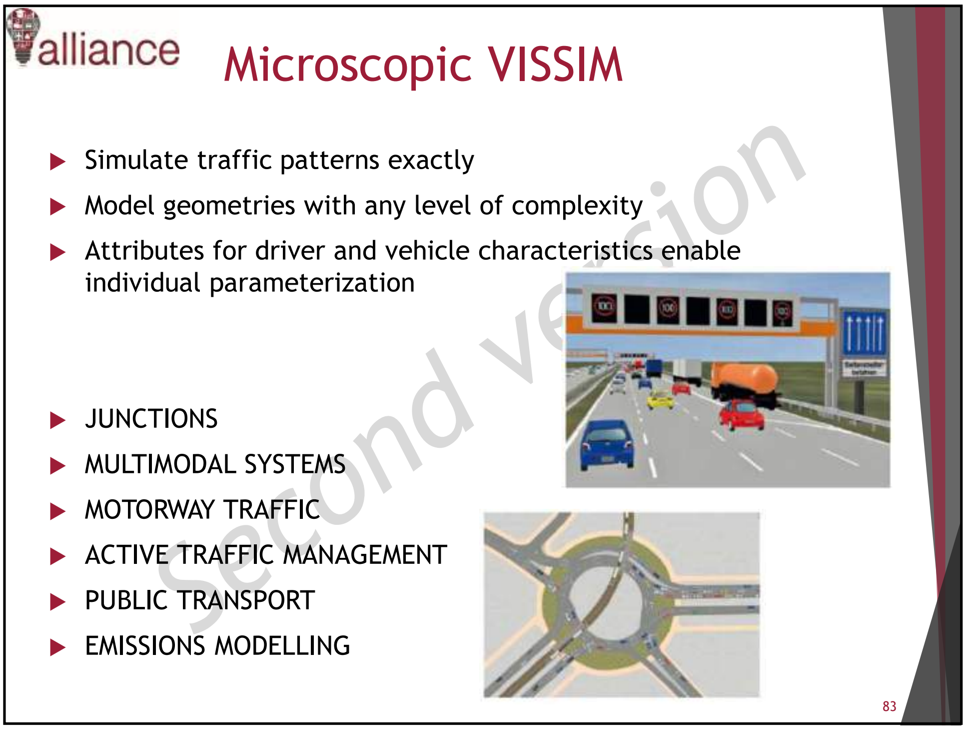
Microscopic models

- Simulate characteristics and interactions of individual vehicles
- Study area: Intersection or a road segment
- Enclose theories and rules for vehicle acceleration, passing manoeuvres and lane-changing
- PARAMICS, VISSIM, AIMSUN, SUMO, MatSIM, TransModeler SE

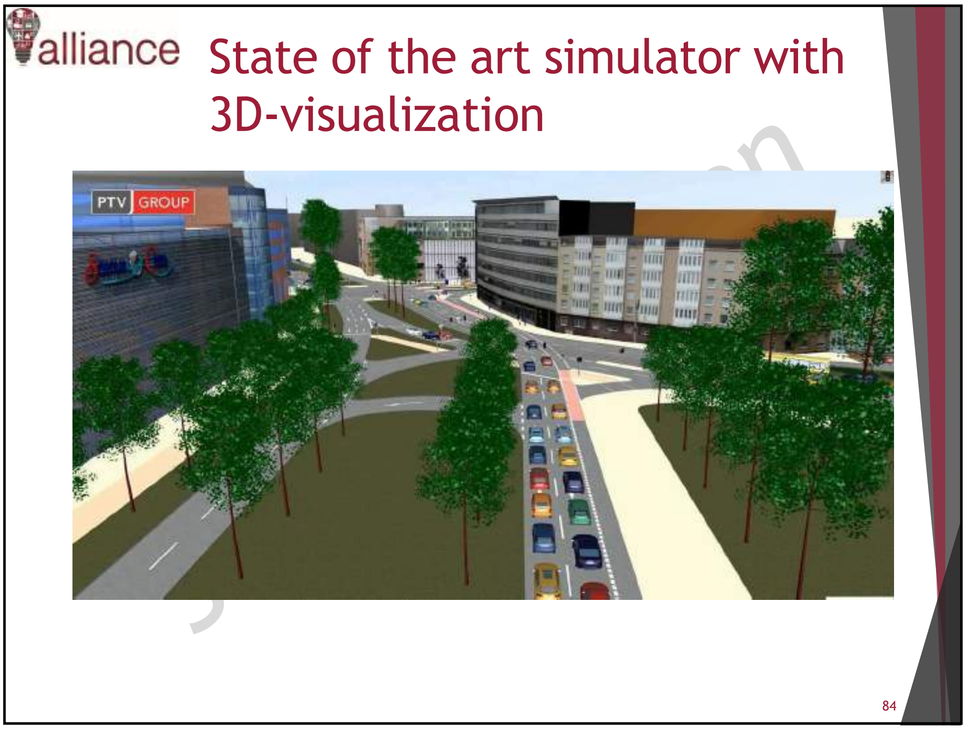
Reference: Papaioannou et al. (2009) 82



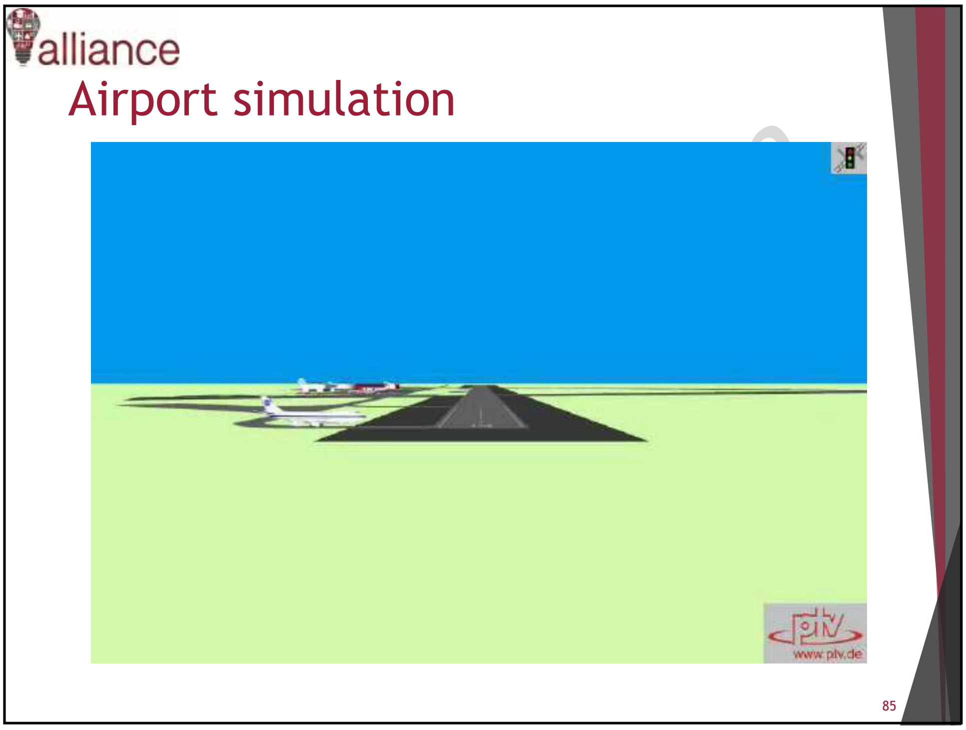
Microscopic VISSIM

- Simulate traffic patterns exactly
- Model geometries with any level of complexity
- Attributes for driver and vehicle characteristics enable individual parameterization

- JUNCTIONS
- MULTIMODAL SYSTEMS
- MOTORWAY TRAFFIC
- ACTIVE TRAFFIC MANAGEMENT
- PUBLIC TRANSPORT
- EMISSIONS MODELLING



State of the art simulator with 3D-visualization



Airport simulation

Container terminals

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Anylogic

- Supply chains
- Manufacturing
- Transportation
- Healthcare
- Passenger terminals
- Marketing
- Business processes
- Warehouse operations

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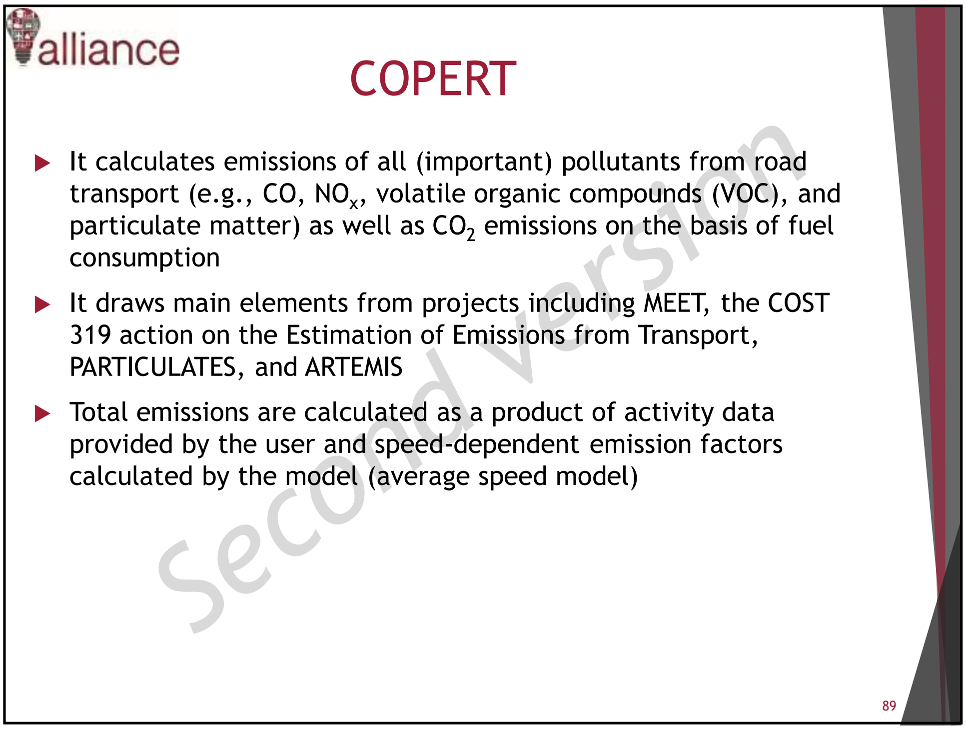
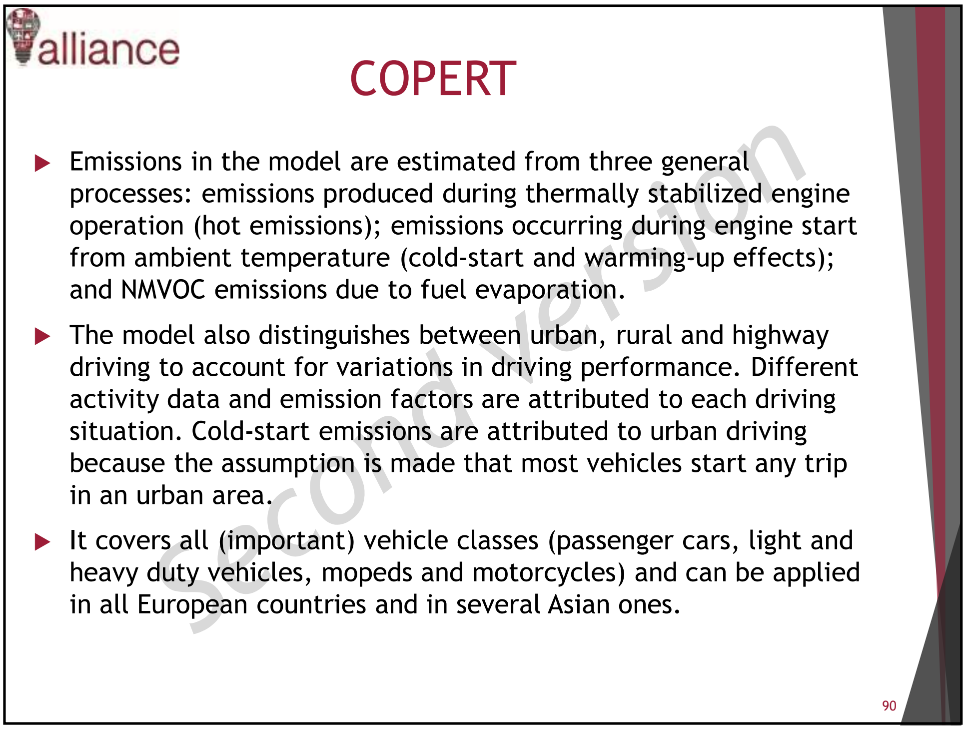
Environmental impact assessment



COPERT

- It calculates emissions of all (important) pollutants from road transport (e.g., CO, NO_x, volatile organic compounds (VOC), and particulate matter) as well as CO_2 emissions on the basis of fuel consumption
- It draws main elements from projects including MEET, the COST 319 action on the Estimation of Emissions from Transport, PARTICULATES, and ARTEMIS
- Total emissions are calculated as a product of activity data provided by the user and speed-dependent emission factors calculated by the model (average speed model)



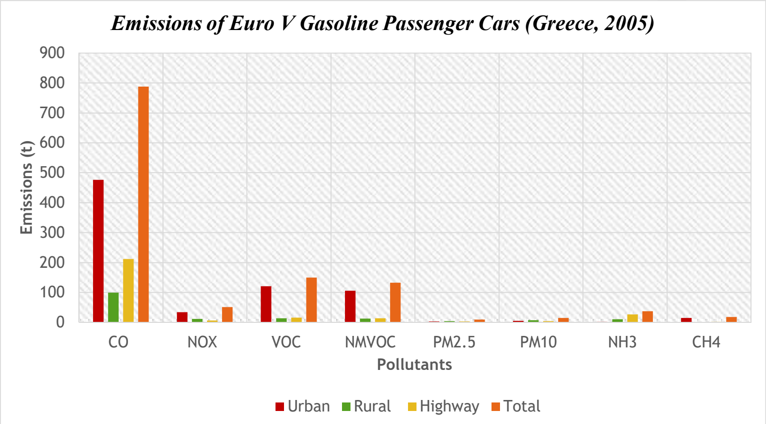
COPERT

- Emissions in the model are estimated from three general processes: emissions produced during thermally stabilized engine operation (hot emissions); emissions occurring during engine start from ambient temperature (cold-start and warming-up effects); and NMVOC emissions due to fuel evaporation.
- The model also distinguishes between urban, rural and highway driving to account for variations in driving performance. Different activity data and emission factors are attributed to each driving situation. Cold-start emissions are attributed to urban driving because the assumption is made that most vehicles start any trip in an urban area.
- It covers all (important) vehicle classes (passenger cars, light and heavy duty vehicles, mopeds and motorcycles) and can be applied in all European countries and in several Asian ones.

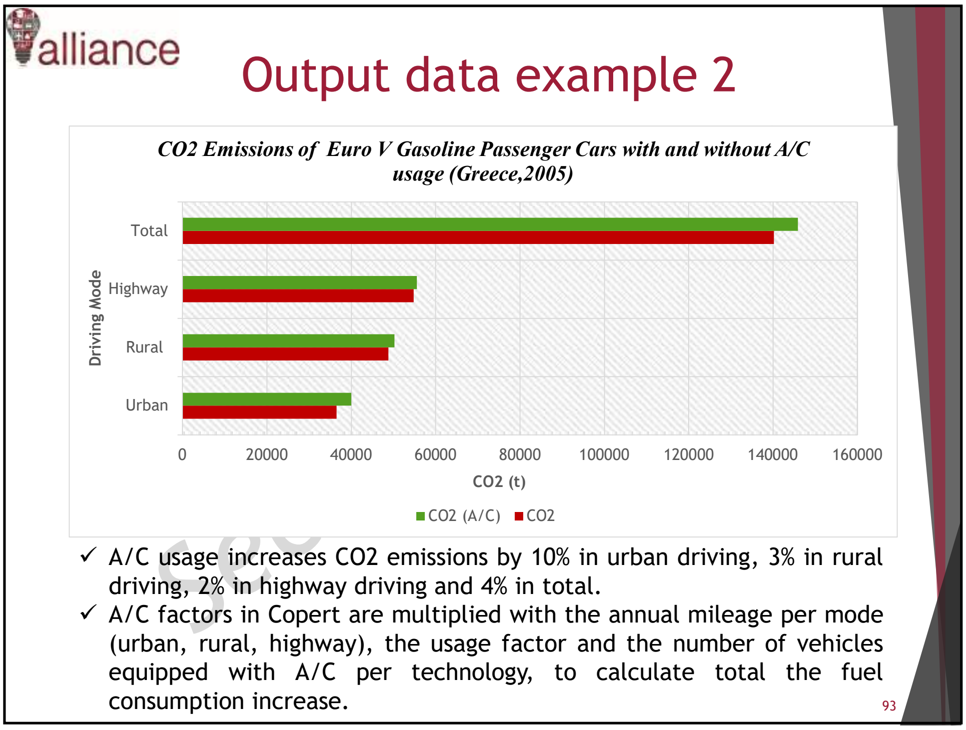
Input data

- Fuel variables
  - Consumption
- Activity data
  - Number of vehicles per vehicle category
  - Distribution of the vehicle fleet into different exhaust emission legislation classes
  - Mileage per road class
- Driving conditions
  - Average speed per vehicle type and per road
- Other variables
  - Climatic conditions
  - Mean trip distance
  - Evaporation distribution

Output data example 1



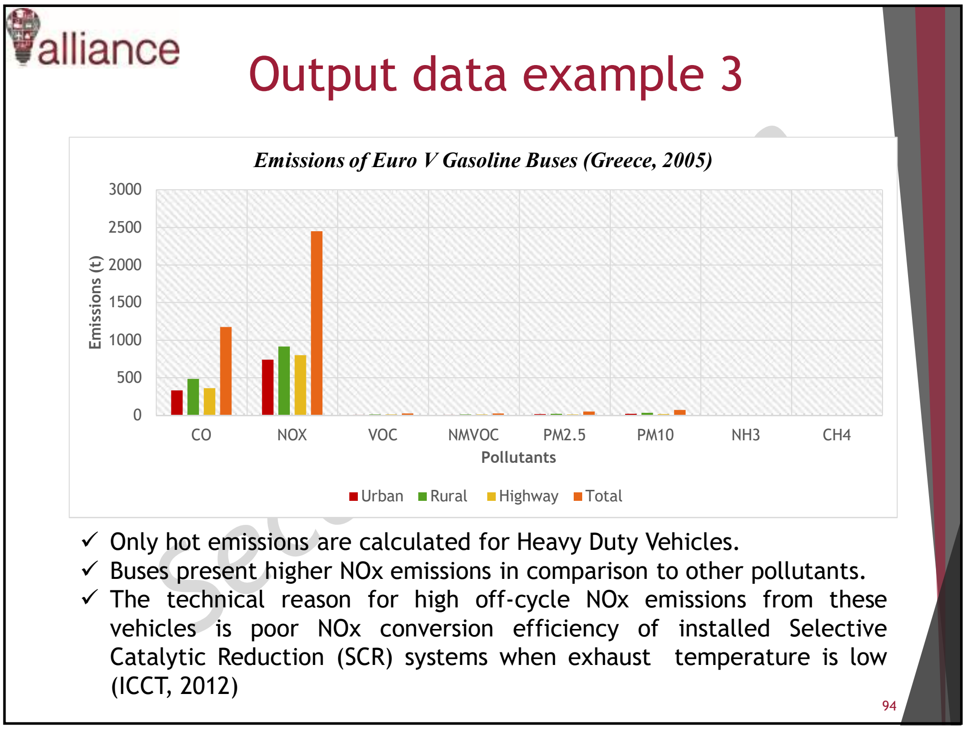
- ✓ For the majority of pollutants, urban driving shows higher emissions due to larger cold emissions.
- ✓ Carbon Oxide (CO), Volatile Organic Compounds (VOC), Non-Methane Volatile Organic Compounds (VOC) and Nitrous Oxides (NOx) are the most important emissions.



Output data example 2

CO2 Emissions of Euro V Gasoline Passenger Cars with and without A/C usage (Greece,2005)

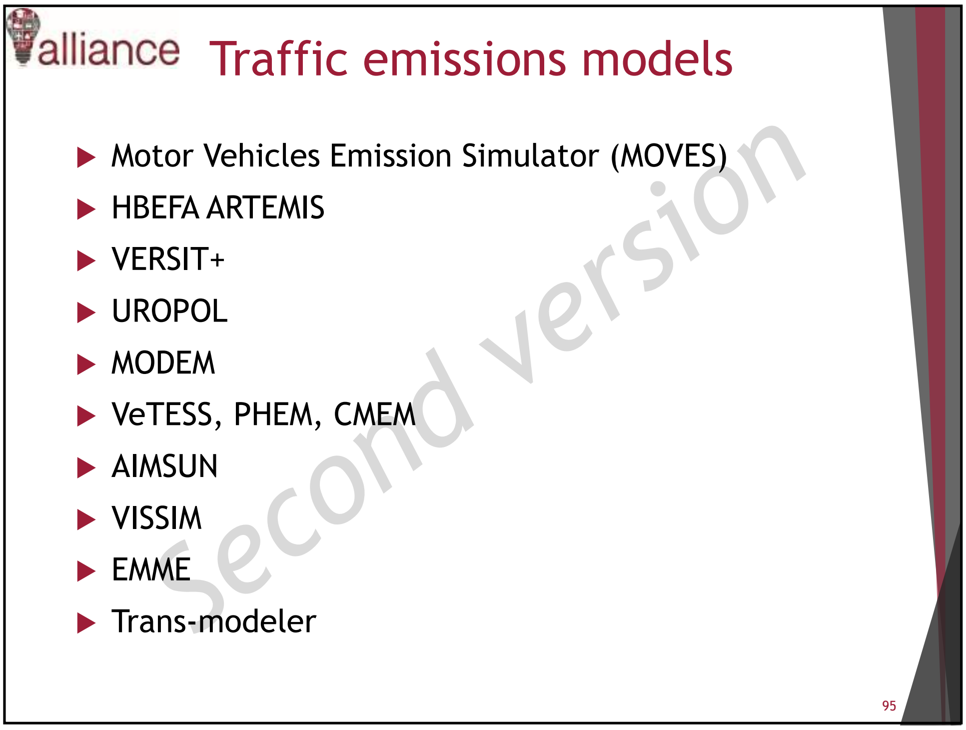
- ✓ A/C usage increases CO2 emissions by 10% in urban driving, 3% in rural driving, 2% in highway driving and 4% in total.
- ✓ A/C factors in Copert are multiplied with the annual mileage per mode (urban, rural, highway), the usage factor and the number of vehicles equipped with A/C per technology, to calculate total the fuel consumption increase.



Output data example 3

Emissions of Euro V Gasoline Buses (Greece, 2005)

- ✓ Only hot emissions are calculated for Heavy Duty Vehicles.
- ✓ Buses present higher NOx emissions in comparison to other pollutants.
- ✓ The technical reason for high off-cycle NOx emissions from these vehicles is poor NOx conversion efficiency of installed Selective Catalytic Reduction (SCR) systems when exhaust temperature is low (ICCT, 2012)



Traffic emissions models

- Motor Vehicles Emission Simulator (MOVES)
- HBEFA ARTEMIS
- VERSIT+
- UROPOL
- MODEM
- VeTESS, PHEM, CMEM
- AIMSUN
- VISSIM
- EMME
- Trans-modeler

Safety impact assessment

Safety performance function

$$N_{spf\ x} = e^{\left(a + b \times \ln\left(AADT\right) + \ln\left(L/1.609\right)\right)}$$

where,

$N_{spf\ x} =$ predicted average frequency of crashes for a specific year on road section x for base conditions

$AADT =$ annual average daily traffic on road section (vehicles)

$L =$ length of road section (km)

$a, b =$ regression coefficients

Reference: Nathanail E. (2013)

Generic function

$$N_{prex} = N_{spfx} \times \left(AMF_{1x} \times AMF_{2x} \times \ldots\ldots \times AMF_{yx}\right) \times C_x$$

where,

$N_{prex} =$ predicted average frequency of crashes for a specific year on a road section x

$N_{spfx} =$ predicted average frequency of crashes for base conditions, by using the SPF for road section x

$AMF_{yx} =$ accident modification factors for accidents for road section x and specific geometric and traffic control characteristics y

$C_x =$ Calibration factor of the SPF in local conditions of road section x

Empirical method Bayes (EB)

In this method, the closer to zero the coefficient of variation approaches the more statistically reliable the SPF is.

$$k = \frac{1}{e^{\left(c + \ln\left(L/1.609\right)\right)}}$$

where,

k = Coefficient of variation for road section

L = Length of road section (km)

c = Regression coefficient that affects the coefficient of variation

---

EB method

- Application of EB method on road section (if possible).
  - If the EB method is used, the AADT is required for each year of period of study for which data for observed frequency of crashes are available

$$N_{\exp} = w \times N_{pre} + (1 - w) \times N_{obs} \qquad w = \frac{1}{1 + k \times (\sum N_{pre})}$$

N_{exp} = Expected average number of crashes for the study period

N_{pre} = Predicted average number of crashes for the period of study

N_{obs} = Observed average number of crashes for the period of study

w = weight

k = Coefficient of variation for SPF

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Sustainable development and transportation planning

University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426

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Content

1. Sustainable transport
2. Smart solutions in sustainable transportation planning
3. Sustainable urban development and mobility plans
4. Transportation planning principles
5. Transportation planning models
6. Transport impacts
7. Environmental impact assessment
8. Safety impact assessment
9. Suggested literature

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General information

Course title	Sustainable development and transportation planning
Hours	2
Lecturer/Institution	Eftihia Nathanail University of Thessaly *enath@uth.gr*
Teaching methods	Lecture
Prerequisites	No

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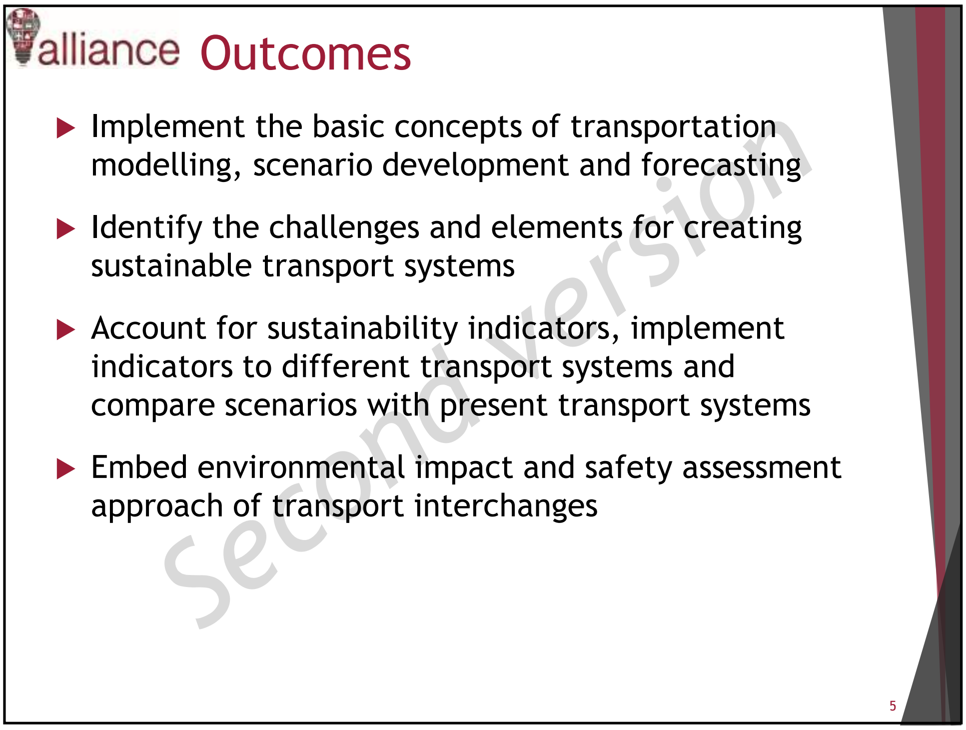
Course aim

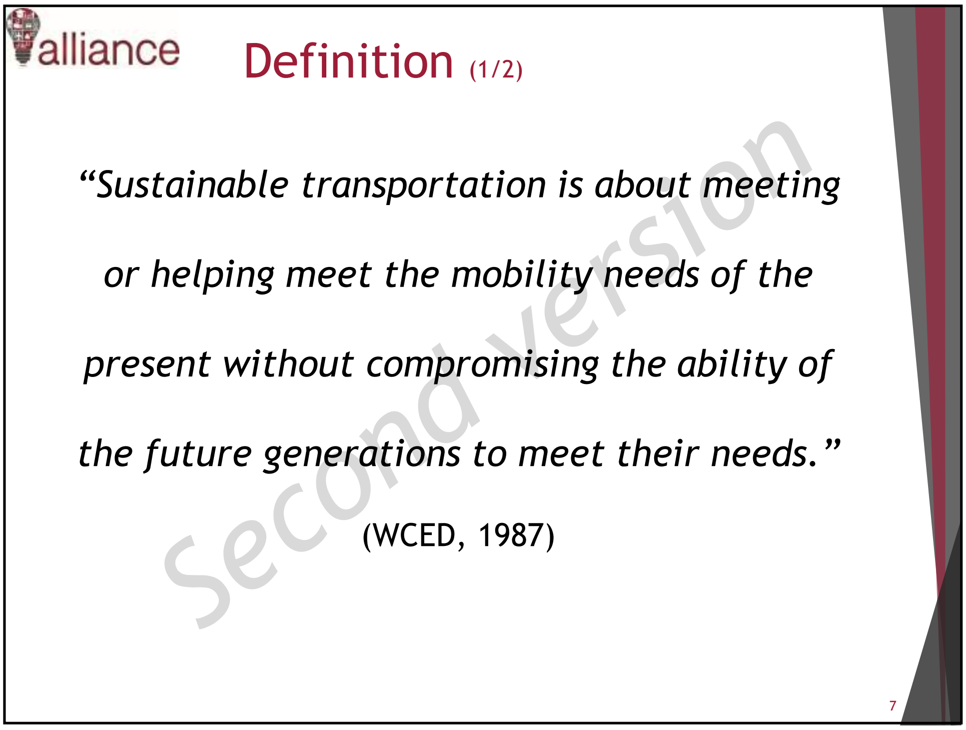
- Provide an understanding of transportation planning at a national, regional and local context
- Outline transport strategies, policies and smarter choices for increasing sustainability
- Present methods and approaches for analysing intermodal transport and sustainable transport interchanges
- Provide knowledge on planning and operations of intermodal transport systems
- Embed environmental impact in transportation planning



Outcomes

- Implement the basic concepts of transportation modelling, scenario development and forecasting
- Identify the challenges and elements for creating sustainable transport systems
- Account for sustainability indicators, implement indicators to different transport systems and compare scenarios with present transport systems
- Embed environmental impact and safety assessment approach of transport interchanges

Sustainable transport



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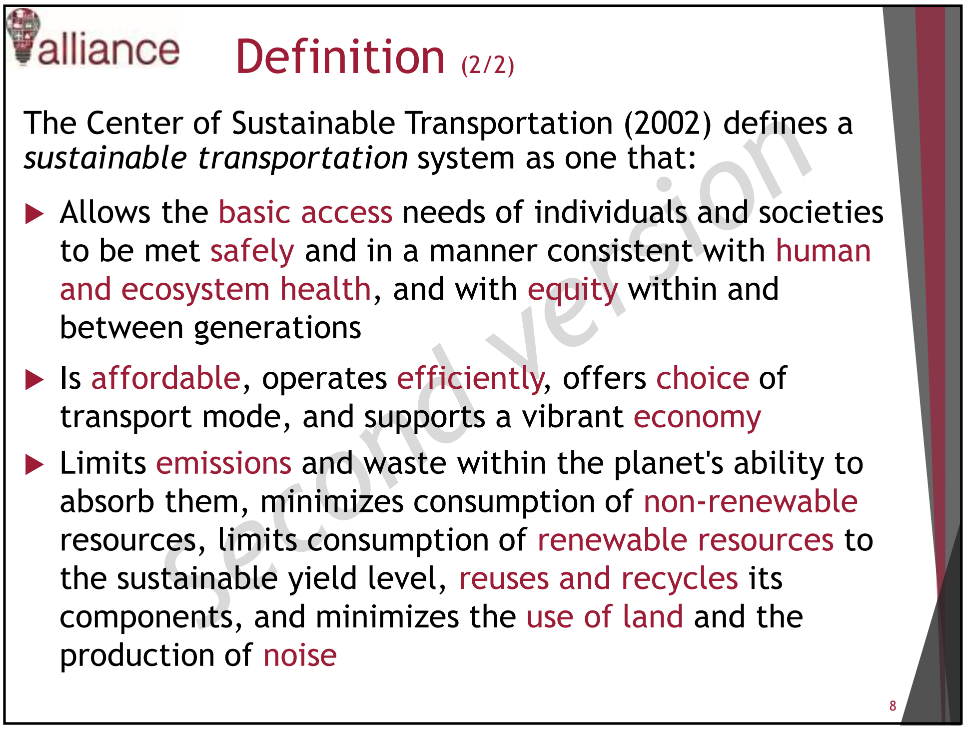
Definition (1/2)

"Sustainable transportation is about meeting or helping meet the mobility needs of the present without compromising the ability of the future generations to meet their needs."

(WCED, 1987)



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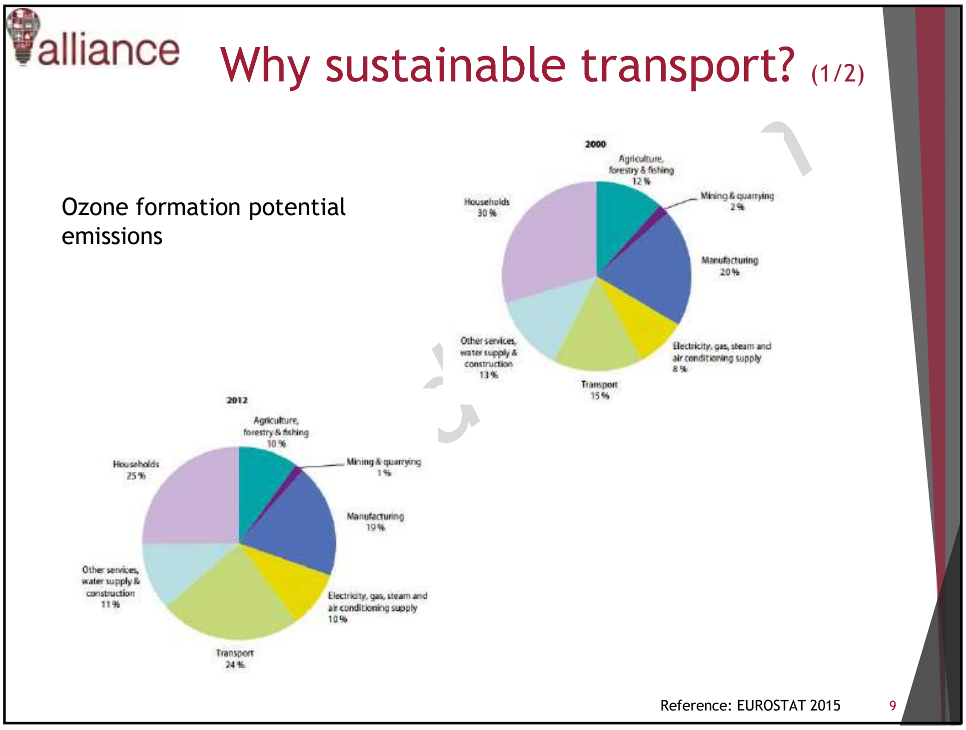
Definition (2/2)

The Center of Sustainable Transportation (2002) defines a *sustainable transportation* system as one that:

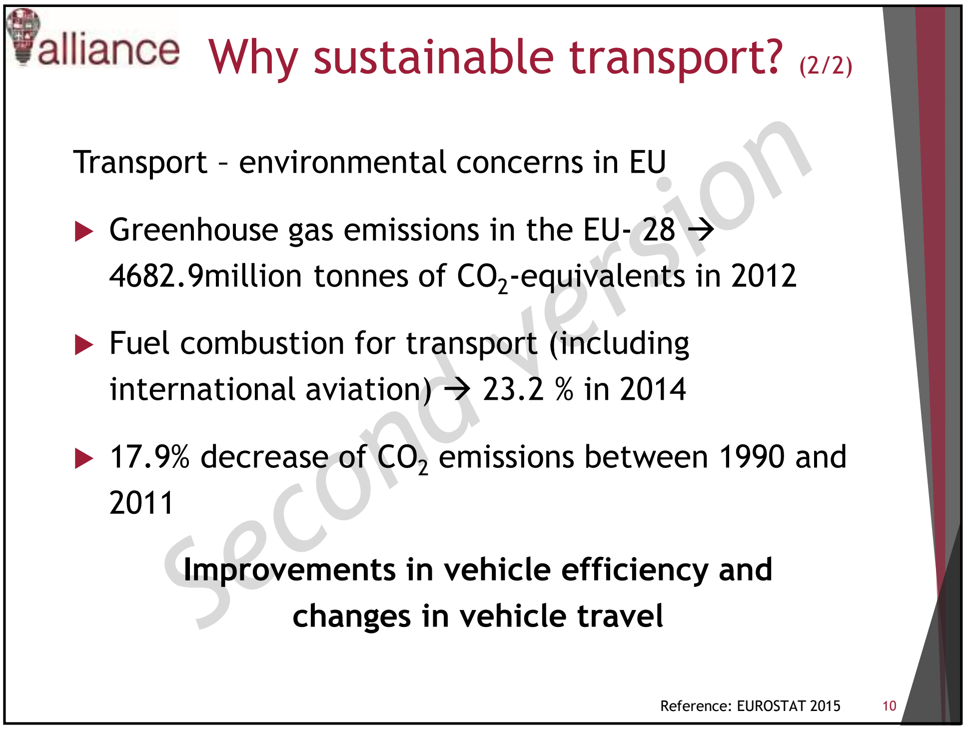
- Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise



Why sustainable transport? (1/2)

Ozone formation potential emissions

Reference: EUROSTAT 2015



Why sustainable transport? (2/2)

Transport – environmental concerns in EU

- Greenhouse gas emissions in the EU- 28 → 4682.9million tonnes of CO_2-equivalents in 2012
- Fuel combustion for transport (including international aviation) → 23.2 % in 2014
- 17.9% decrease of CO_2 emissions between 1990 and 2011

Improvements in vehicle efficiency and changes in vehicle travel

Reference: EUROSTAT 2015

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Smart solutions in sustainable transport planning

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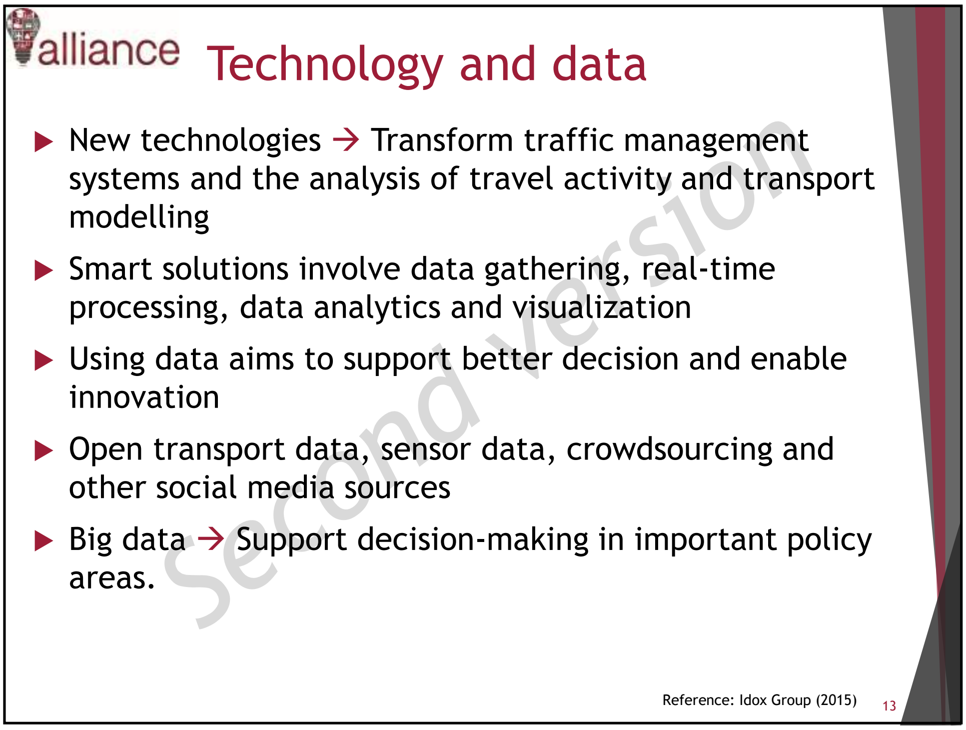
Smart transport

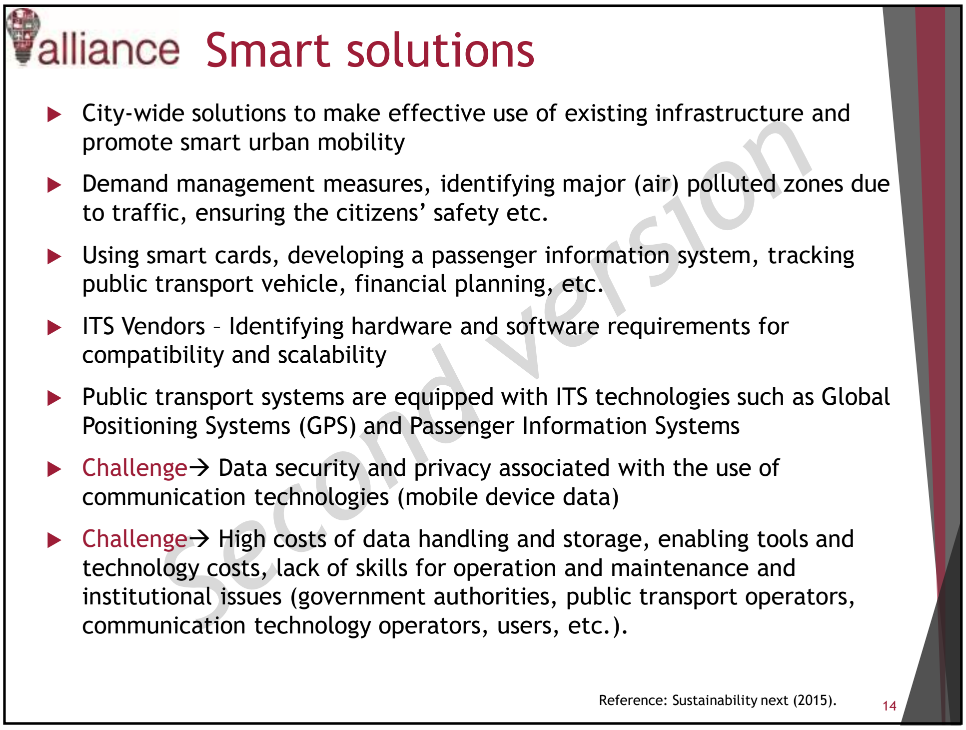
Smart transportation planning deals with the sustainable evaluation, assessment and design of movement of people and goods through transport networks.



Technology and data

- New technologies → Transform traffic management systems and the analysis of travel activity and transport modelling
- Smart solutions involve data gathering, real-time processing, data analytics and visualization
- Using data aims to support better decision and enable innovation
- Open transport data, sensor data, crowdsourcing and other social media sources
- Big data → Support decision-making in important policy areas.

Reference: Idox Group (2015)



Smart solutions

- City-wide solutions to make effective use of existing infrastructure and promote smart urban mobility
- Demand management measures, identifying major (air) polluted zones due to traffic, ensuring the citizens' safety etc.
- Using smart cards, developing a passenger information system, tracking public transport vehicle, financial planning, etc.
- ITS Vendors – Identifying hardware and software requirements for compatibility and scalability
- Public transport systems are equipped with ITS technologies such as Global Positioning Systems (GPS) and Passenger Information Systems
- Challenge→ Data security and privacy associated with the use of communication technologies (mobile device data)
- Challenge→ High costs of data handling and storage, enabling tools and technology costs, lack of skills for operation and maintenance and institutional issues (government authorities, public transport operators, communication technology operators, users, etc.).

Reference: Sustainability next (2015).

alliance Alternative fuels

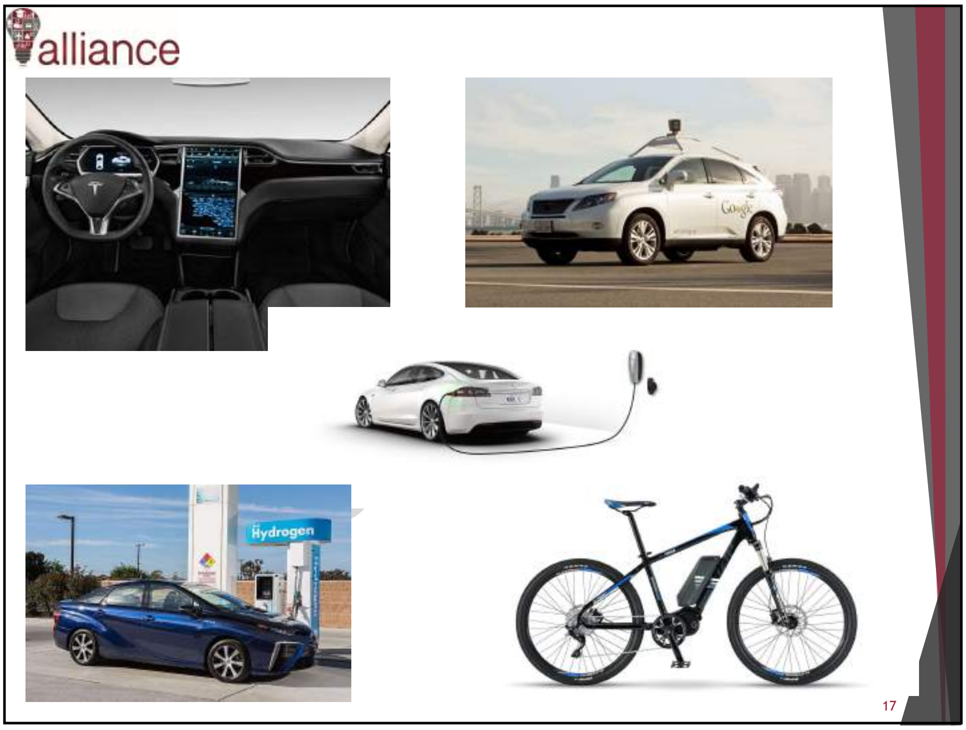
- Between 2010 and 2015, consumers purchased approximately 210,000 Battery Electric Vehicles and 190,000 plug-in hybrid electric vehicles (PHEVs) — small numbers compared to 226 million registered vehicles in the US
- In 2015, cars, motorcycles, trucks, and buses drove more than 3 trillion miles in US — farther than driving to the Sun and back 16,000 times
- Even if the typical electric vehicle range is small (ordinarily less than 100 miles on a fully charged battery), it would still be enough for more than 90% of all household vehicle trips in the US

Reference: National academies of sciences, engineering, medicine (2016)

alliance New modes

Hydrogen-powered tram - China

Top speed → 70 km/h and will be used in urban areas only.
Capacity → 380 passengers.



Sustainable urban development and mobility plan

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SUMP (2010-13)

GUIDELINES

DEVELOPING AND IMPLEMENTING A SUSTAINABLE URBAN MOBILITY PLAN

- Common understanding of Sustainable Urban Mobility Plans (SUMP)
- Seminars and workshops
- Guidelines on the process of *'Developing and Implementing a Sustainable Urban Mobility Plan'*
- Final version published 2013
- Referenced in DG MOVE's Urban Mobility Package of 2013

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Mobility plans portal

www.mobilityplans.eu

Mobility plans portal

A platform website to disseminate relevant information.

- Integrated in Eltis website
- Presenting SUMP background and concept
- Present key initiatives of EU-supported actions
- Mobility Plans database
- Access to information in Members States

Mobility plans portal

Platform on Sustainable Urban Mobility Plans

The Platform was established in response to the Commission's announcement in the Urban Mobility Package.

Mobility Plan case studies

10 Jul 2014

Engaging citizens in Bristol on visions of a low-carbon future (UK)

Mobility Plan tools & resources

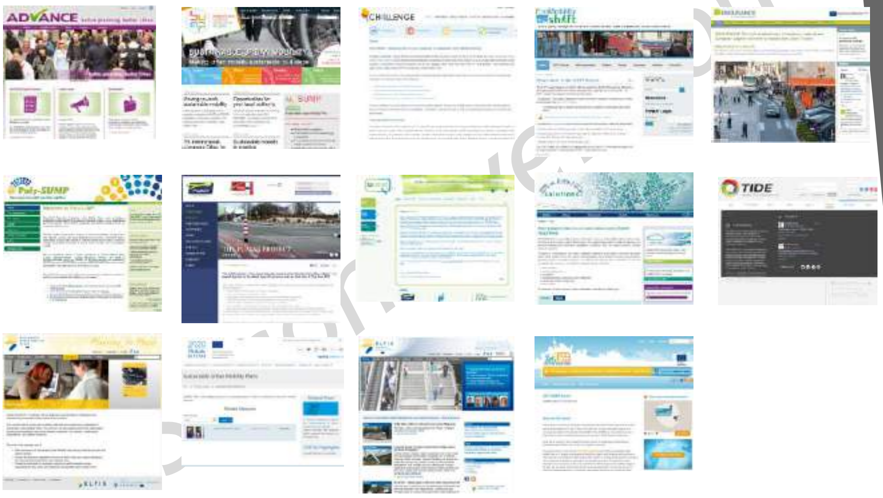
Policy development

TERM 2013: transport indicators tracking progress towards environmental targets in Europe

How can we help?

Get answers to your questions or simply share your suggestions.

SUMP related projects and initiatives



European platform on SUMP

Objectives

- Support the further development of the SUMP concept and of necessary tools
- Provide interested parties with a "one-stop shop"
- Realise synergies from coordination and cooperation across the different actions
- Increase the visibility for EU-supported actions on Sustainable Urban Mobility Plans.

European Platform
on Sustainable Urban
Mobility Plans

What is the scope?

- The policies and measures should address comprehensively all modes and forms of transport
- Sustainable Urban Mobility Plans builds on and expands existing plan documents

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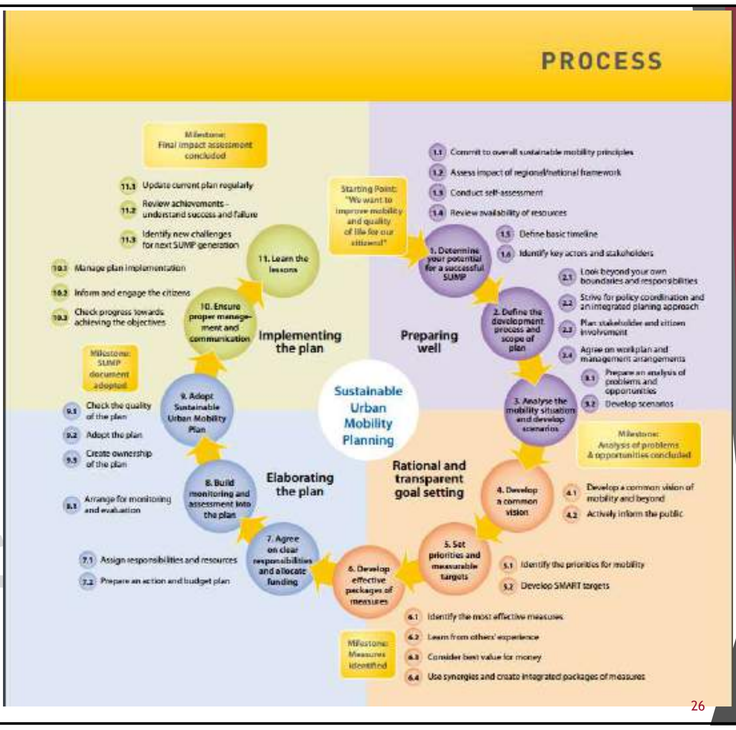
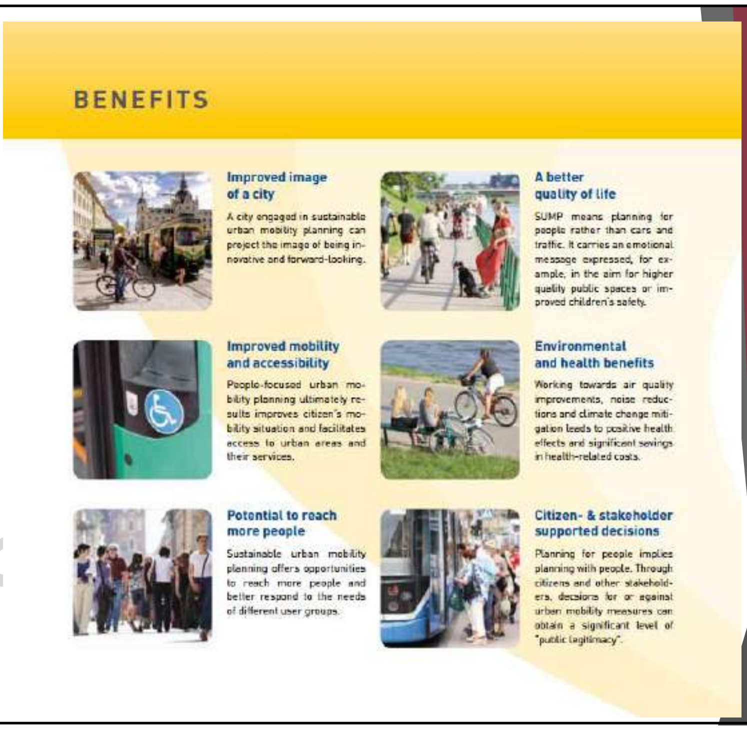




BENEFITS

Improved image of a city

A city engaged in sustainable urban mobility planning can project the image of being innovative and forward-looking.

A better quality of life

SUMP means planning for people rather than cars and traffic. It carries an emotional message expressed, for example, in the aim for higher quality public spaces or improved children's safety.

Improved mobility and accessibility

People-focused urban mobility planning ultimately results improves citizen's mobility situation and facilitates access to urban areas and their services.

Environmental and health benefits

Working towards air quality improvements, noise reductions and climate change mitigation leads to positive health effects and significant savings in health-related costs.

Potential to reach more people

Sustainable urban mobility planning offers opportunities to reach more people and better respond to the needs of different user groups.

Citizen- & stakeholder supported decisions

Planning for people implies planning with people. Through citizens and other stakeholders, decisions for or against urban mobility measures can obtain a significant level of "public legitimacy".

Transport planning principles

Background

- Planning → Process of deciding what to do and how to do it
- Planning at many levels → Community land use and transport planning
- Planners → Professionals who facilitate decision-making
- Planners → Support decision-makers (managers, public officials, citizens) by coordinating information and activities
- Role → Create a logical, systematic decision-making process that results in the best actions

Reference: VTPI (2013)

Planning principles

Good planning → Clearly defines the steps that lead to optimal solutions. Principles:

1. Comprehensive - all significant options and impacts are considered
2. Efficient – the process should not waste time or money
3. Inclusive - people affected by the plan have opportunities to be involved
4. Informative - results are understood by stakeholders (people affected by a decision)
5. Integrated - individual, short-term decisions should support strategic, long-term goals
6. Logical - each step leads to the next
7. Transparent - everybody involved understands how the process operates

Reference: VTPI (2013)

Planning framework

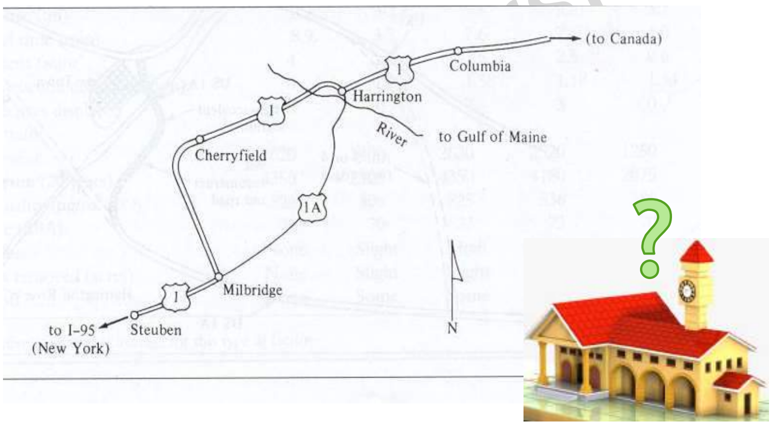
- **Principles** - A basic rule or concept used for decision-making
- **Vision** - A general description of the desired result of the planning process.
- **Problem** - An undesirable condition to be mitigated
- **Goals** - A general desirable condition to be achieved
- **Objectives** - Specific, potentially quantifiable ways to achieve goals
- **Targets or standards** - Quantitative levels of objectives to be achieved, such as a particular increase in income or reduction in crash rates
- **Performance indicators** - Practical ways to measure progress toward objectives
- **Plans** - A scheme or set of actions
- **Options** - Possible ways to achieve an objective or solutions to a problem
- **Policies or strategies** - A course of action implemented by a jurisdiction or organization
- **Programs** - A specific set of objectives, responsibilities and tasks within an organization
- **Tasks or actions** - A specific thing to be accomplished
- **Scope** - The range (area, people, time, activities, etc.) to be included in a process
- **Evaluation criteria** - The impacts (costs and benefits) considered in an analysis
- **Evaluation methodology** - The process of valuing and comparing options, such as cost effectiveness, benefit/cost, or lifecycle cost analysis

Reference: VTPI (2013)

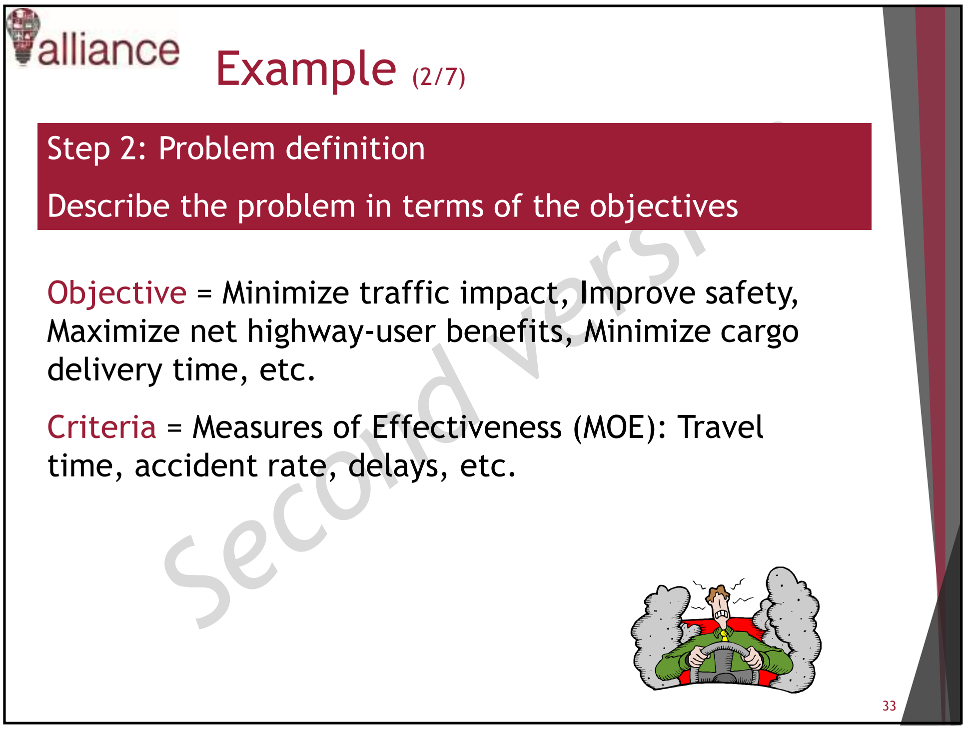
Example (1/7)

Step 1: Situation definition

Problem → Need to build a rail hub along a highway



Source: The Ira A. Fulton College of Engineering and Technology (2013)



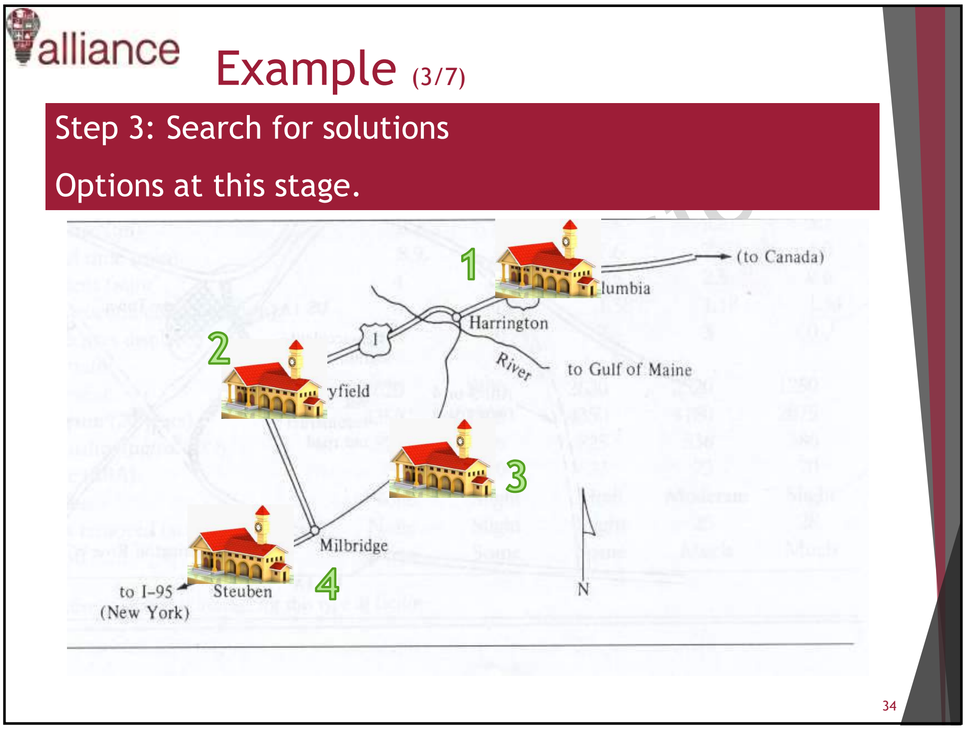
Example (2/7)

Step 2: Problem definition

Describe the problem in terms of the objectives

Objective = Minimize traffic impact, Improve safety, Maximize net highway-user benefits, Minimize cargo delivery time, etc.

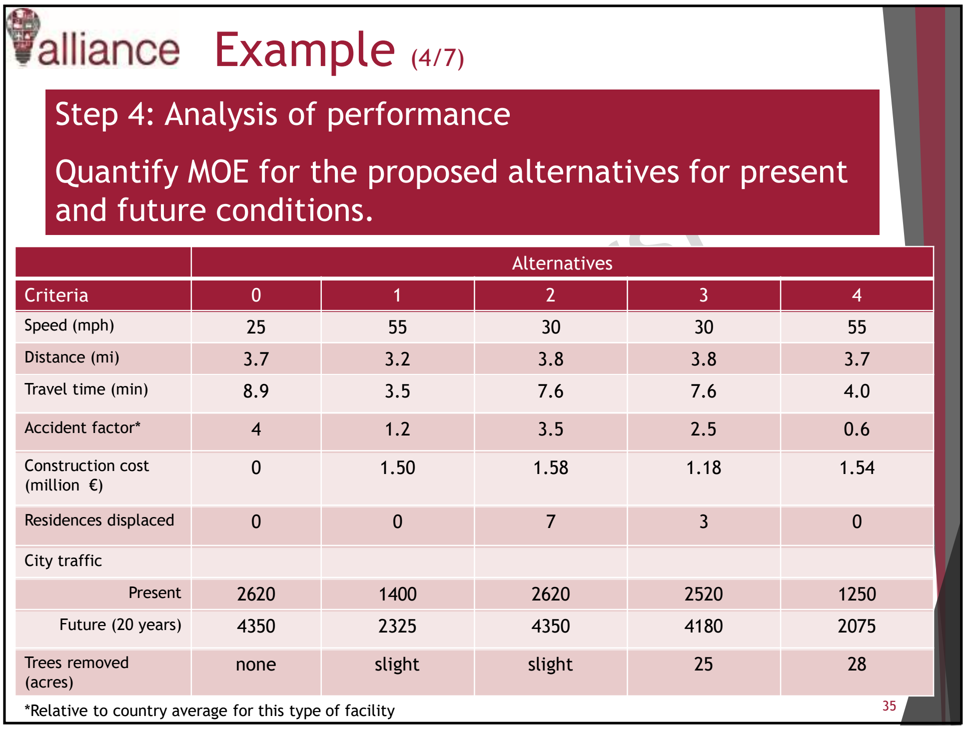
Criteria = Measures of Effectiveness (MOE): Travel time, accident rate, delays, etc.



Example (3/7)

Step 3: Search for solutions

Options at this stage.



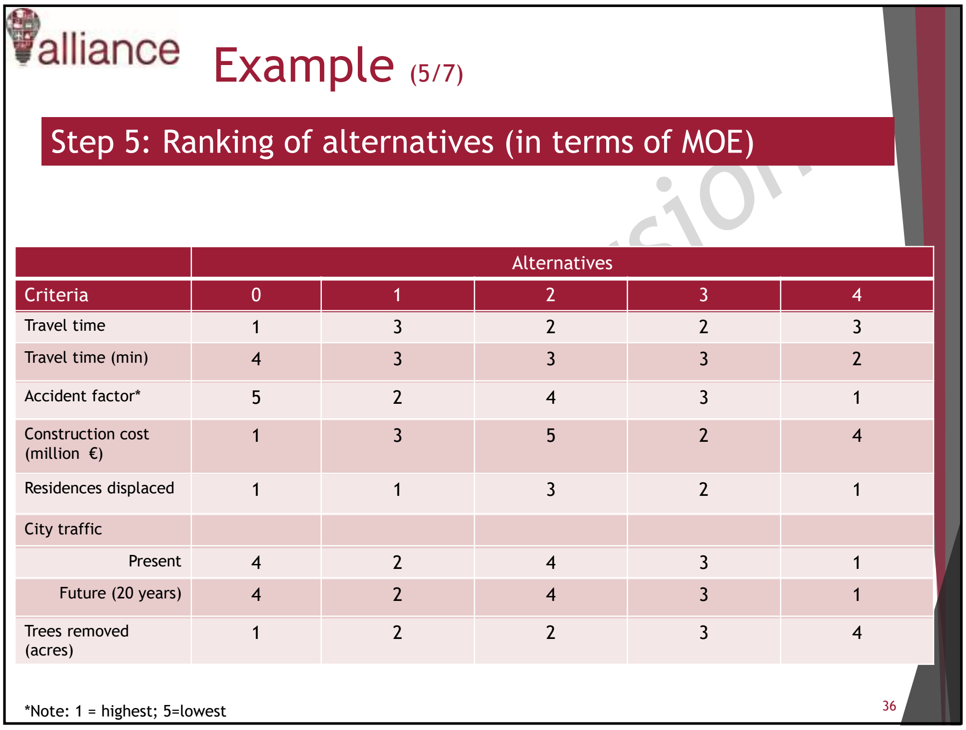
Example (4/7)

Step 4: Analysis of performance

Quantify MOE for the proposed alternatives for present and future conditions.

	Alternatives				
Criteria	0	1	2	3	4
Speed (mph)	25	55	30	30	55
Distance (mi)	3.7	3.2	3.8	3.8	3.7
Travel time (min)	8.9	3.5	7.6	7.6	4.0
Accident factor*	4	1.2	3.5	2.5	0.6
Construction cost (million €)	0	1.50	1.58	1.18	1.54
Residences displaced	0	0	7	3	0
City traffic					
Present	2620	1400	2620	2520	1250
Future (20 years)	4350	2325	4350	4180	2075
Trees removed (acres)	none	slight	slight	25	28

*Relative to country average for this type of facility

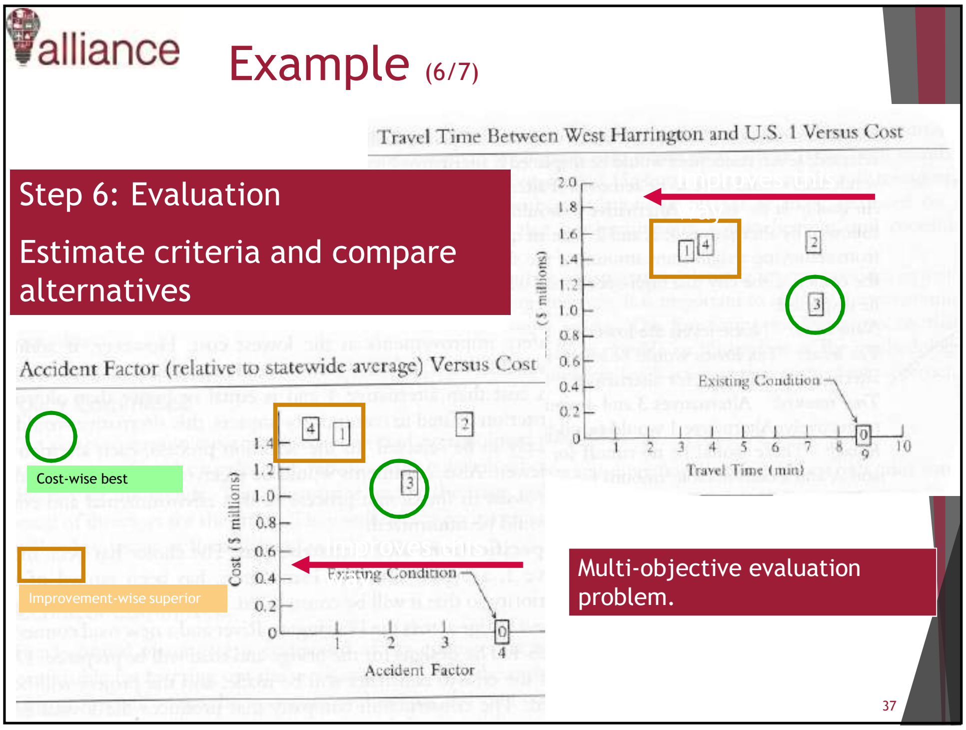


Example (5/7)

Step 5: Ranking of alternatives (in terms of MOE)

	Alternatives				
Criteria	0	1	2	3	4
Travel time	1	3	2	2	3
Travel time (min)	4	3	3	3	2
Accident factor*	5	2	4	3	1
Construction cost (million €)	1	3	5	2	4
Residences displaced	1	1	3	2	1
City traffic					
Present	4	2	4	3	1
Future (20 years)	4	2	4	3	1
Trees removed (acres)	1	2	2	3	4

*Note: 1 = highest; 5=lowest



Example (6/7)

Step 6: Evaluation

Estimate criteria and compare alternatives

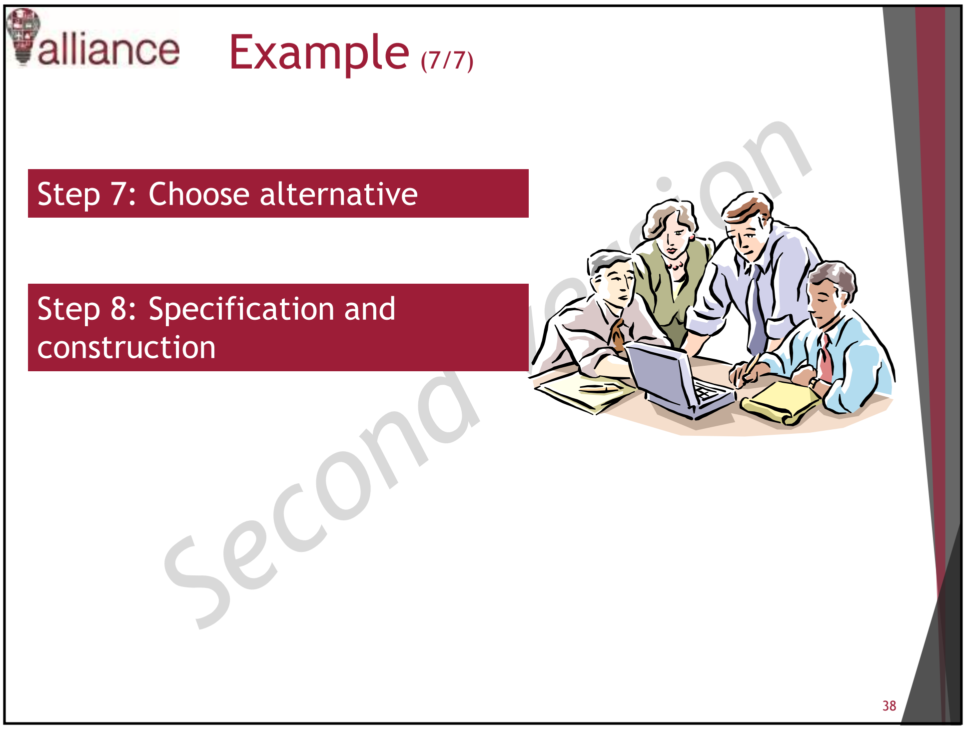
Travel Time Between West Harrington and U.S. 1 Versus Cost

Accident Factor (relative to statewide average) Versus Cost

🟩 Cost-wise best

▭ Improvement-wise superior

Multi-objective evaluation problem.



Example (7/7)

Step 7: Choose alternative

Step 8: Specification and construction

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Transportation planning models

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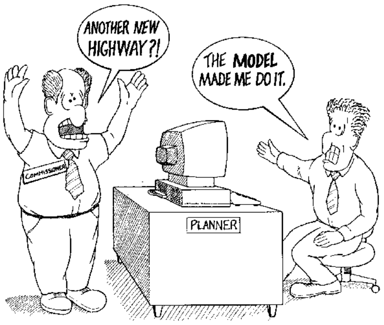
Model

- Represent human behavior making decisions → choices
- Assumptions + data ➔ models

A model is defined as a simplified representation of a part of the real world-the system of interest-which concentrates on certain elements considered important for its analysis from a particular point of view (Ortuzar and Willumsen, pp.2, 2011)



Reference: Beimborn, E Kennedy, R. (1996)

Forecasting models

- Population → Birth/death rates, rate of migration
- Economic forecasts → Employment levels
- Land use → Where people will live, work, shop and go to school

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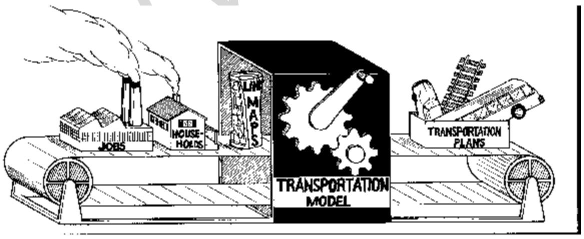
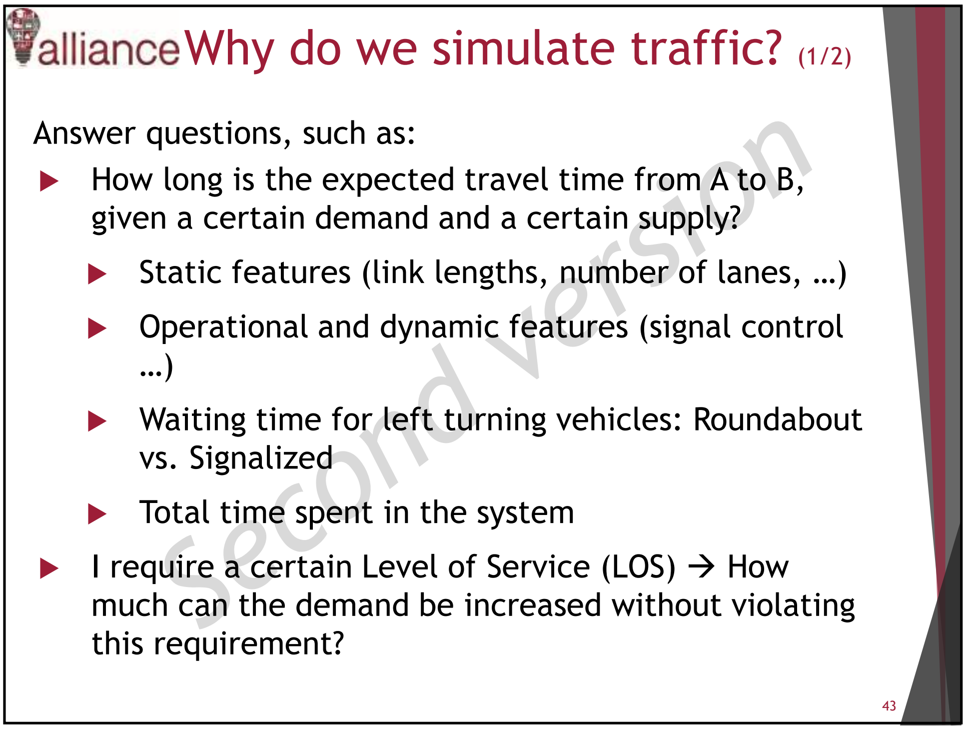
Transportation planning

Series of mathematical equations to represent how – where – when to travel



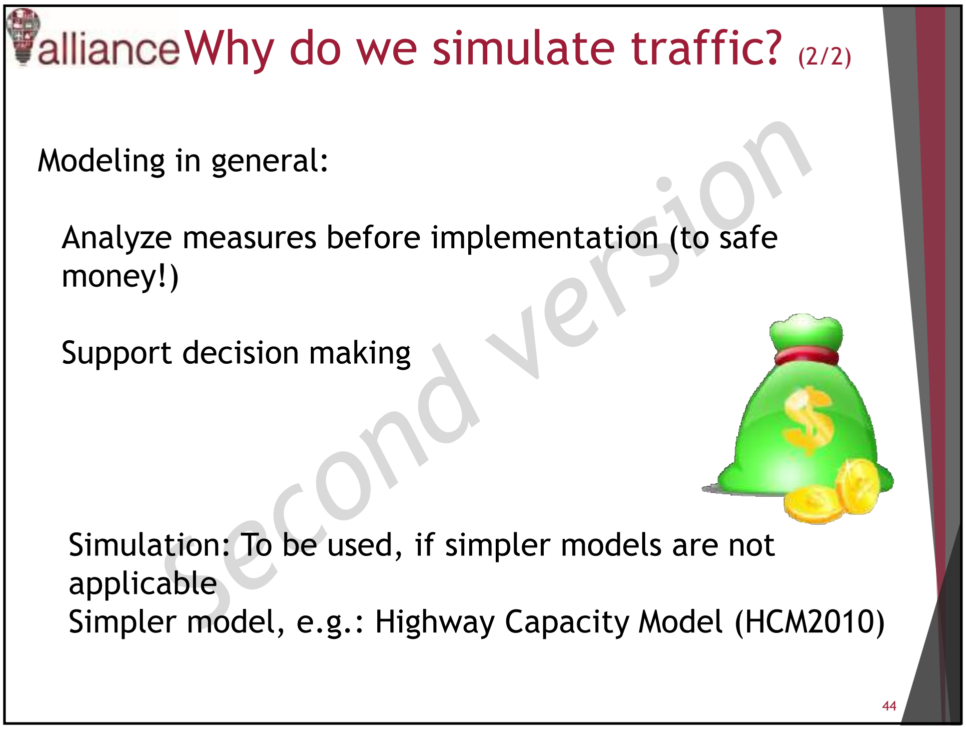
Reference: Beimborn, E Kennedy, R. (1996)



Why do we simulate traffic? (1/2)

Answer questions, such as:

- How long is the expected travel time from A to B, given a certain demand and a certain supply?
  - Static features (link lengths, number of lanes, …)
  - Operational and dynamic features (signal control …)
  - Waiting time for left turning vehicles: Roundabout vs. Signalized
  - Total time spent in the system
- I require a certain Level of Service (LOS) → How much can the demand be increased without violating this requirement?



Why do we simulate traffic? (2/2)

Modeling in general:

Analyze measures before implementation (to safe money!)

Support decision making

Simulation: To be used, if simpler models are not applicable

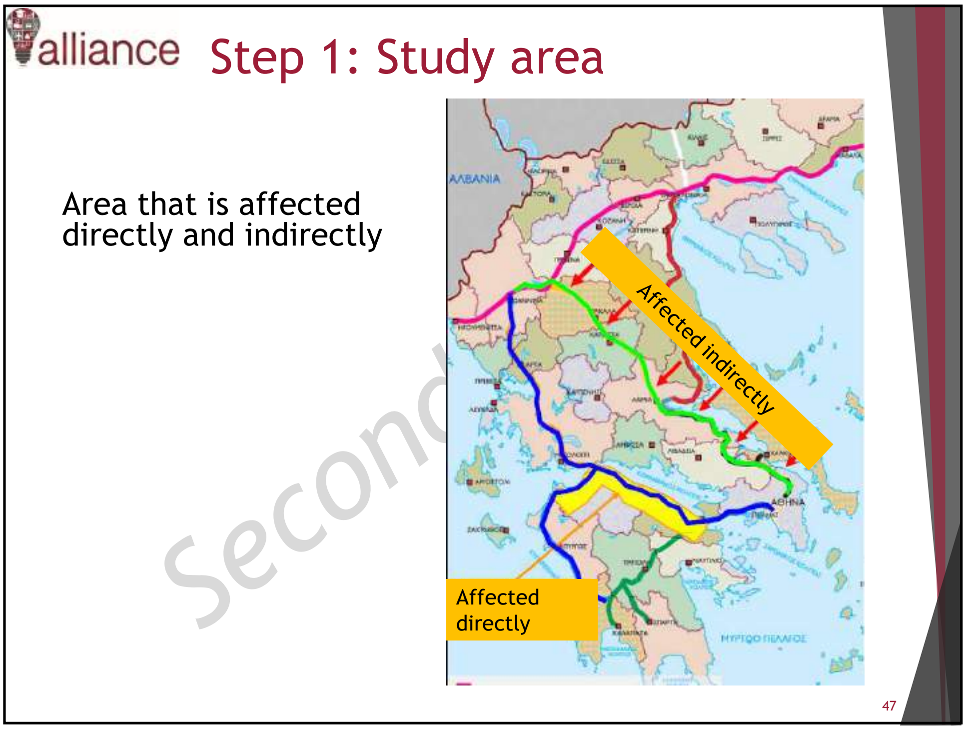
Simpler model, e.g.: Highway Capacity Model (HCM2010)

Developing transport models

1. Set Traffic Analysis Zones (TAZ) and convert roads and traffic zones into a set of nodes and links
2. Data collection
3. Develop mathematical model
4. Calibrate and validate model
5. Define variables
6. Apply model
7. Evaluate model

Step 1: Study area

- Study area is the area that is affected by project under study
- Strategic planning should include major origin destination points
- In smaller areas traffic changes should be captured by the transport model

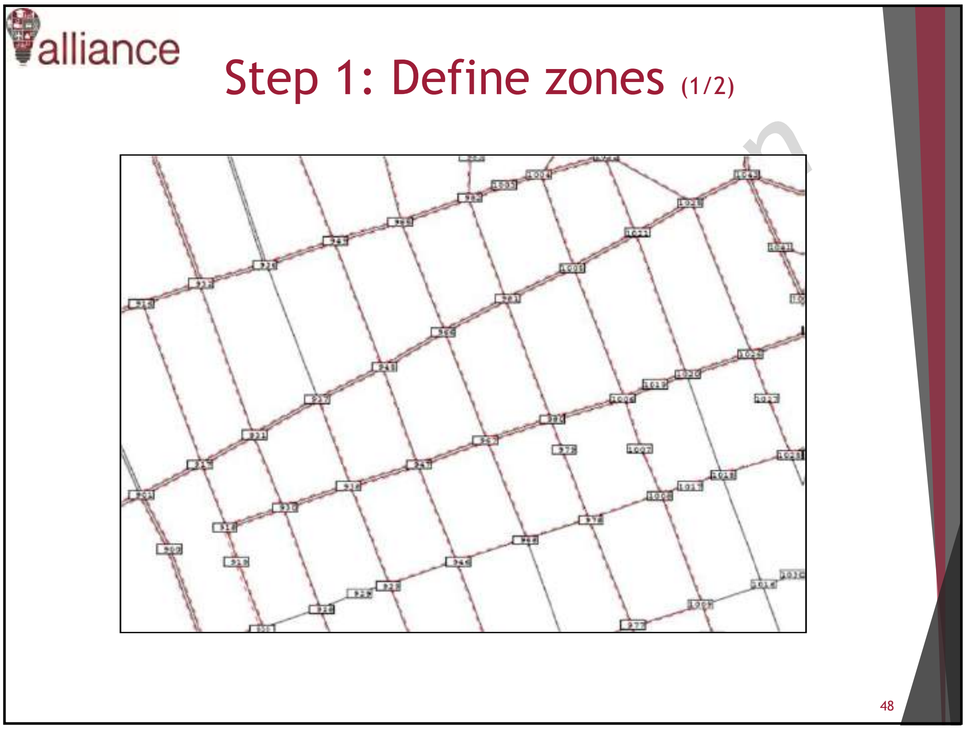


Step 1: Study area

Area that is affected directly and indirectly

Affected indirectly

Affected directly



Step 1: Define zones (1/2)

Step 1: Define zones (2/2)

Define Traffic Analysis Zone:

- Traffic Analysis Zone (TAZ) is a number of households with uniform characteristics that can be represented as one unit

Centroid:

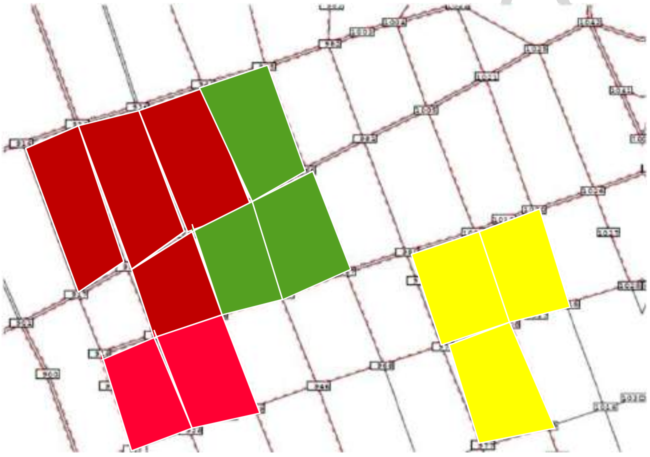
- A virtual center of the TAZ where all the activity is concentrated

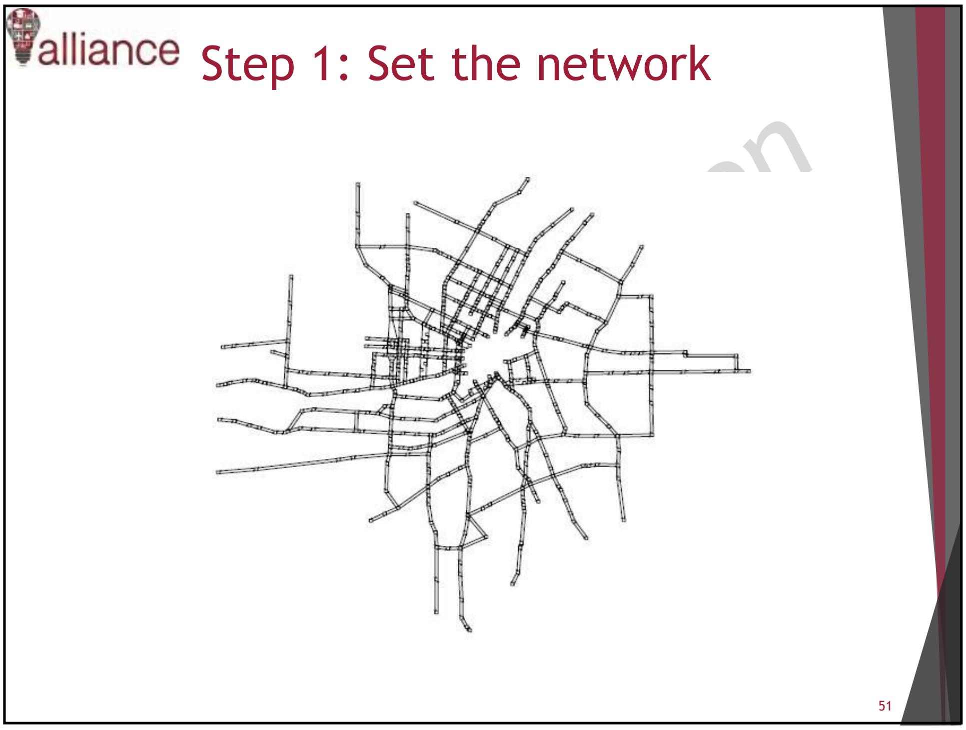
Criteria for defining TAZ:

- Compatibility with local administrative divisions
- Uniformity of population mix and land uses
- Compatibility with traffic lines
- Simplicity of TAZ shape for defining centroids
- Compatibility of travel times between TAZs.

Step 1: Zone characteristics

Consider socioeconomic characteristics of zones





Step 1: Set the network

Step 2: Data collection (1/2)

- The reliability of the transport model and forecasts depends on the quality of data for the system under various conditions
- Sources: Observation (e.g. traffic volume counts, passengers, transit), national statistics (population, households, consumption), mobility research, travel diary, etc.
- Land use, development trends, environmental factors, financial resources
- Explore travel behavior – Trip generation and mode choice
- Research stated preference

Step 2: Data collection (2/2)

- Network layout (e.g. OS mapping, aerial photography)
- Familiarity with site operation and driver behavior
- Traffic flows and turning proportions
- Traffic flow compositions (i.e. according to vehicle classifications)
- Bus frequencies
- Bus stop locations
- Bus stop dwell times
- Signal timings and controller logic
- Saturation flows; Vehicle journey times
- Queue lengths
- Mandatory speed limits
- Parking and loading.
- Depending on the purpose of the model: Origin-destination surveys; Speed and acceleration profiles; Bus boarding and alighting survey; Pedestrian flows; and Bus occupancy survey.

Step 3: Traffic models

Define model

i. Model structure
    - Deterministic, static
    - Stochastic, dynamic

ii. Define function of model
    - Linear
    - Non-linear

iii. Identify variables and their form

Example: Stochastic model choose route

	Perceived time		Time
	Driver 1	Driver 2	
Route 1	25	20	21
Route 2	20	25	22
Route 3	25	25	23

Perceived time ≠ True time
Deterministic model → Both drivers choose route 1
But driver 1 perceives route 2 as the fastest

Static model $Y = f(x, \theta)$

- ✓ Y: Forecasted choices
- ✓ θ: parameters determined during calibration process.

Dynamic model $Y(t) = f(Y(t-1), X(t), \theta)$

- ✓ X: variables of transport system (socioeconomic characteristics of travelers and operational characteristics of the transport system)

Step 3: The 4-step model

1. **Trip Generation**

   Estimates the number of trips from given origins and destinations

2. **Trip Distribution**

   Determines the destination for each trip from a given origin

3. **Modal Split**

   Determines the mode choice for each trip

4. **Route Assignment**

   Determines the specific route for each trip

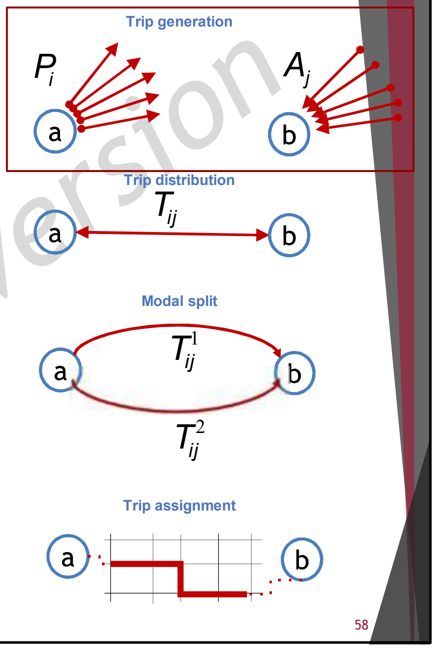
Limitations of 4-step model

- Zones are too large aggregates
- Does not incorporate the reason for traveling - the activity at the end of the trip
- Main motivation is the purpose as an activity location (places for leisure, work, shopping)
- Trips are treated as if they were independent and ignores their spatial, temporal, and social interactions
- Emphasis on commuting trips and home-based trips
- Limited ability to incorporate environment and behavioral context
- Not a dynamic framework of travel behavior

Trip generation (1/2)

Estimate trips which are generated and attracted per zone

- Home based work trips
- Home based shopping trips
- School trips
- Non-home based trips



Trip generation (2/2)

- Trip generation as based on household characteristics of the zones
- Cross classification table

Number of trips by household classifications or grouping

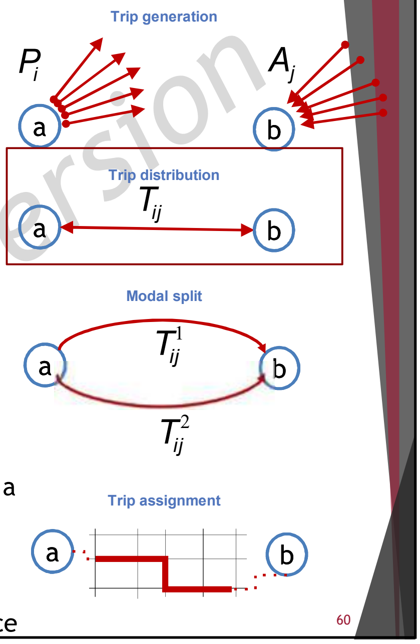
	Number of vehicles owned			
Household size	0	1	2	3+
1	1.487	2.811	3.866	4.417
2	3.038	4.363	5.417	5.969
3	4.515	5.840	6.894	7.446
4	6.584	7.909	8.963	9.515
5	8.205	9.530	10.584	11.136
6+	10.180	11.504	12.559	13.110

- Combinations of trips are ignored

Trip distribution (1/2)

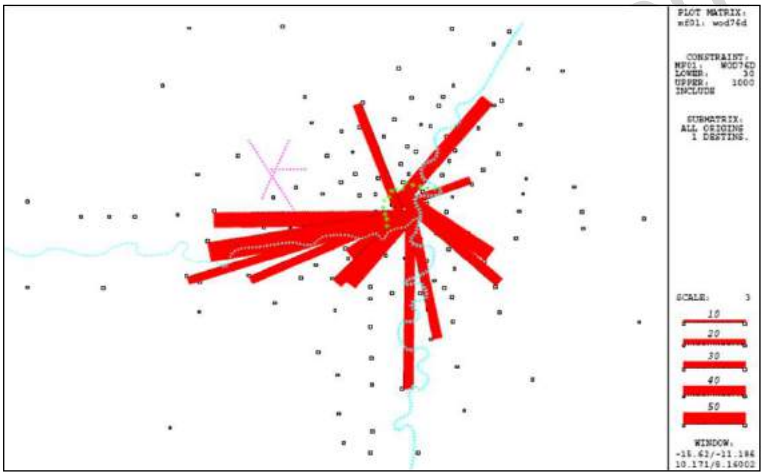
- Trip distribution links the trip ends to form an origin-destination pattern
- Most used procedure → Gravity model

$$T_{ij} = T_i \frac{A_j / C_{ij}^{a}}{Sum\left(A_x / C_{ix}^{a}\right)}$$



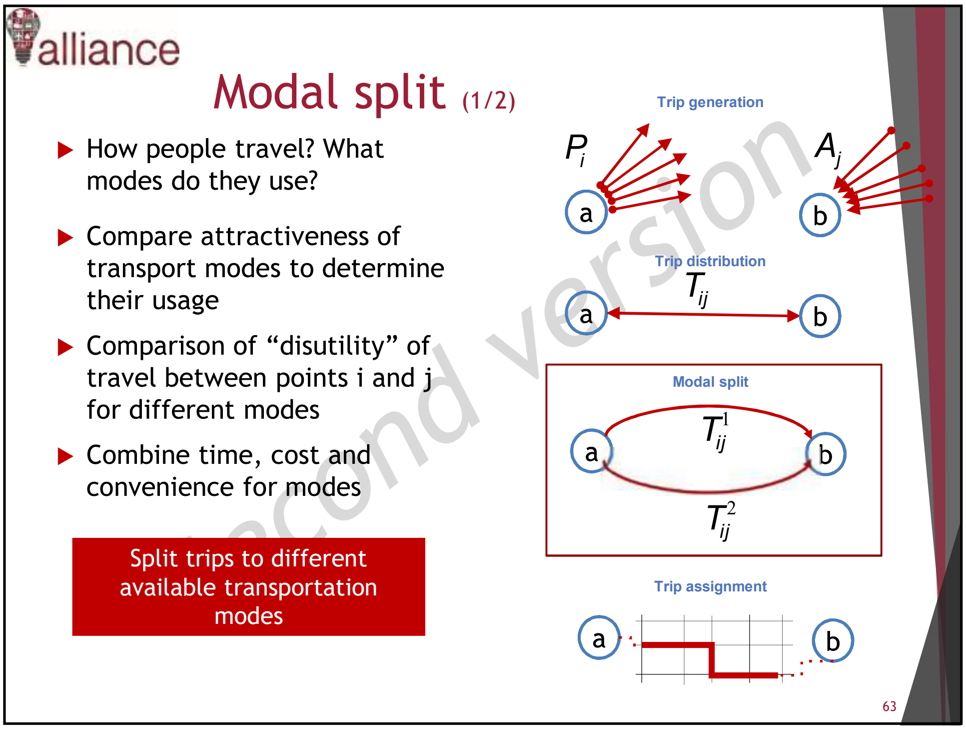
- T_{ij} = trips from zone i to zone j
- T_i = total trips originating at zone i
- A_j = attraction factor at j
- A_x = attraction factor at any zone x
- C_{ij} = travel friction from i to j expressed as a generalized cost function
- C_{ix} = travel friction from i to any zone x expressed as a generalized cost function
- a = friction exponent or restraining influence

Trip distribution (2/2)



O - D Matrix Example

				Destinations			
Origins	1	2	3	4	5	6	Sum
1	T_{11}	T_{12}	T_{13}	T_{14}	T_{15}	T_{16}	O_1
2	T_{21}	T_{22}	T_{23}	T_{24}	T_{25}	T_{26}	O_2
3	T_{31}	T_{32}	T_{33}	T_{34}	T_{35}	T_{36}	O_3
4	T_{41}	T_{42}	T_{43}	T_{44}	T_{45}	T_{46}	O_4
5	T_{51}	T_{52}	T_{53}	T_{54}	T_{55}	T_{56}	O_5
6	T_{61}	T_{62}	T_{63}	T_{64}	T_{65}	T_{66}	O_6
Sum	D_1	D_2	D_3	D_4	D_5	D_6	



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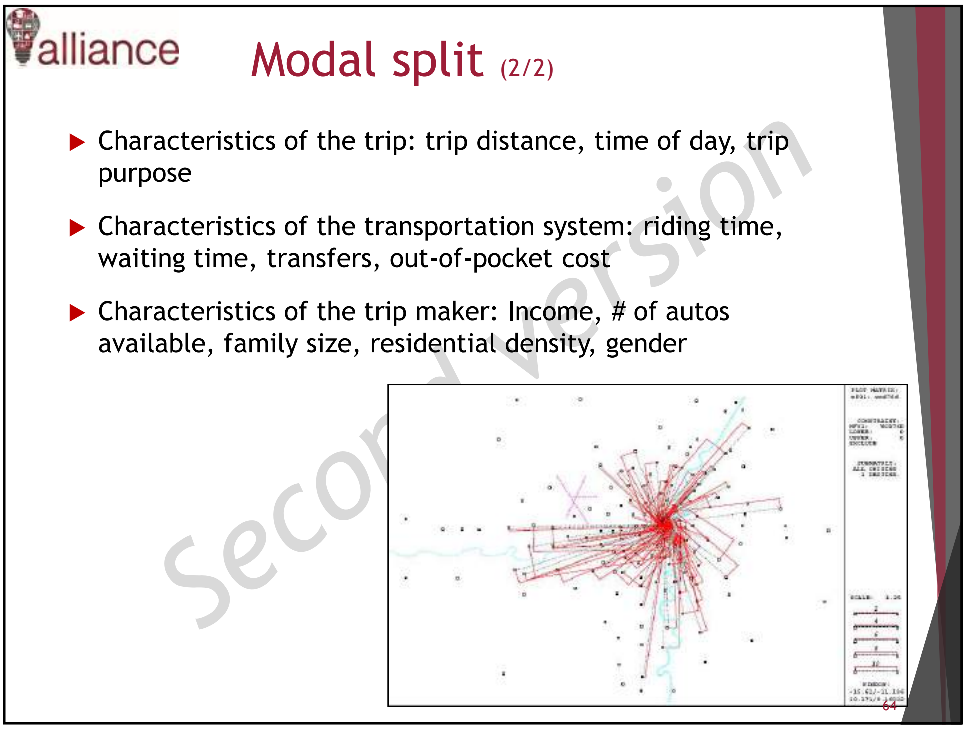
Modal split (1/2)

- How people travel? What modes do they use?
- Compare attractiveness of transport modes to determine their usage
- Comparison of “disutility” of travel between points i and j for different modes
- Combine time, cost and convenience for modes

Split trips to different available transportation modes



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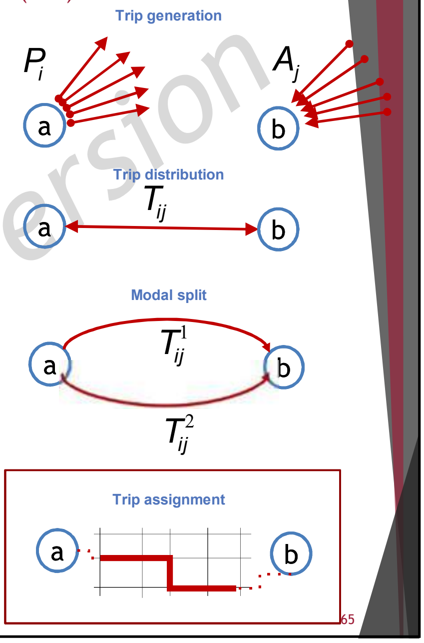
Modal split (2/2)

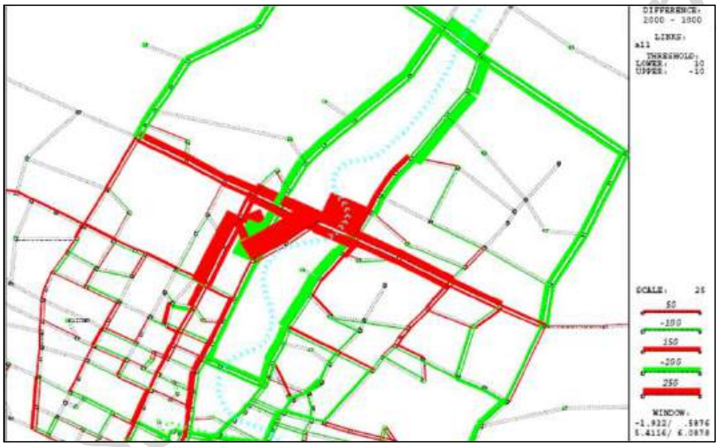
- Characteristics of the trip: trip distance, time of day, trip purpose
- Characteristics of the transportation system: riding time, waiting time, transfers, out-of-pocket cost
- Characteristics of the trip maker: Income, # of autos available, family size, residential density, gender

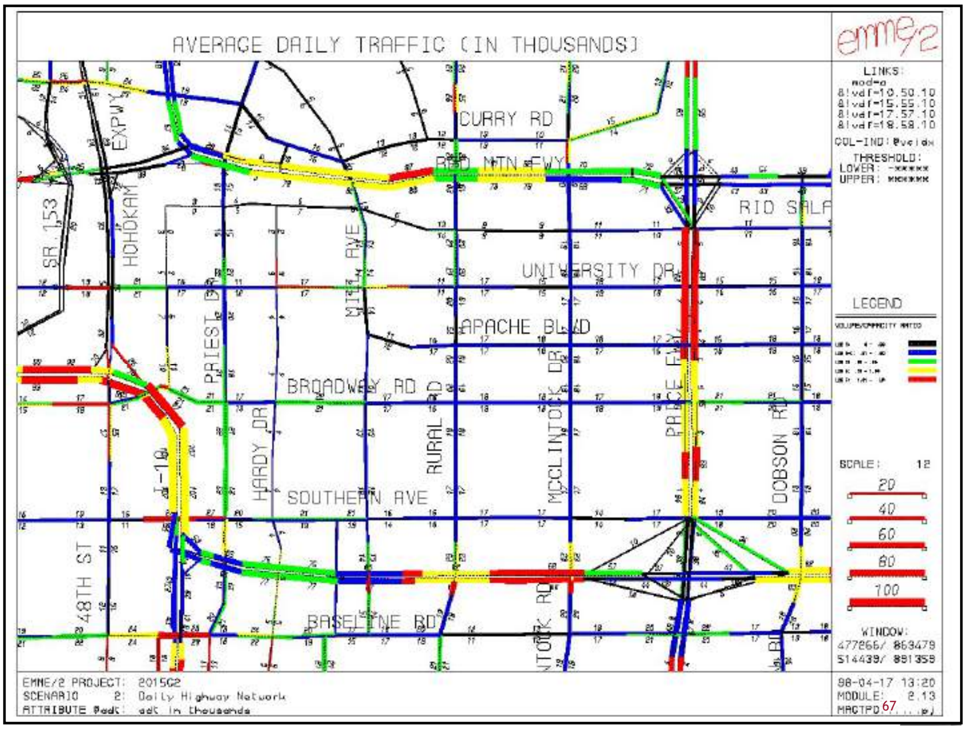
Trip assignment (1/2)

- How do people use the transport system?
  - Given a mode, which route do they choose?
  - Do they satisfy multiple activities in one tour?
  - Which parts of the transport system do they use?
  - How do they react to varying transport service quality?



Trip assignment (2/2)





Step 4: Model calibration and validation

- Model calibration is defined as the process by which the model user establishes input parameter values in order to reflect the local traffic conditions being modelled
- Optimum calibration values are these that provide results close to real traffic conditions
- Following calibration, the model is validated and verified where it is checked if the model logic proposed by the model developer, is correctly represented by the computer code. Data used here differs from data used in calibration

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Step 5: Define variables

- Apply model to different future scenarios
- Forecast variables → Requires socioeconomic forecast for the area under interest (population, jobs, income, land use, economic, commercial and social activities etc.)

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Step 6: Apply model

- Use forecasted values as input to the model to estimate future O-D matrix
- Use future O-D matrix to estimate future volumes and level of service

Step 7: Evaluate model

- Evaluate cost and benefits for each scenario
- Scenario results are evaluated against initial objectives
- Evaluation process for each scenario provides:
  - Development plan for transport system
  - Formulation of transport policy
  - Investment plan for transport
    - ✓ Satisfy transport demand in the area of study
    - ✓ Satisfy objectives while overcome potential restrictions and maximize benefits

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...and other models

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Activity based models (1/4)

- Trip based model → 4 step model
- Activity based model → Replicate actual traveler decisions and thus may provide better forecasts of future travel patterns
- Similarities (Trip vs Activity Models)
  - Activities are generated
  - Destinations for the activities are identified
  - Travel modes are determined
  - Specific network facilities or routes used for each trip are predicted

Reference: Activity-Based Travel Demand Models, a primer (2015)

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Activity based models (2/4)

Advances over 4-step trip models

- Explicit representation of realistic constraints of time and space
- Linkages among activities and travel for an individual person as well as across multiple persons in a household

↓

Work at a disaggregate person-level

↓

Enable more realistically representation of the effect of travel conditions on activity and travel choices

Reference: Activity-Based Travel Demand Models, a primer (2015)

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Activity based models (3/4)

Conventional 4-Step Model-Mode Choice	Activity/Tour-Based/Simulation-Mode Choice
For each market segment, defined by trip purpose and household demographic group, predict the probability of each mode for each O-D pair.	Predict probability of each simulated chooser selecting each mode for a specific O-D pair and purpose.
Allocate the number of trips for each market segment and O-D pair to modes in proportion to their predicted probabilities.	Use Monte Carlo random draws to predict a single mode choice.
Sum over market segments to form trip tables.	Sum over choosers and purposes, grouped by O-D pair, to form trip tables for network assignment.

Activity-based models are based on behavioral theories about how people make decisions about activity participation in the presence of constraints, including decisions about where to participate in activities, when to participate in activities, and how to get to these activities.

Reference: Activity-Based Travel Demand Models, a primer (2015)

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Activity based models (4/6)

Activity-based models are travel demand models.

Activity-based models forecast the demand for travel for regional residents:

- the purpose and number of activities to participate in
- the amount and type of travel required to fulfill these activities
- the destinations of these activities
- the mode of travel used to access activity locations
- the timing of this travel.

Reference: Activity-Based Travel Demand Models, a primer (2015)

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Activity based models (5/6)

- The central focus of the models is whether, when, and where to participate in activities and for how long.
- Disaggregate estimates of demand are predicted first
- These estimates are aggregated by geography, time of day, and market segment for input in the network assignment model.
- Actually model the trips within an activity-based modeling system as separate entities that allow persons to travel between activity locations.

Reference: Activity-Based Travel Demand Models, a primer (2015)

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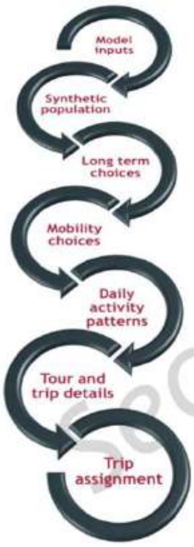
Activity based models (6/6)



- Model the schedule of activities and travel
- Allowing for the possibility of in-home substitutions and trade-offs → Telecommuting from home, at-home leisure, eating, and other activities. This is important for modeling future scenarios in which gasoline prices are higher
- Consider:
  - the expected amounts of time that individuals will spend in each activity
  - how they prioritize their time between work or school, and shopping and recreational activities
  - and how much time they are willing to devote to travel.

Development considerations (1/2)

- Data
  - The same household surveys used to develop trip-based models; however for activity-based model all the survey data should be consistent internally across all the individuals in each household.
  - Development of “synthetic population” → Represents a region’s travelers and their detailed attributes
  - Often include networks with more time-period-specific information
- Staff and consultant requirements
  - More experienced staff → Good understanding of the activity-based modeling process and its statistical modeling methods

Reference: Activity-Based Travel Demand Models, a primer (2015)

Development considerations (2/2)

- Costs and schedule
  - Approximately the same as traditional trip based model development efforts
- Model run times
  - Dependent primarily on the size of the population of the region being simulated, the number of zones and time periods for which the network supply models are run, and the amount of computing resources available
  - The network model run times increase with the square of the number of zones,
- Stakeholder acceptance
  - Depend on clear communication of the purposes and structure of the model,

Reference: Activity-Based Travel Demand Models, a primer (2015)

Intermodal models (1/3)

- Intermodal transportation is the shipment of cargo and the movement of people involving more than one mode of transport during a single seamless journey.
- Cars
- Buses
- Trains
- Bikes
- Motorbikes
- Boars
- Other transport modes

Reference: Graham D.W., Cassady C.R., Bowden R.O., LeMay S.A. (1999).

Intermodal models (2/3)

4-step model → Multimodal

- Demand across multiple modes
  - Before mode split stage → All modes
  - After mode split stage → Each mode
- Unimodal models →Don't follow the 4-stage model
- Focus on demand for a specific transport mode

Reference: Graham D.W., Cassady C.R., Bowden R.O., LeMay S.A. (1999).

Intermodal models (3/3)

Intermodal transportation emphasizes facilities over networks

Freight

- Ship terminal models
- Dockside container intermodal terminal
- Linear programming model of intermodal container terminal
- Probabilistic model of a port intermodal terminal
- Bulk cargo port

Passenger

- Intermodal train terminal with personal vehicle, taxi, regional and local bus, courtesy vehicle, rail rapid transit, commuter rail and high speed rail
- Airport passenger terminal

Reference: Graham D.W., Cassady C.R., Bowden R.O., LeMay S.A. (1999).

Transport impacts

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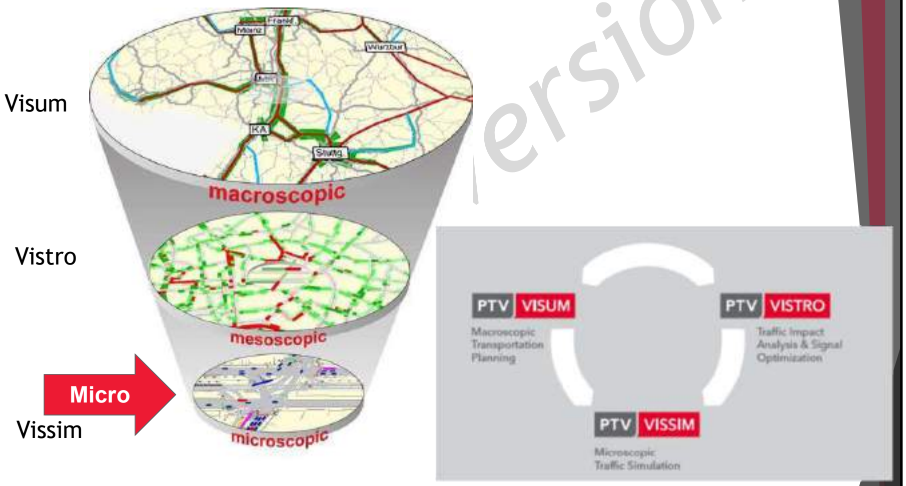
Modeling Levels



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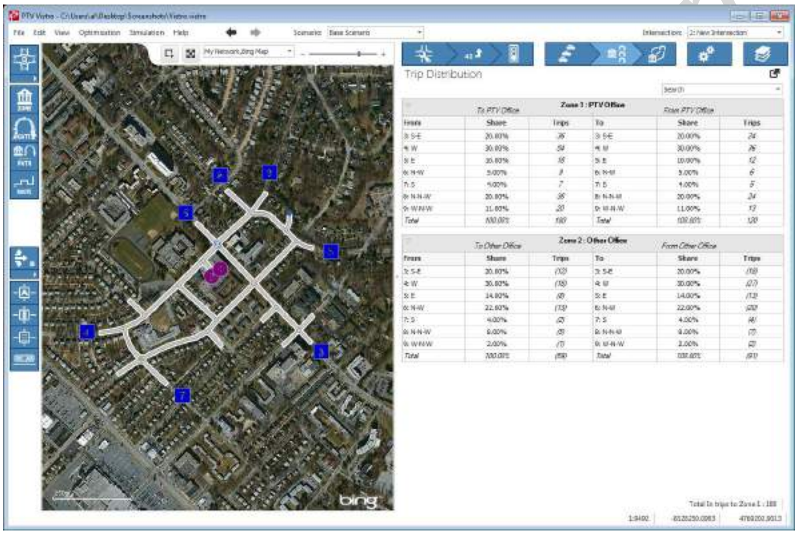
Macroscopic models

- Consider transportation network attributes such as capacity, speed limit, flow and density
- Simulate large scale facilities (highways, regions etc.)
- No need to track individual vehicles (aggregate theory)
- No detailed information about road design and signal plans are required
- CUBE, TRIPS and VISUM, TransModeler

Reference: Papaioannou et al. (2009)

Mesoscopic – Vistro (1/2)

Traffic Impact Analysis



Zone 1 : PTV Office					
To PTV Office			*From PTV Office*		
From	Share	Trips	To	Share	Trips
3: S-E	20.00%	*36*	3: S-E	20.00%	*24*
4: W	30.00%	*54*	4: W	30.00%	*36*
5: E	10.00%	*18*	5: E	10.00%	*12*
6: N-W	5.00%	*9*	6: N-W	5.00%	*6*
7: S	4.00%	*7*	7: S	4.00%	*5*
8: N-N-W	20.00%	*36*	8: N-N-W	20.00%	*24*
9: W-N-W	11.00%	*20*	9: W-N-W	11.00%	*13*
Total	*100.00%*	*180*	*Total*	*100.00%*	*120*

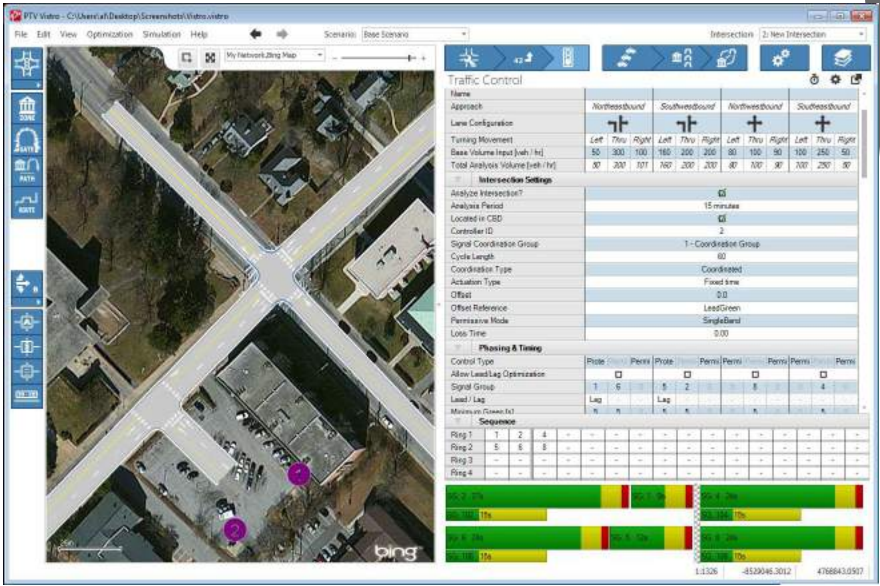
Zone 2 : Other Office					
To Other Office			*From Other Office*		
From	Share	Trips	To	Share	Trips
3: S-E	20.00%	*(12)*	3: S-E	20.00%	*(18)*
4: W	30.00%	*(18)*	4: W	30.00%	*(27)*
5: E	14.00%	*(8)*	5: E	14.00%	*(13)*
6: N-W	22.00%	*(13)*	6: N-W	22.00%	*(20)*
7: S	4.00%	*(2)*	7: S	4.00%	*(4)*
8: N-N-W	8.00%	*(5)*	8: N-N-W	8.00%	*(7)*
9: W-N-W	2.00%	*(1)*	9: W-N-W	2.00%	*(2)*
Total	*100.00%*	*(59)*	*Total*	*100.00%*	*(91)*

Total In trips to Zone 1 : 180

Reference: PTV Group. (2016)

Mesoscopic – Vistro (2/2)

Signal optimization



Name												
Approach	*Northeastbound*			*Southwestbound*			*Northwestbound*			*Southeastbound*		
Turning Movement	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*	*Left*	*Thru*	*Right*
Base Volume Input [veh / hr]	50	300	100	160	200	200	80	100	90	100	250	50
Total Analysis Volume [veh / hr]	*50*	*300*	*101*	*160*	*200*	*200*	*80*	*100*	*90*	*100*	*250*	*50*

Intersection Settings

Analyze Intersection?	☑
Analysis Period	15 minutes
Located in CBD	☑
Controller ID	2
Signal Coordination Group	1 - Coordination Group
Cycle Length	60
Coordination Type	Coordinated
Actuation Type	Fixed time
Offset	0.0
Offset Reference	LeadGreen
Permissive Mode	SingleBand
Lost Time	0.00

Phasing & Timing

Control Type	Prote		Permi	Prote		Permi	Permi		Permi	Permi		Permi
Allow Lead/Lag Optimization	☐			☐			☐			☐		
Signal Group	1	6	-	5	2	-	-	8	-	-	4	-
Lead / Lag	Lag			Lag								

Sequence

Ring 1	1	2	4	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 2	5	6	8	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ring 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

1:1326 -8529046.3012 4768843.0907

Reference: PTV Group. (2016)

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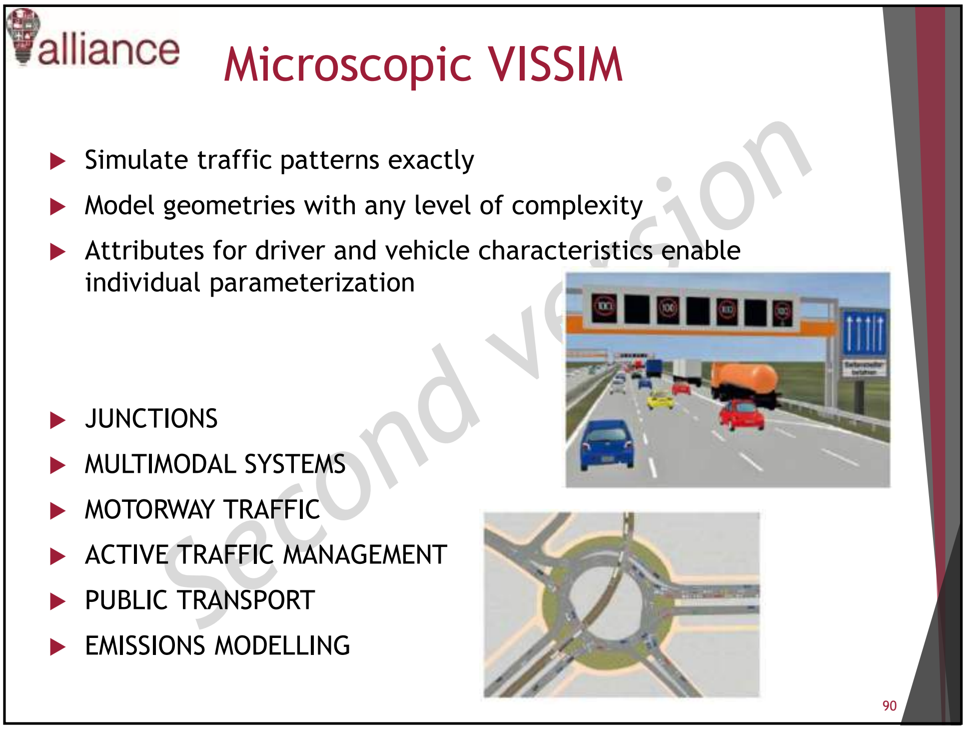
Microscopic models

- Simulate characteristics and interactions of individual vehicles
- Study area: Intersection or a road segment
- Enclose theories and rules for vehicle acceleration, passing manoeuvres and lane-changing
- PARAMICS, VISSIM, AIMSUN, SUMO, MatSIM, TransModeler SE

Reference: Papaioannou et al. (2009)



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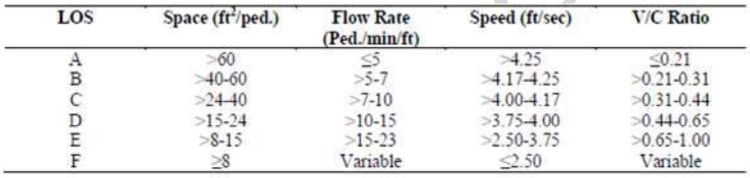
Microscopic VISSIM

- Simulate traffic patterns exactly
- Model geometries with any level of complexity
- Attributes for driver and vehicle characteristics enable individual parameterization

- JUNCTIONS
- MULTIMODAL SYSTEMS
- MOTORWAY TRAFFIC
- ACTIVE TRAFFIC MANAGEMENT
- PUBLIC TRANSPORT
- EMISSIONS MODELLING

Pedestrians level of service

Pedestrian LOS criteria



LOS	Space (ft^2/ped.)	Flow Rate (Ped./min/ft)	Speed (ft/sec)	V/C Ratio
A	>60	≤5	>4.25	≤0.21
B	>40-60	>5-7	>4.17-4.25	>0.21-0.31
C	>24-40	>7-10	>4.00-4.17	>0.31-0.44
D	>15-24	>10-15	>3.75-4.00	>0.44-0.65
E	>8-15	>15-23	>2.50-3.75	>0.65-1.00
F	≥8	Variable	≤2.50	Variable

Reference: Highway Capacity Manual, (2000)

State of the art simulator with 3D-visualization

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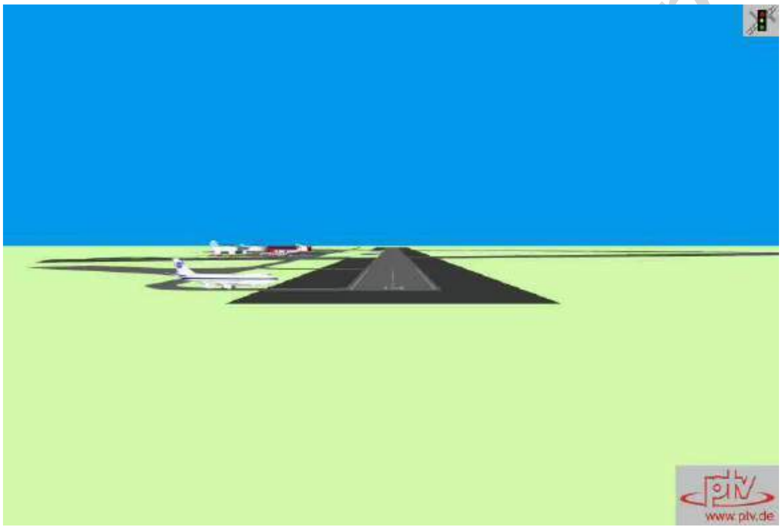
Airport simulation



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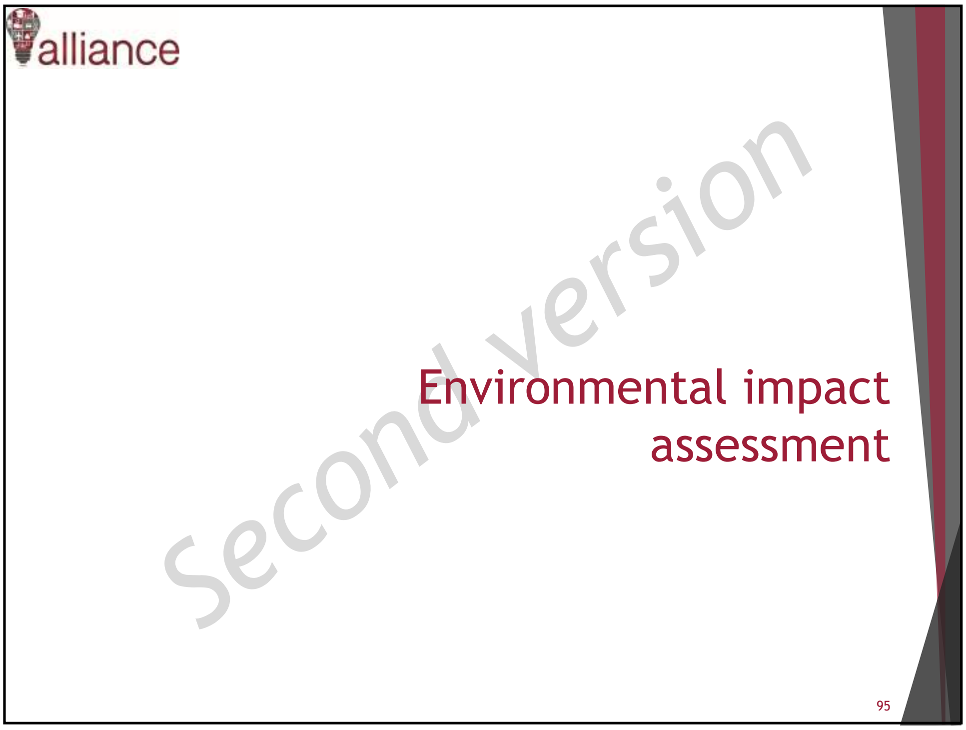
Container terminals



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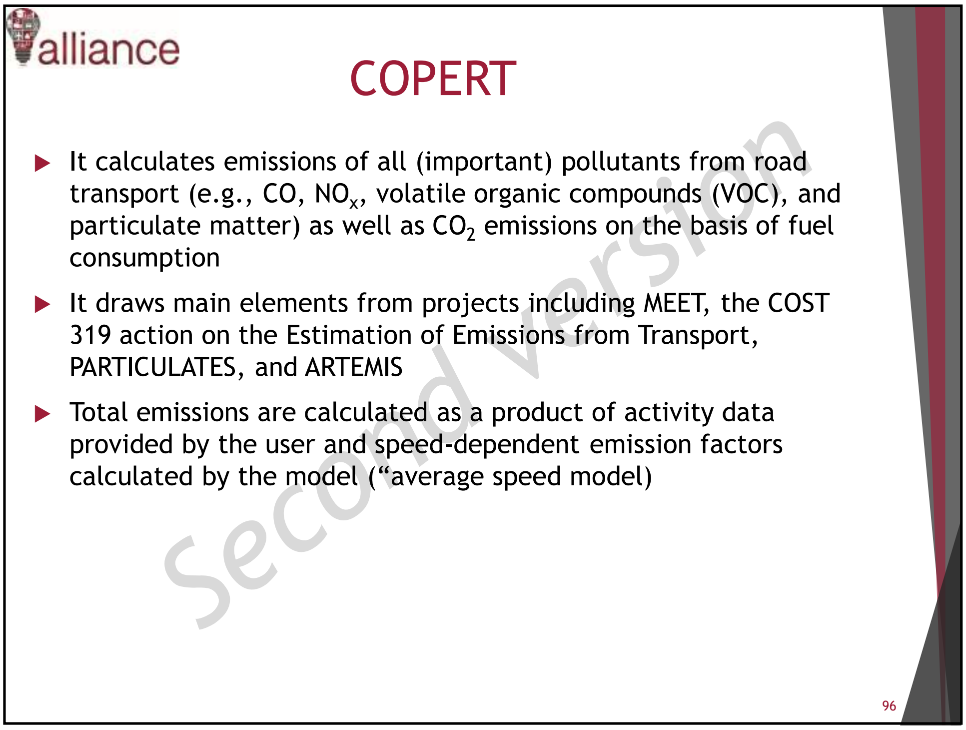
Environmental impact assessment



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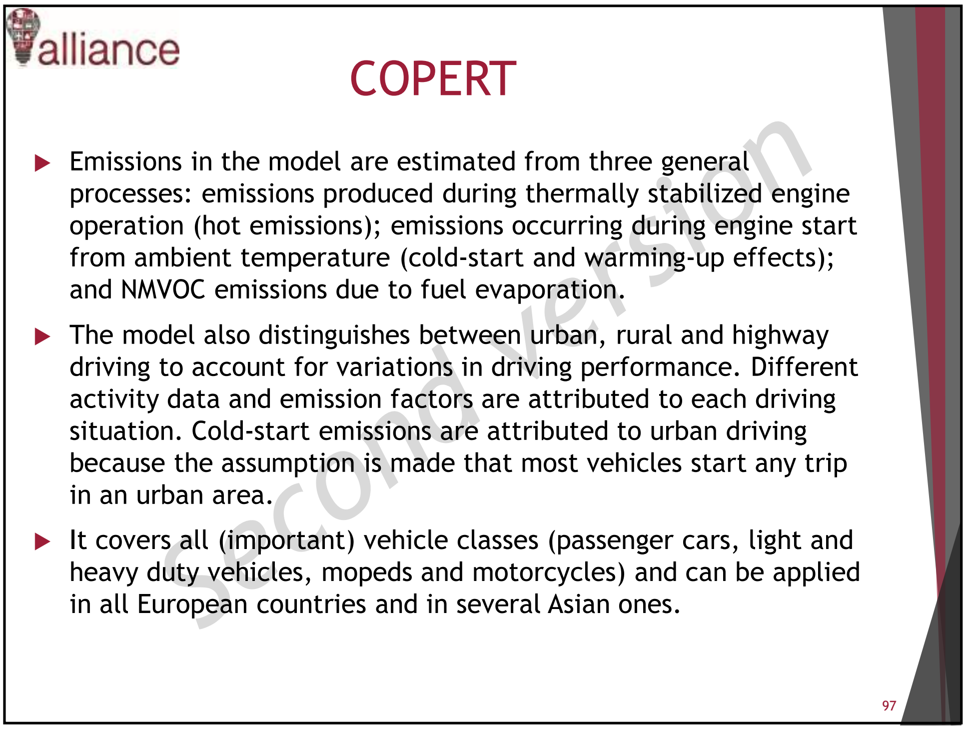
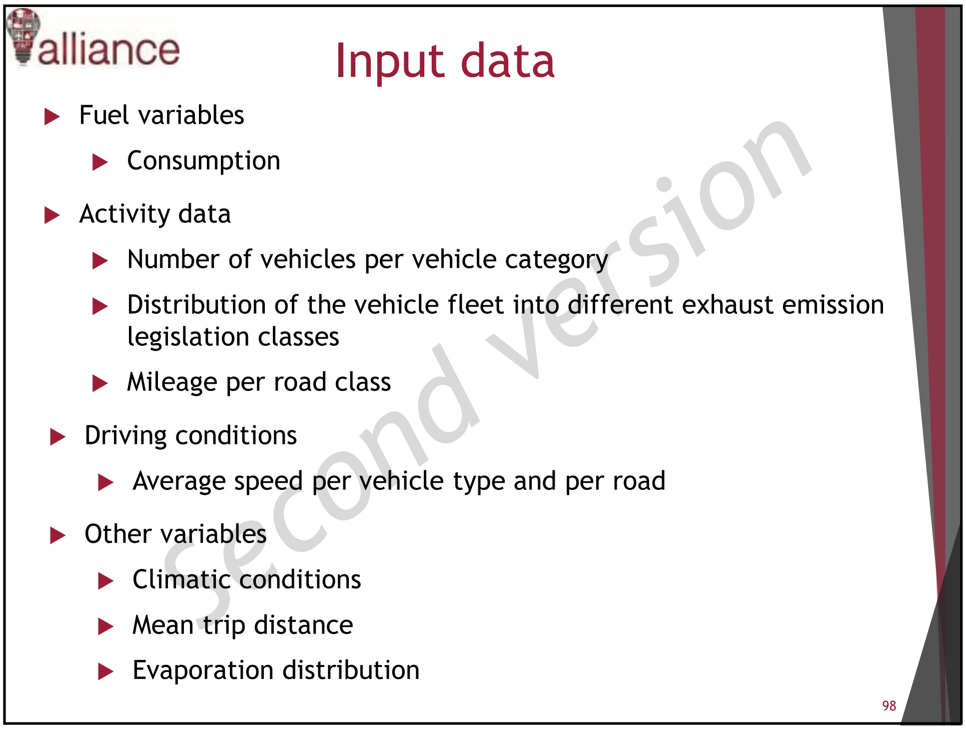
COPERT

- It calculates emissions of all (important) pollutants from road transport (e.g., CO, NO_x, volatile organic compounds (VOC), and particulate matter) as well as CO_2 emissions on the basis of fuel consumption
- It draws main elements from projects including MEET, the COST 319 action on the Estimation of Emissions from Transport, PARTICULATES, and ARTEMIS
- Total emissions are calculated as a product of activity data provided by the user and speed-dependent emission factors calculated by the model (“average speed model)



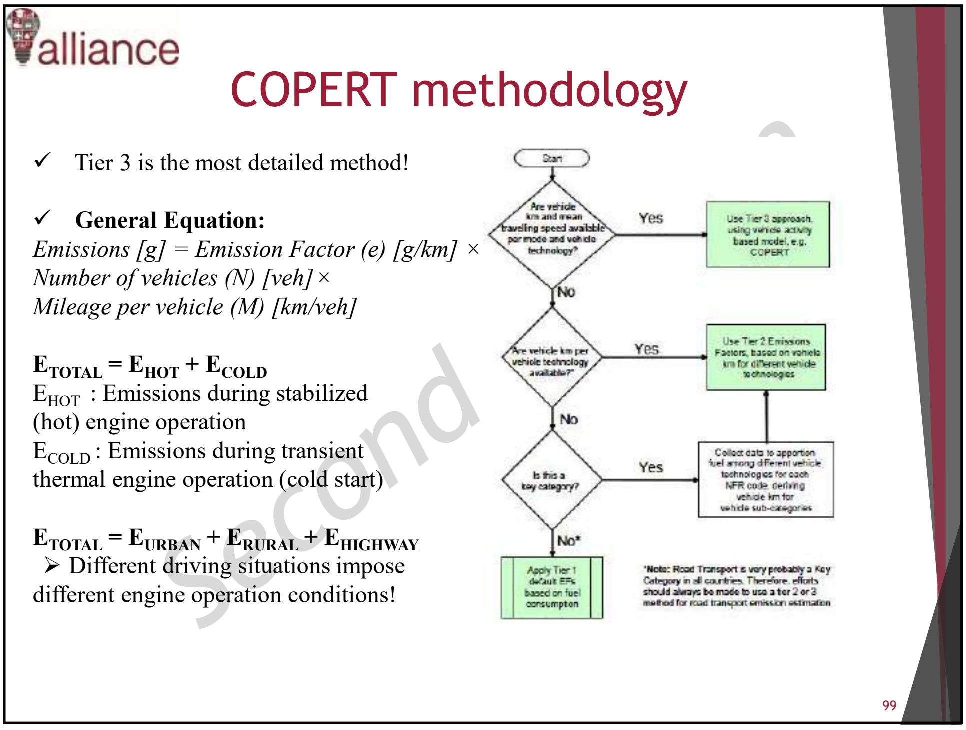
COPERT

- Emissions in the model are estimated from three general processes: emissions produced during thermally stabilized engine operation (hot emissions); emissions occurring during engine start from ambient temperature (cold-start and warming-up effects); and NMVOC emissions due to fuel evaporation.
- The model also distinguishes between urban, rural and highway driving to account for variations in driving performance. Different activity data and emission factors are attributed to each driving situation. Cold-start emissions are attributed to urban driving because the assumption is made that most vehicles start any trip in an urban area.
- It covers all (important) vehicle classes (passenger cars, light and heavy duty vehicles, mopeds and motorcycles) and can be applied in all European countries and in several Asian ones.



Input data

- Fuel variables
  - Consumption
- Activity data
  - Number of vehicles per vehicle category
  - Distribution of the vehicle fleet into different exhaust emission legislation classes
  - Mileage per road class
- Driving conditions
  - Average speed per vehicle type and per road
- Other variables
  - Climatic conditions
  - Mean trip distance
  - Evaporation distribution



COPERT methodology

- ✓ Tier 3 is the most detailed method!
- ✓ **General Equation:**

Emissions [g] = Emission Factor (e) [g/km] × Number of vehicles (N) [veh] × Mileage per vehicle (M) [km/veh]

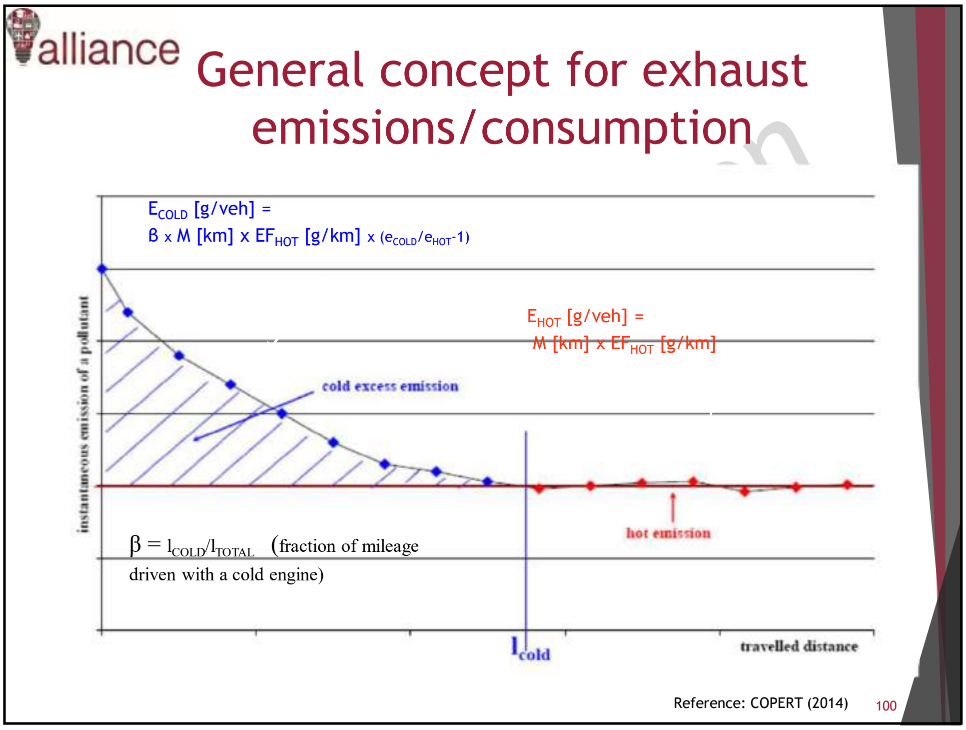
$E_{TOTAL} = E_{HOT} + E_{COLD}$

E_{HOT} : Emissions during stabilized (hot) engine operation

E_{COLD} : Emissions during transient thermal engine operation (cold start)

$E_{TOTAL} = E_{URBAN} + E_{RURAL} + E_{HIGHWAY}$

➢ Different driving situations impose different engine operation conditions!



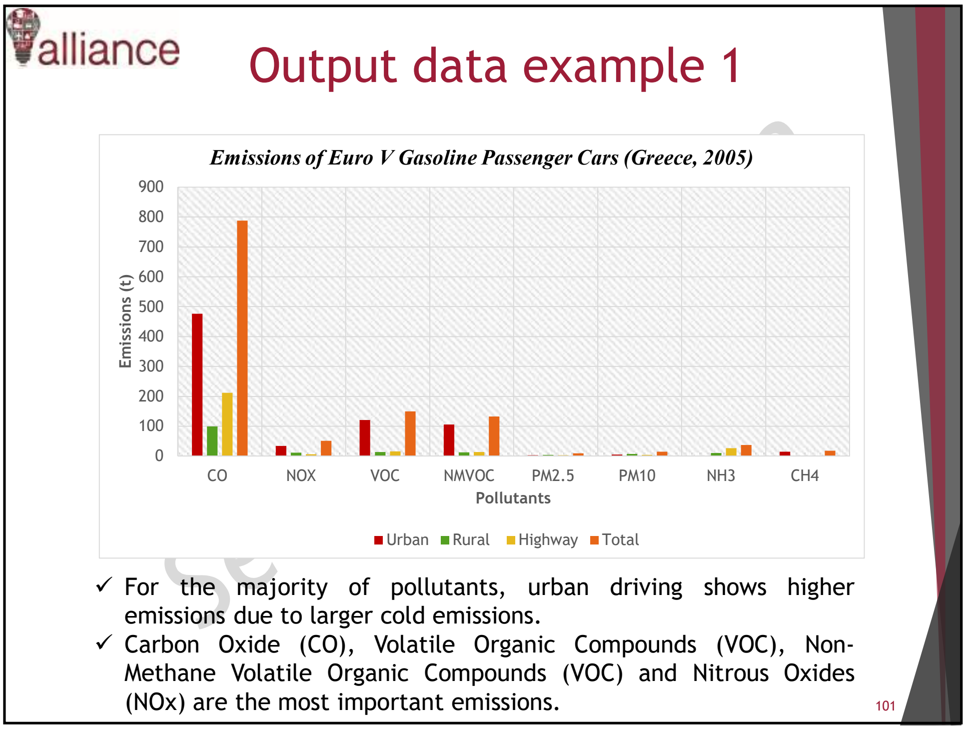
General concept for exhaust emissions/consumption

E_{COLD} [g/veh] = β x M [km] x EF_{HOT} [g/km] x (e_{COLD}/e_{HOT}-1)

E_{HOT} [g/veh] = M [km] x EF_{HOT} [g/km]

β = l_{COLD}/l_{TOTAL} (fraction of mileage driven with a cold engine)

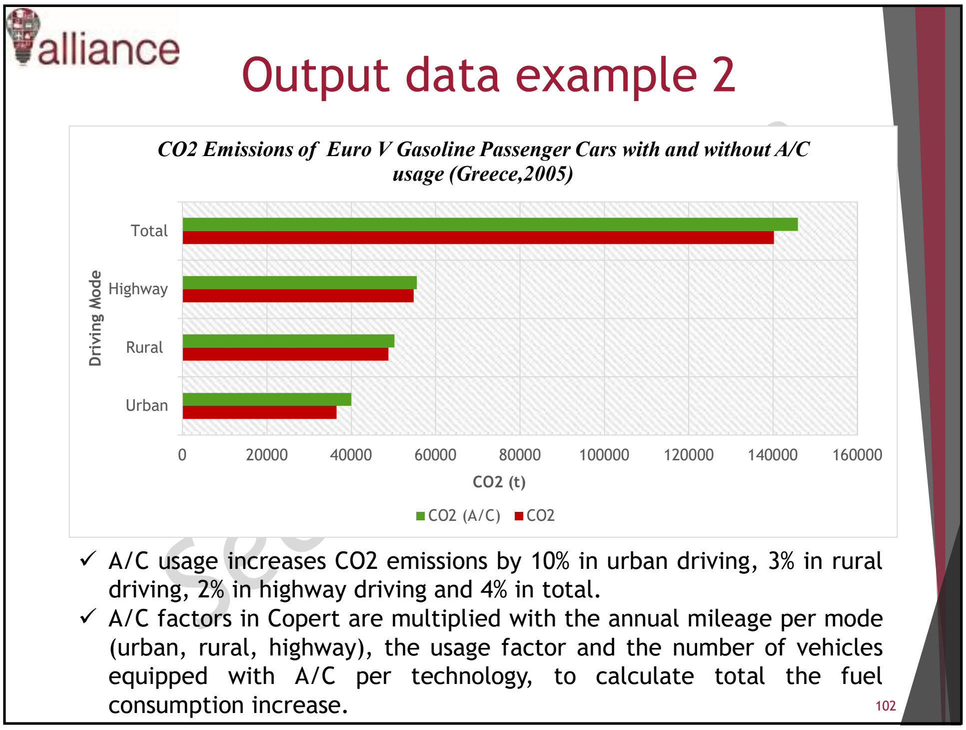
Reference: COPERT (2014)



Output data example 1

Emissions of Euro V Gasoline Passenger Cars (Greece, 2005)

- ✓ For the majority of pollutants, urban driving shows higher emissions due to larger cold emissions.
- ✓ Carbon Oxide (CO), Volatile Organic Compounds (VOC), Non-Methane Volatile Organic Compounds (VOC) and Nitrous Oxides (NOx) are the most important emissions.



Output data example 2

CO2 Emissions of Euro V Gasoline Passenger Cars with and without A/C usage (Greece,2005)

- ✓ A/C usage increases CO2 emissions by 10% in urban driving, 3% in rural driving, 2% in highway driving and 4% in total.
- ✓ A/C factors in Copert are multiplied with the annual mileage per mode (urban, rural, highway), the usage factor and the number of vehicles equipped with A/C per technology, to calculate total the fuel consumption increase.

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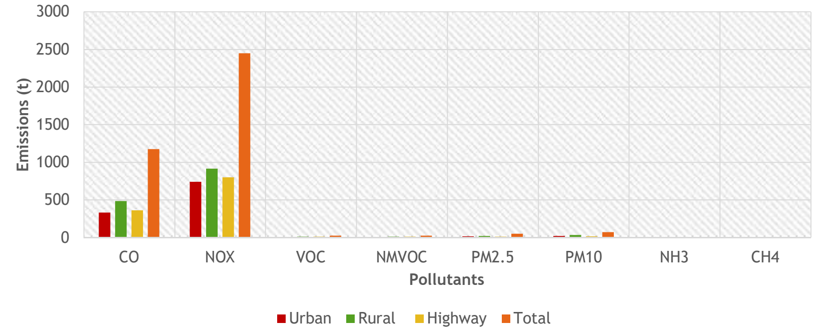
Output data example 3

Emissions of Euro V Gasoline Buses (Greece, 2005)



- ✓ Only hot emissions are calculated for Heavy Duty Vehicles.
- ✓ Buses present higher NOx emissions in comparison to other pollutants.
- ✓ The technical reason for high off-cycle NOx emissions from these vehicles is poor NOx conversion efficiency of installed Selective Catalytic Reduction (SCR) systems when exhaust temperature is low (ICCT, 2012)

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Traffic emissions models

- Motor Vehicles Emission Simulator (MOVES)
- HBEFA ARTEMIS
- VERSIT+
- UROPOL
- MODEM
- VeTESS, PHEM, CMEM
- AIMSUN
- VISSIM
- EMME
- Trans-modeler

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Safety impact assessment

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Safety performance function

$$N_{spf\ x} = e^{(a + b \times \ln(AADT) + \ln(L/1.609))}$$

where,

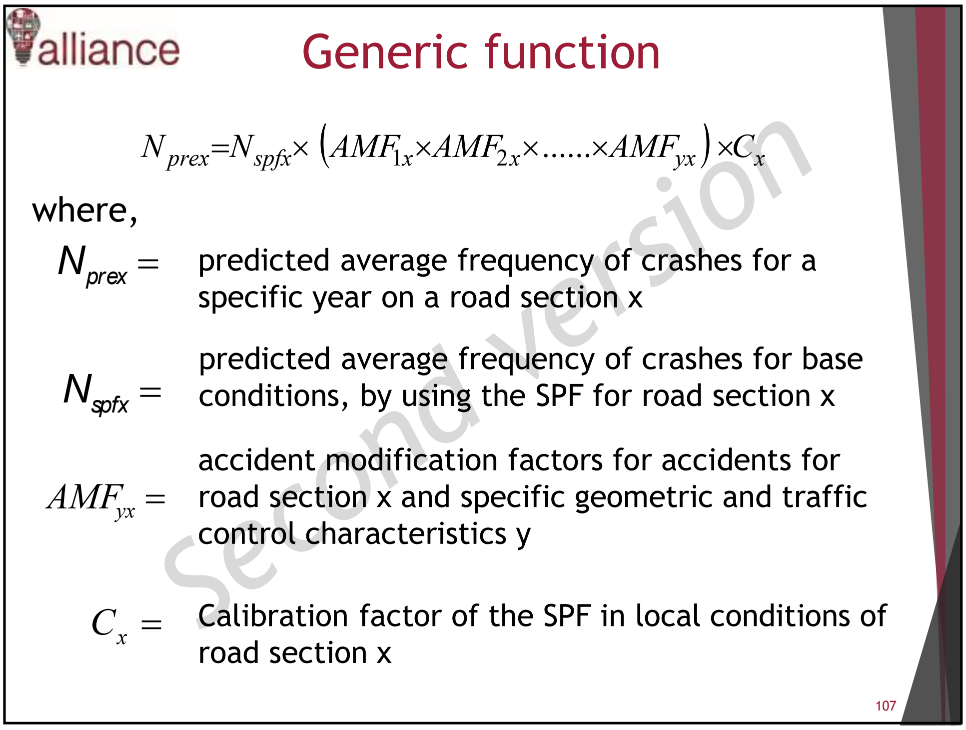
$N_{spf\ x} =$ predicted average frequency of crashes for a specific year on road section x for base conditions

$AADT =$ annual average daily traffic on road section (vehicles)

$L =$ length of road section (km)

$a, b =$ regression coefficients

Reference: Nathanail E. (2013)



Generic function

$$N_{prex}=N_{spfx}\times\left(AMF_{1x}\times AMF_{2x}\times......\times AMF_{yx}\right)\times C_{x}$$

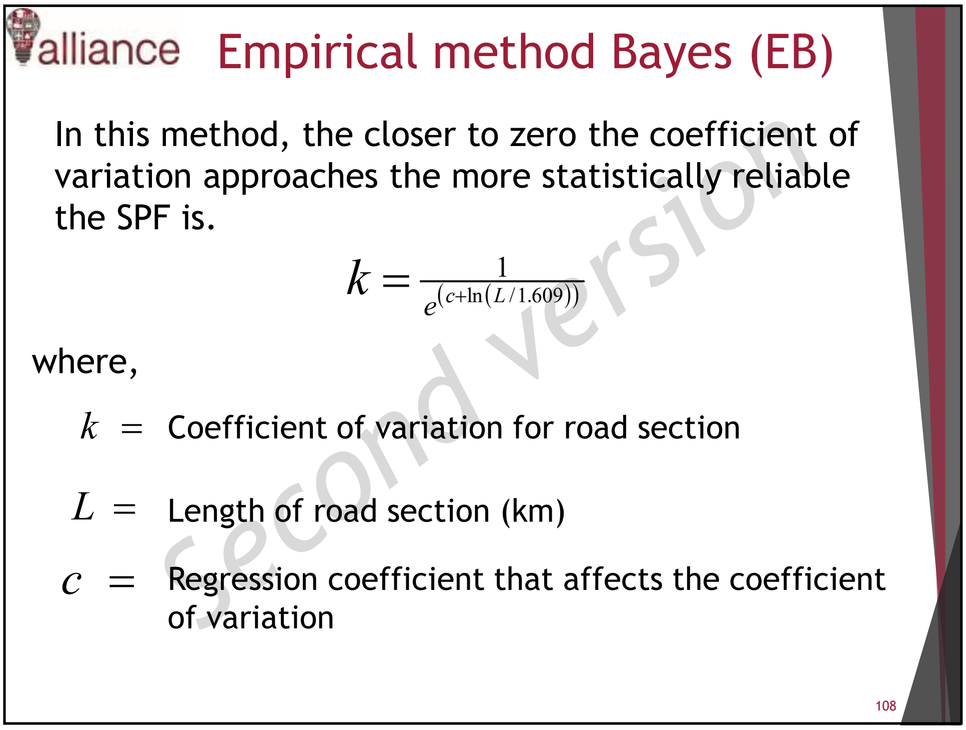
where,

N_{prex} = predicted average frequency of crashes for a specific year on a road section x

N_{spfx} = predicted average frequency of crashes for base conditions, by using the SPF for road section x

AMF_{yx} = accident modification factors for accidents for road section x and specific geometric and traffic control characteristics y

C_{x} = Calibration factor of the SPF in local conditions of road section x



Empirical method Bayes (EB)

In this method, the closer to zero the coefficient of variation approaches the more statistically reliable the SPF is.

$$k=\frac{1}{e^{\left(c+\ln\left(L/1.609\right)\right)}}$$

where,

k = Coefficient of variation for road section

L = Length of road section (km)

c = Regression coefficient that affects the coefficient of variation

EB method

- Application of EB method on road section (if possible).
- If the EB method is used, the AADT is required for each year of period of study for which data for observed frequency of crashes are available

$$N_{\exp} = w \times N_{pre} + (1-w) \times N_{obs} \qquad w = \frac{1}{1 + k \times (\sum N_{pre})}$$

N_{exp} = Expected average number of crashes for the study period

N_{pre} = Predicted average number of crashes for the period of study

N_{obs} = Observed average number of crashes for the period of study

w = weight

k = Coefficient of variation for SPF

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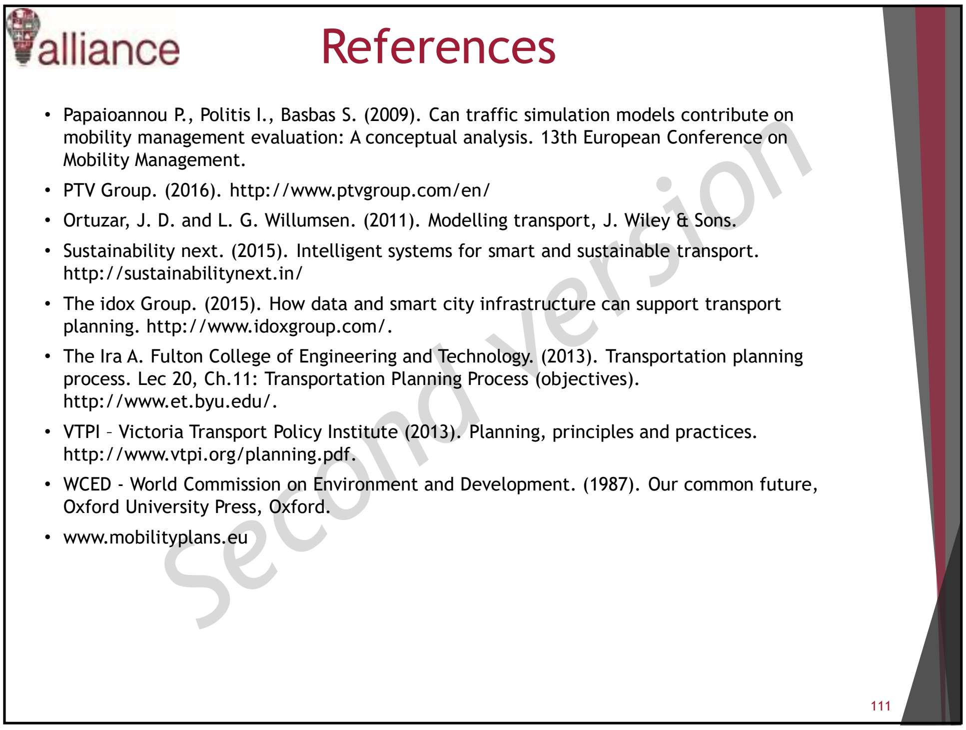

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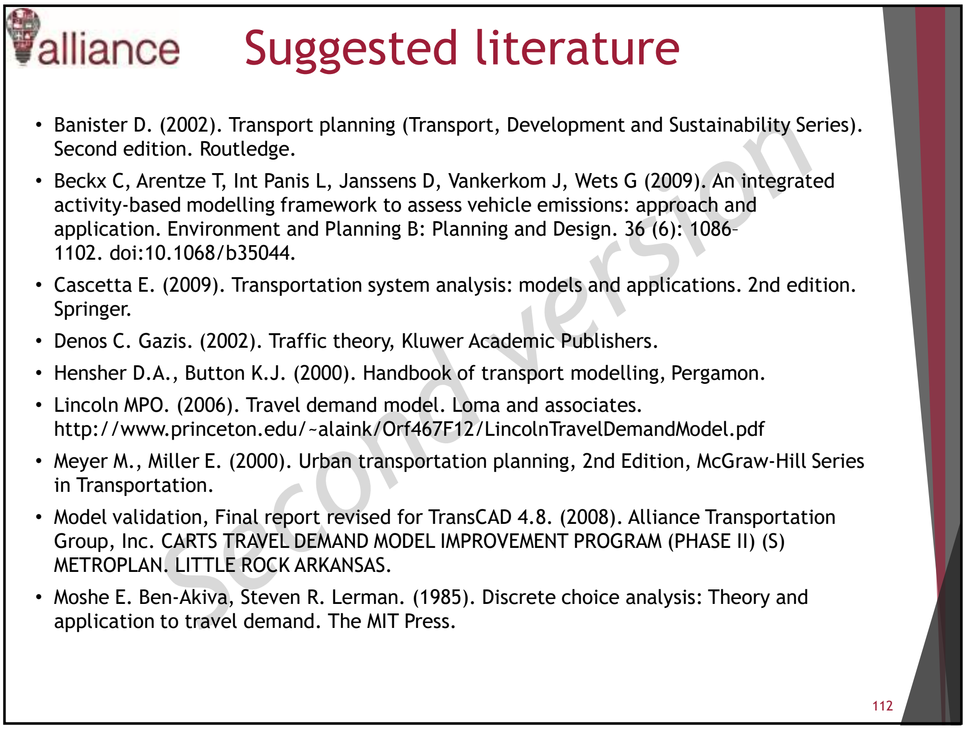

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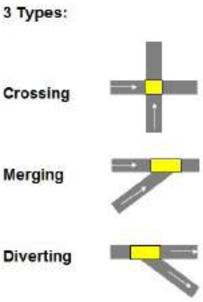
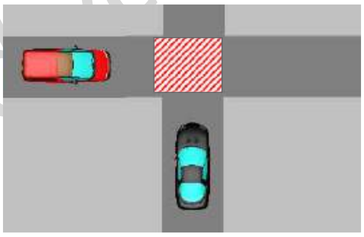
Annex

Conflict areas

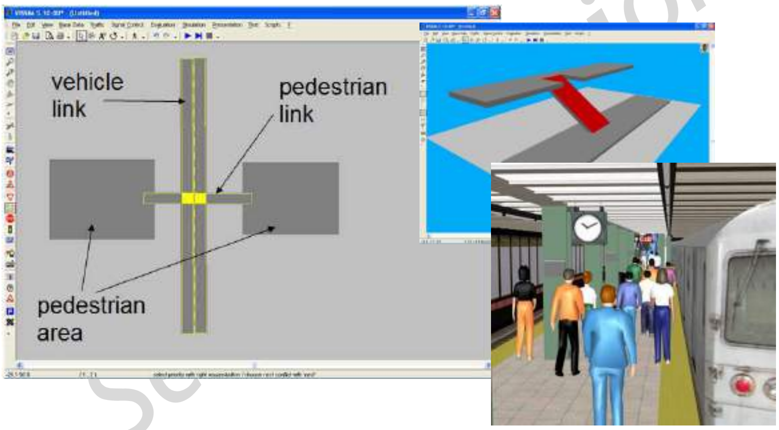
Replaced the old priority rules

Explicit anticipation:
Drivers have a planned acceleration profile for some seconds





Pedestrians modeling



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Pedestrian simulation

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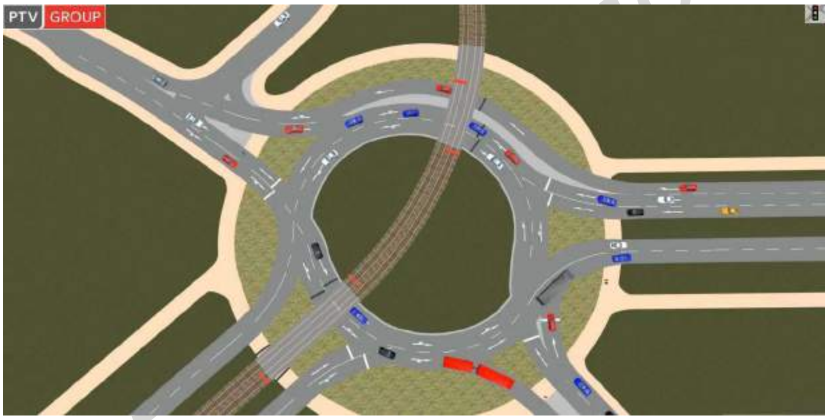
Active traffic management on freeways

Exclusive bus/tram lanes

Public transport priority



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Public transport and shared space

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Automated parking facilities

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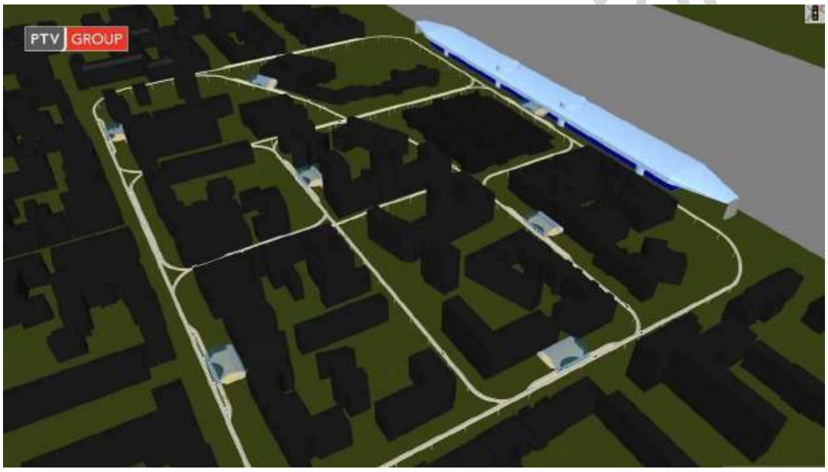
New transport systems - PRT



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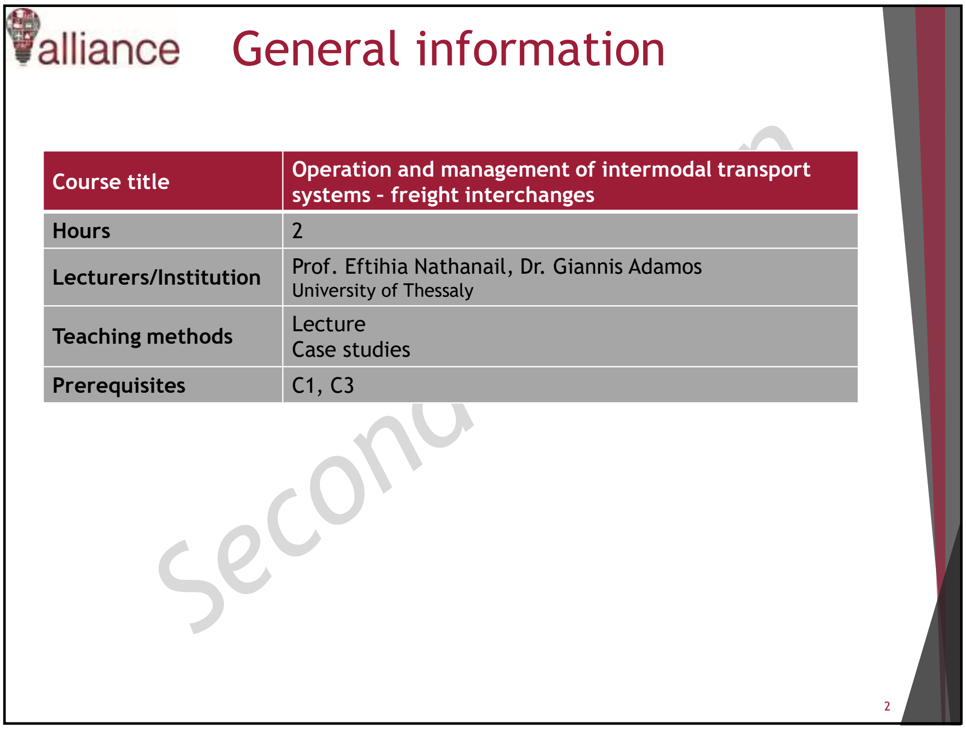
Operation and management of intermodal transport systems: freight interchanges

University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



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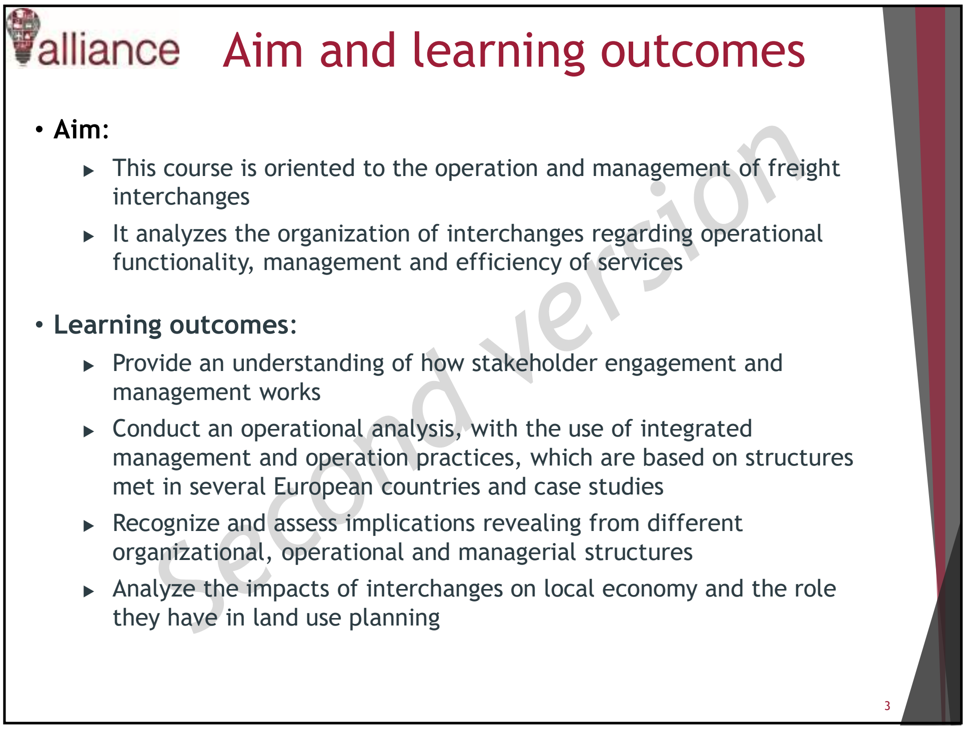
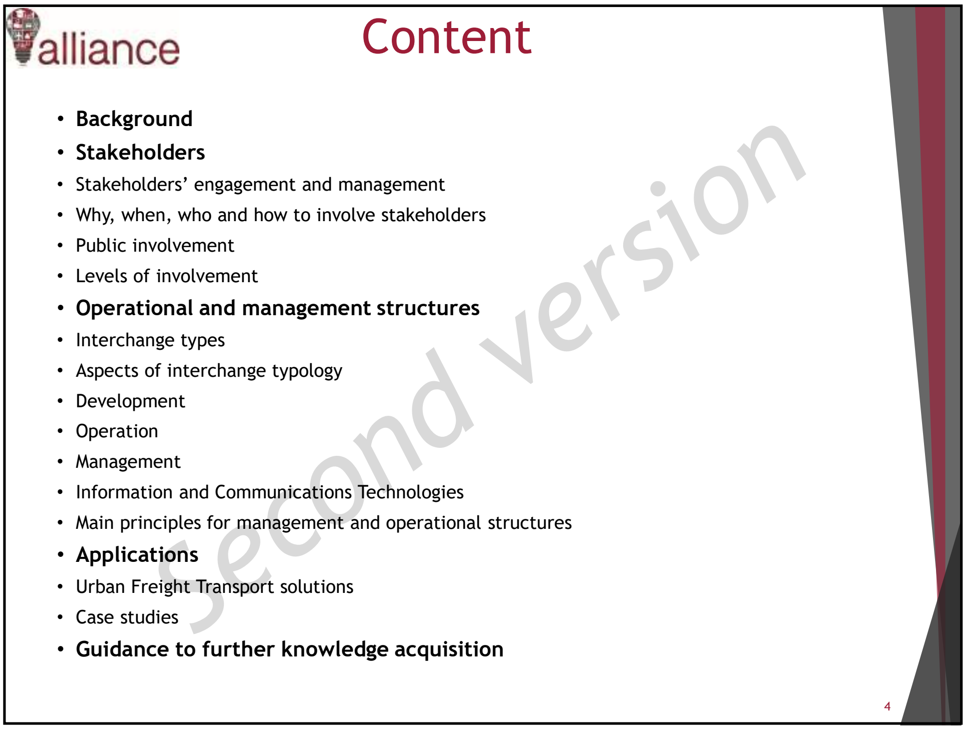
General information

Course title	Operation and management of intermodal transport systems - freight interchanges
Hours	2
Lecturers/Institution	Prof. Eftihia Nathanail, Dr. Giannis Adamos University of Thessaly
Teaching methods	Lecture Case studies
Prerequisites	C1, C3



Aim and learning outcomes

- **Aim:**
  - This course is oriented to the operation and management of freight interchanges
  - It analyzes the organization of interchanges regarding operational functionality, management and efficiency of services
- **Learning outcomes:**
  - Provide an understanding of how stakeholder engagement and management works
  - Conduct an operational analysis, with the use of integrated management and operation practices, which are based on structures met in several European countries and case studies
  - Recognize and assess implications revealing from different organizational, operational and managerial structures
  - Analyze the impacts of interchanges on local economy and the role they have in land use planning



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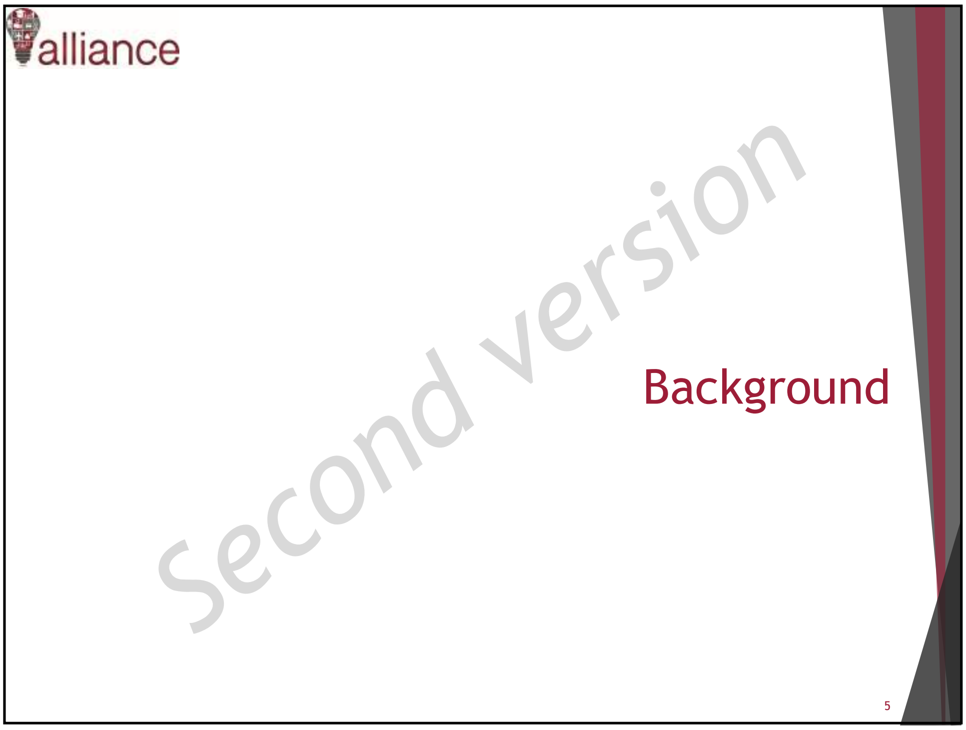
- Development
- Operation
- Management
- Information and Communications Technologies
- Main principles for management and operational structures
- **Applications**
- Urban Freight Transport solutions
- Case studies
- **Guidance to further knowledge acquisition**



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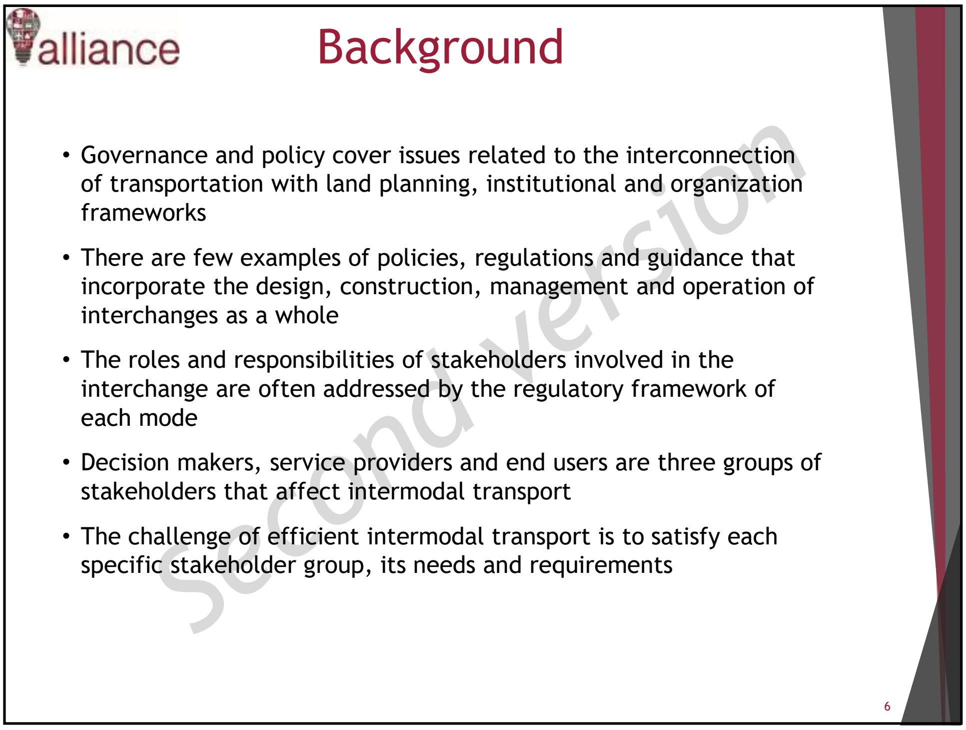
Background



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Background

- Governance and policy cover issues related to the interconnection of transportation with land planning, institutional and organization frameworks
- There are few examples of policies, regulations and guidance that incorporate the design, construction, management and operation of interchanges as a whole
- The roles and responsibilities of stakeholders involved in the interchange are often addressed by the regulatory framework of each mode
- Decision makers, service providers and end users are three groups of stakeholders that affect intermodal transport
- The challenge of efficient intermodal transport is to satisfy each specific stakeholder group, its needs and requirements

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Stakeholders

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Stakeholders’ engagement and management

- **Stakeholders’ identification:**
  - Why involve stakeholders?
  - When to involve stakeholders?
  - Which stakeholders to involve?
- **Stakeholders’ engagement**:
  - Strategy
  - Public involvement
  - Techniques for public involvement

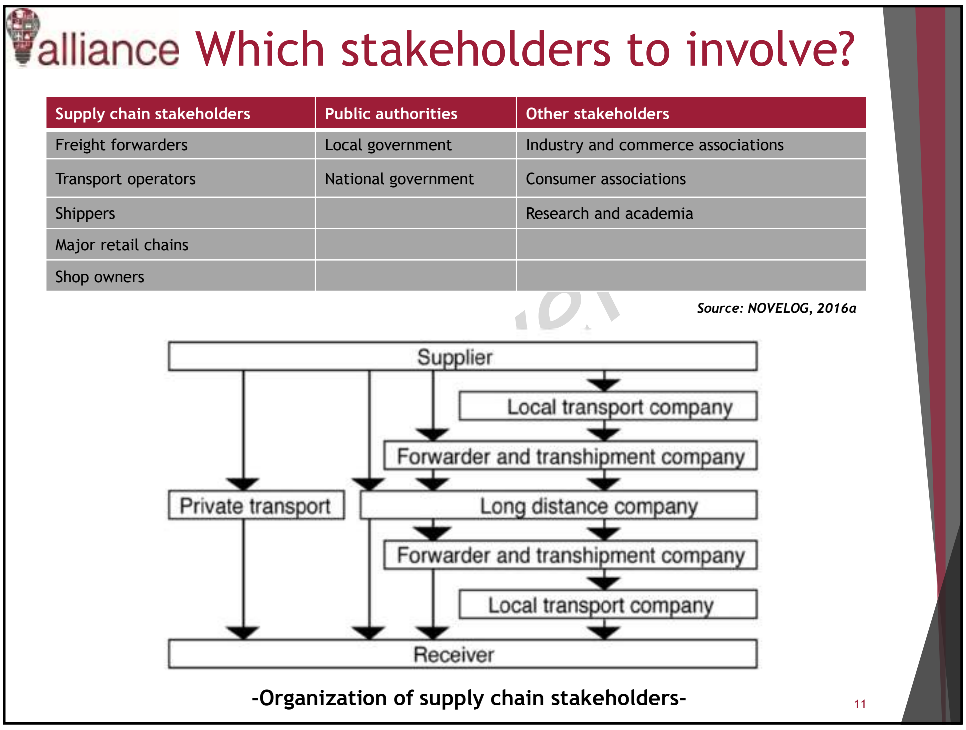
Why involve stakeholders?

- Local stakeholders can highlight local challenges that may be addressed by localized solutions
- Political support and public acceptance can be achieved more easily
- Input from stakeholders who are involved in real-time implementation and operation of intermodal interchanges can help to identify potential barriers, problems and concerns
- Establishing a process of dialogue between the public authorities and professionals helps to make both parties become more aware of the issues and options available, which will assist the later stages of implementation

When to involve stakeholders?

In the interchange planning process, stakeholders may be involved, when:

- Setting the objectives/goals for the interchange
- Identifying current and potential future problems
- Developing ideas for measures/facilities to be associated with the interchange
- Indicating levels of support for different proposals
- Deciding on the preferred plan for the interchange



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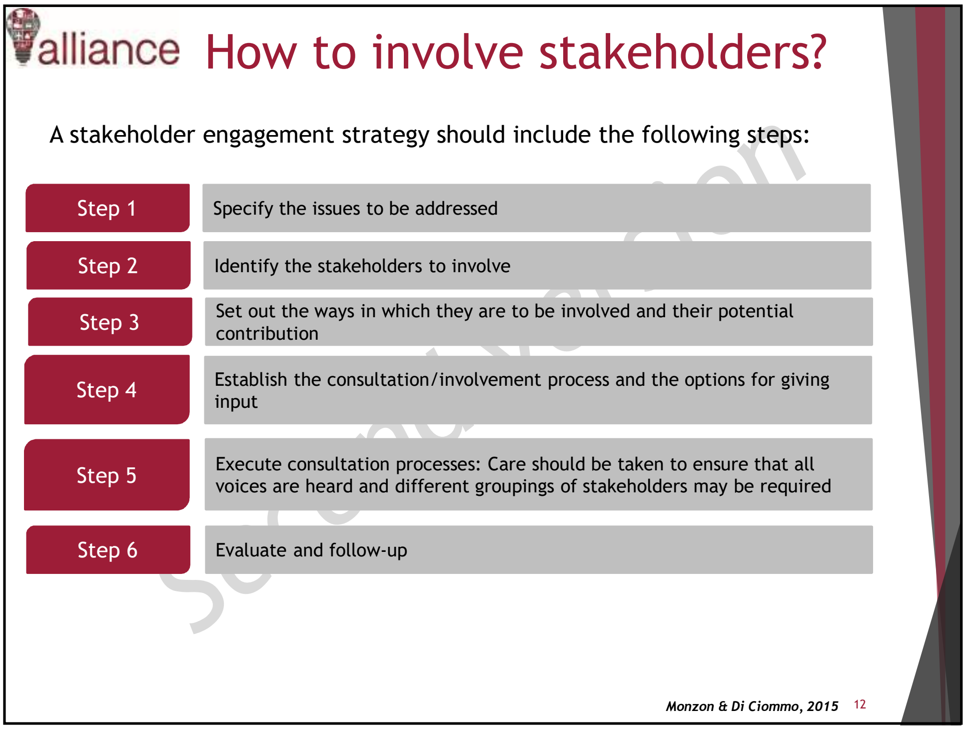
Which stakeholders to involve?

Supply chain stakeholders	Public authorities	Other stakeholders
Freight forwarders	Local government	Industry and commerce associations
Transport operators	National government	Consumer associations
Shippers		Research and academia
Major retail chains		
Shop owners		

Source: NOVELOG, 2016a

-Organization of supply chain stakeholders-



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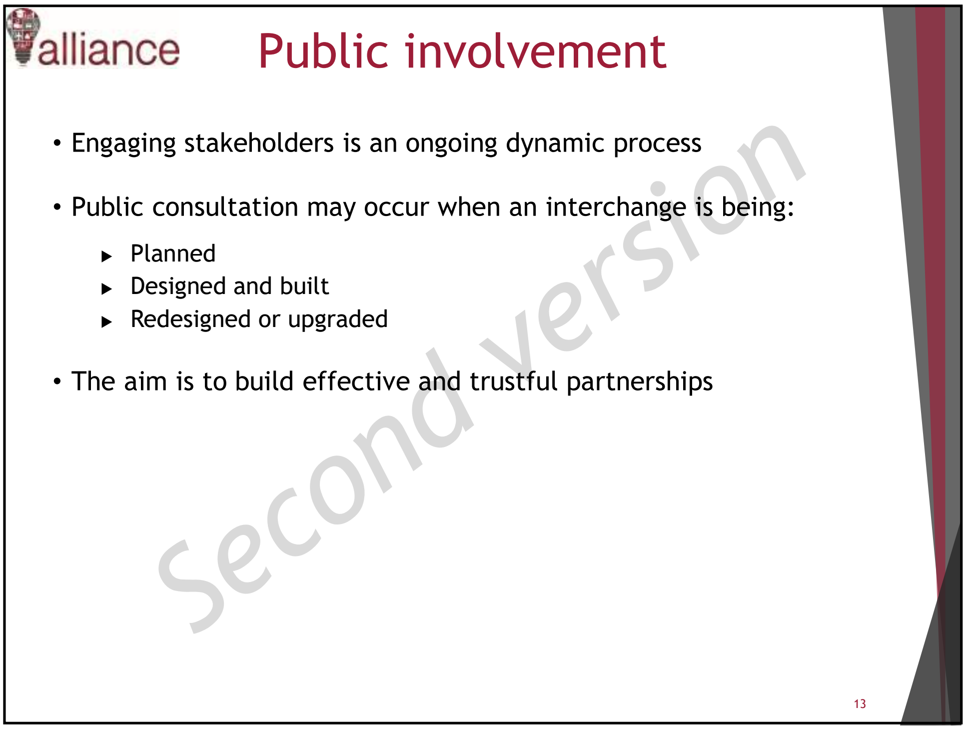
How to involve stakeholders?

A stakeholder engagement strategy should include the following steps:

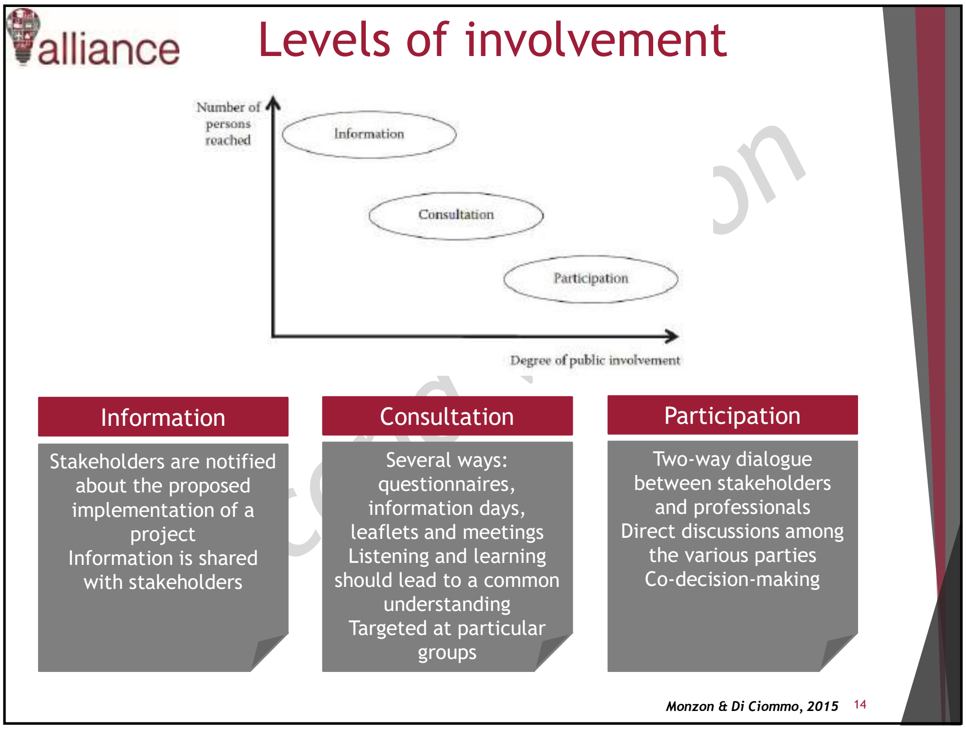
Step 1	Specify the issues to be addressed
Step 2	Identify the stakeholders to involve
Step 3	Set out the ways in which they are to be involved and their potential contribution
Step 4	Establish the consultation/involvement process and the options for giving input
Step 5	Execute consultation processes: Care should be taken to ensure that all voices are heard and different groupings of stakeholders may be required
Step 6	Evaluate and follow-up

Monzon & Di Ciommo, 2015



Public involvement

- Engaging stakeholders is an ongoing dynamic process
- Public consultation may occur when an interchange is being:
  - Planned
  - Designed and built
  - Redesigned or upgraded
- The aim is to build effective and trustful partnerships



Levels of involvement

Information	Consultation	Participation
Stakeholders are notified about the proposed implementation of a project Information is shared with stakeholders	Several ways: questionnaires, information days, leaflets and meetings Listening and learning should lead to a common understanding Targeted at particular groups	Two-way dialogue between stakeholders and professionals Direct discussions among the various parties Co-decision-making

Monzon & Di Ciommo, 2015

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Operational and management structures

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Interchange types

Category	City terminal	Freight village	Industrial and logistics park	Special logistics area
Transport modes	Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air
Main aims	Traffic reduction in the city	Modal shift and urban traffic reduction	Regional economic growth and modal shift	Regional economic growth
Operator	Huge forwarder or retailer	Operating company (public influence)	No operator	Airport or harbor authorities
Company structure	Huge forwarder or retailer	Small companies, also large transport companies	Large industrial companies and transport companies	Large companies
Land use	Small areas in the city	Large areas in outskirts	Large areas in the outskirts or at old industrial areas	Extension to existing sites in the city or in the outskirts
Land price	Very high price	Relatively low	Relatively low	High
Quality of infrastructure	Good access to the city	Direct links to main infrastructure and access to the city	Direct connections to main infrastructure	Very good access to the international infrastructure
Orientation	City	Regional / interregional	Regional / interregional	International / intercontinental

Source: Nathanail, 2007

Main aspects of interchange typology

Main phases of interchange typology

- **Development**
  - Defined by the interchange objectives
  - Formulated by the entity that takes the initiative for development and the rest involved stakeholders
- **Operation**
  - Determined by the range and depth of provided operations
- **Management phase**
  - Determined by the range and responsibilities of the managerial body

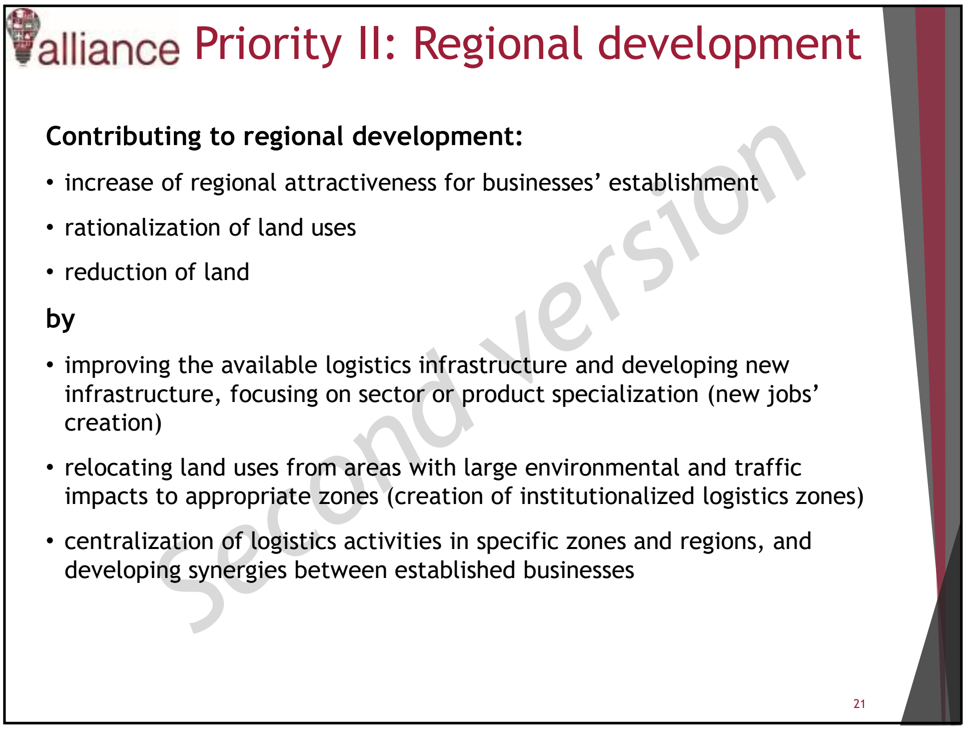
Objectives

- **Priority I: Business development** aiming solely at the profitability of the companies that participate in the development scheme (banks and other financial institutions, real estate companies, etc.)
- **Priority II: Regional development**, especially in areas where transport and logistics services are the main economic activities, due to their location or the lack of economic activities of high added value
- **Priority III:** Rationalizing the transport system and generally goals related to **transport policy** or environmental protection
- **Priority IV:** Improvement of **quality of life**

Priority I: Business development

Enhancing enterprises' competiveness, by:

- improving product access to national and mainly foreign markets in terms of logistics costs, time and reliability
- reducing logistics costs
- supporting modernization processes in the freight transport sector



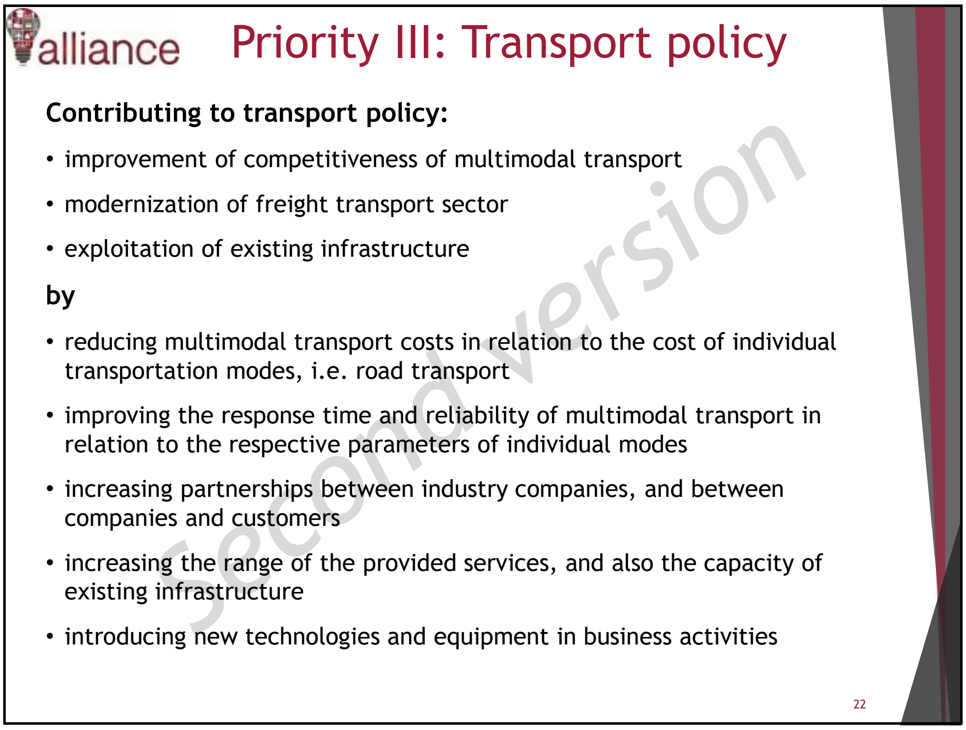
Priority II: Regional development

Contributing to regional development:

- increase of regional attractiveness for businesses’ establishment
- rationalization of land uses
- reduction of land

by

- improving the available logistics infrastructure and developing new infrastructure, focusing on sector or product specialization (new jobs’ creation)
- relocating land uses from areas with large environmental and traffic impacts to appropriate zones (creation of institutionalized logistics zones)
- centralization of logistics activities in specific zones and regions, and developing synergies between established businesses



Priority III: Transport policy

Contributing to transport policy:

- improvement of competitiveness of multimodal transport
- modernization of freight transport sector
- exploitation of existing infrastructure

by

- reducing multimodal transport costs in relation to the cost of individual transportation modes, i.e. road transport
- improving the response time and reliability of multimodal transport in relation to the respective parameters of individual modes
- increasing partnerships between industry companies, and between companies and customers
- increasing the range of the provided services, and also the capacity of existing infrastructure
- introducing new technologies and equipment in business activities

Priority IV: Quality of life

- Reduction of the number of vehicle kilometres traveled, in particular of freight transport vehicles
- Increase of the market share of rail and waterborne transport over road transport, aiming at the promotion of multimodal transport
- Limitation of traffic pollutants, prohibition of heavy vehicles transit from urban areas and traffic diversion peripherally
- Improvement of terms of urban distribution and land use planning

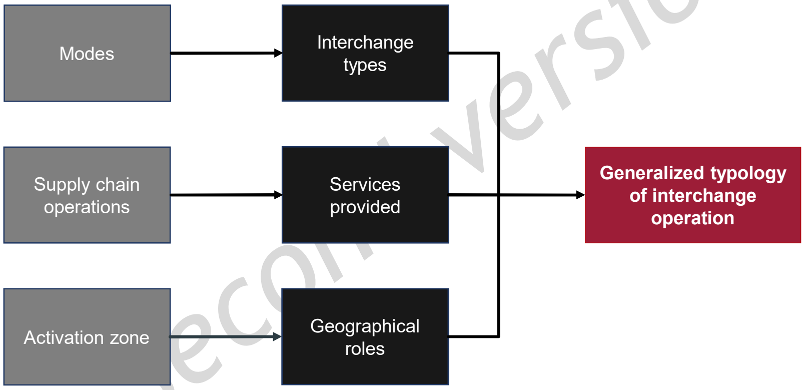
Operation

3 main principles that formulate an interchange, and can be used for its operational organization:

- Scope of the provided operations, expressed by the range and potential of specialization of the services provided (operational scope)
- Provided transport options, expressed by the type of intermodal nodes resulting from the various combinations of transportation modes (intermodal operation)
- Influence scope of the interchange, expressed by the geographic role it has in relation to the provided services (geographical scope)

Key operational factors

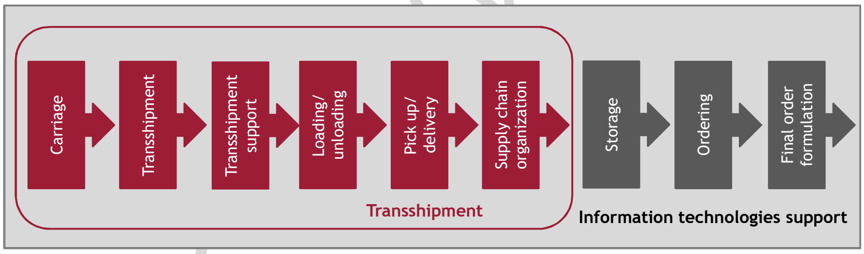
Key factors that form the operational profile of a freight interchange and make it competitive

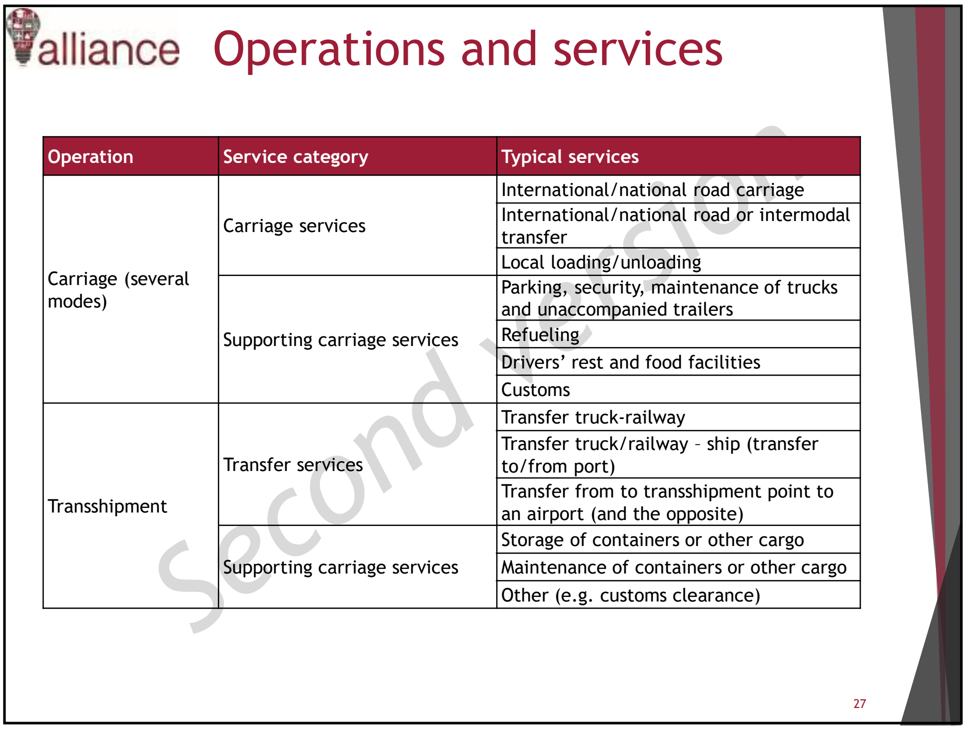


Added value operations

In order to add value to the operations of the users, the interchange must be an integral part of the supply chain, within which various processes are being carried out:

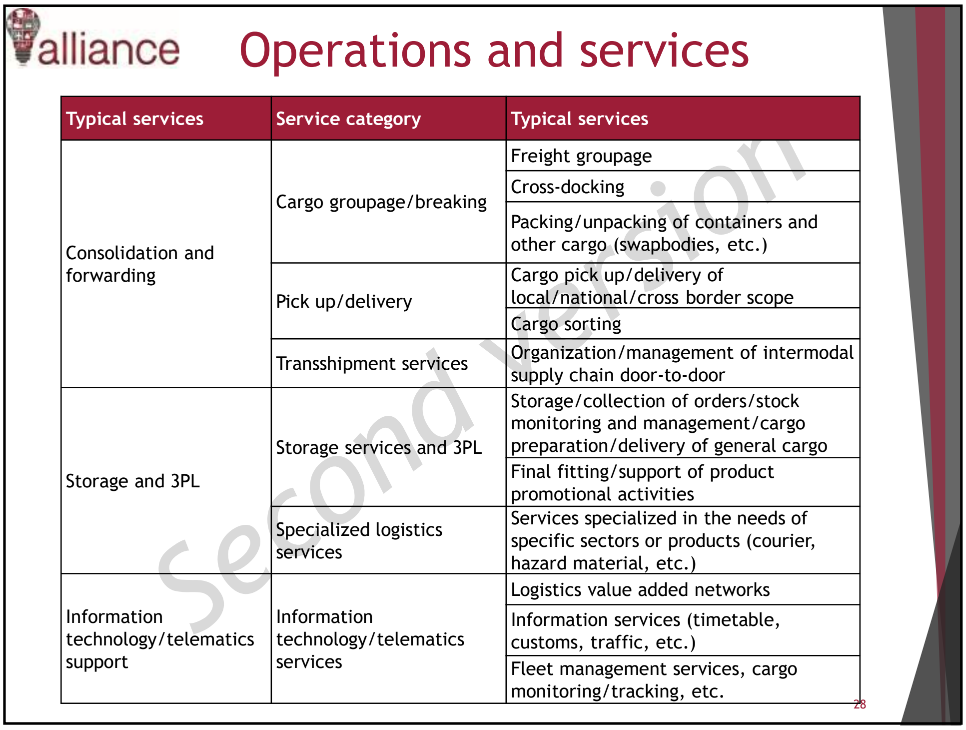
- transshipment
- logistics operations
- information technologies support





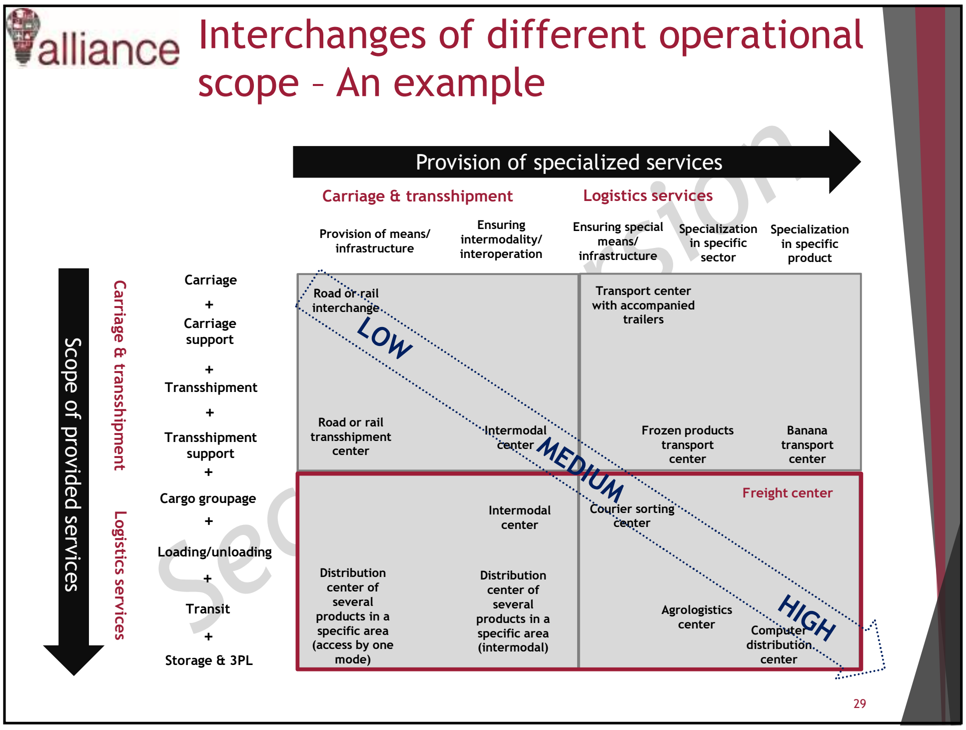
Operations and services

Operation	Service category	Typical services
Carriage (several modes)	Carriage services	International/national road carriage
		International/national road or intermodal transfer
		Local loading/unloading
	Supporting carriage services	Parking, security, maintenance of trucks and unaccompanied trailers
		Refueling
		Drivers' rest and food facilities
		Customs
Transshipment	Transfer services	Transfer truck-railway
		Transfer truck/railway – ship (transfer to/from port)
		Transfer from to transshipment point to an airport (and the opposite)
	Supporting carriage services	Storage of containers or other cargo
		Maintenance of containers or other cargo
		Other (e.g. customs clearance)



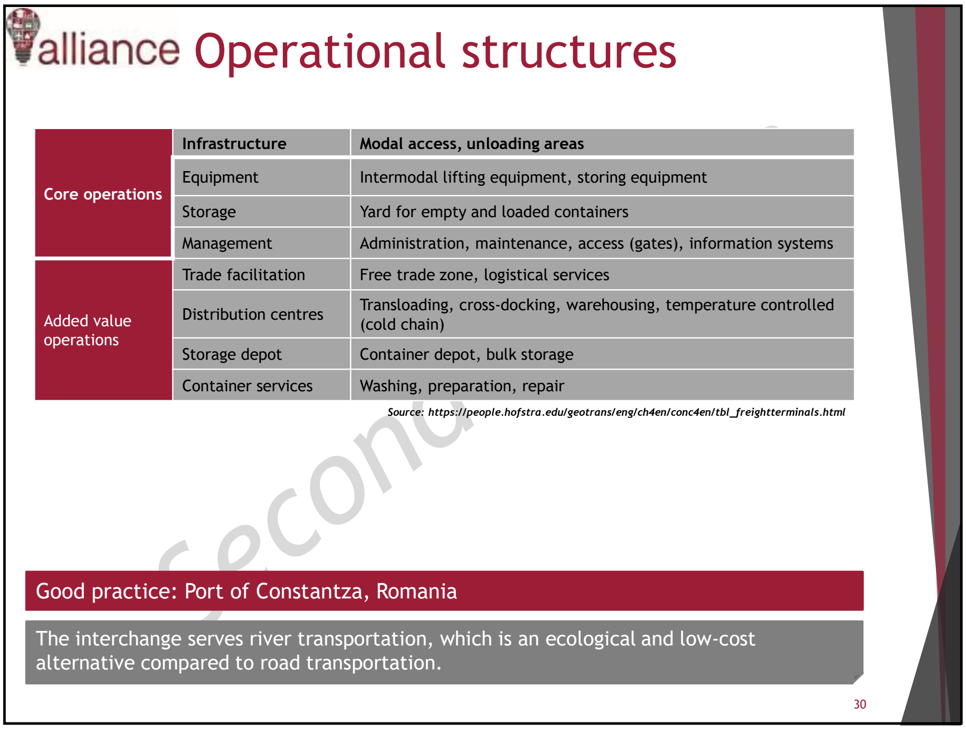
Operations and services

Typical services	Service category	Typical services
Consolidation and forwarding	Cargo groupage/breaking	Freight groupage
		Cross-docking
		Packing/unpacking of containers and other cargo (swapbodies, etc.)
	Pick up/delivery	Cargo pick up/delivery of local/national/cross border scope
		Cargo sorting
	Transshipment services	Organization/management of intermodal supply chain door-to-door
Storage and 3PL	Storage services and 3PL	Storage/collection of orders/stock monitoring and management/cargo preparation/delivery of general cargo
		Final fitting/support of product promotional activities
	Specialized logistics services	Services specialized in the needs of specific sectors or products (courier, hazard material, etc.)
Information technology/telematics support	Information technology/telematics services	Logistics value added networks
		Information services (timetable, customs, traffic, etc.)
		Fleet management services, cargo monitoring/tracking, etc.



Interchanges of different operational scope – An example

Provision of specialized services



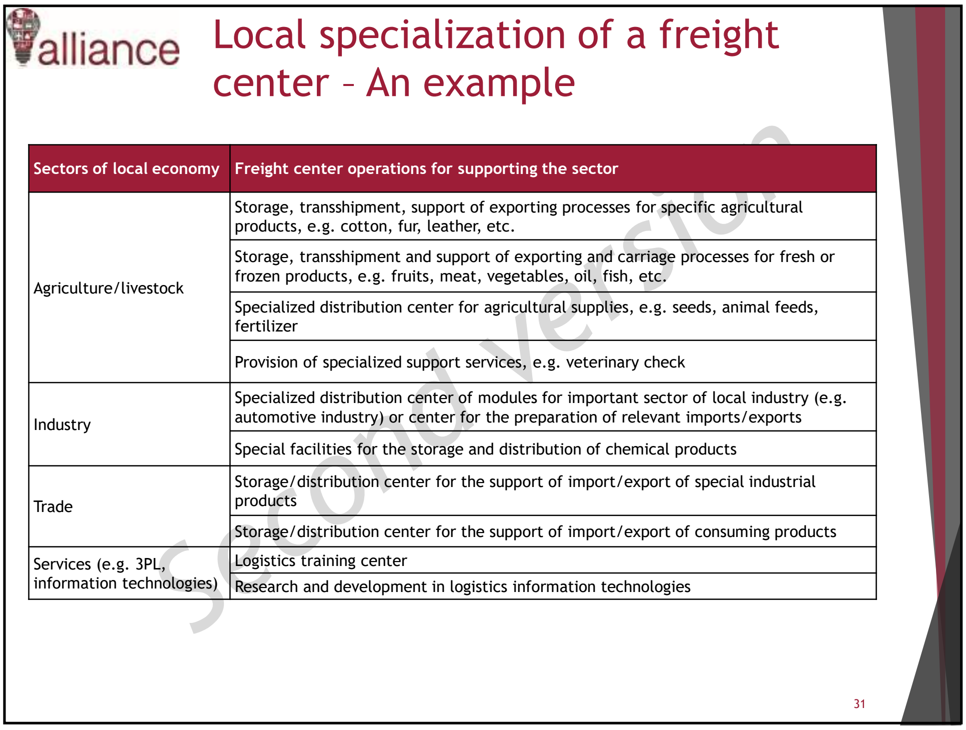
Operational structures

Core operations	Infrastructure	Modal access, unloading areas
	Equipment	Intermodal lifting equipment, storing equipment
	Storage	Yard for empty and loaded containers
	Management	Administration, maintenance, access (gates), information systems
Added value operations	Trade facilitation	Free trade zone, logistical services
	Distribution centres	Transloading, cross-docking, warehousing, temperature controlled (cold chain)
	Storage depot	Container depot, bulk storage
	Container services	Washing, preparation, repair

Source: https://people.hofstra.edu/geotrans/eng/ch4en/conc4en/tbl_freightterminals.html

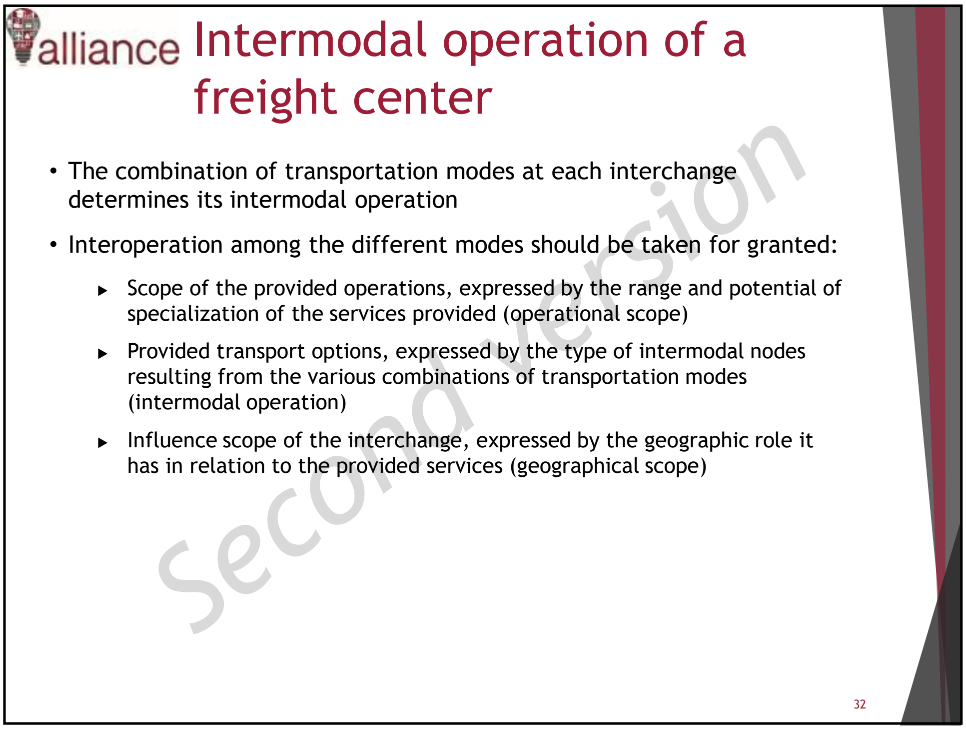
Good practice: Port of Constantza, Romania

The interchange serves river transportation, which is an ecological and low-cost alternative compared to road transportation.



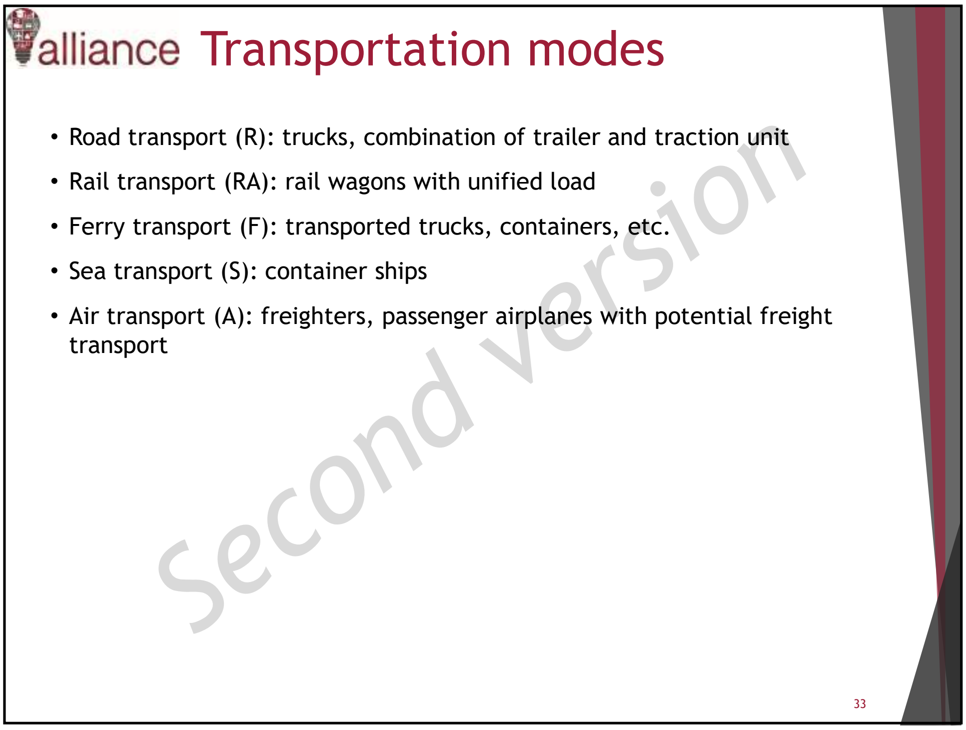
Local specialization of a freight center – An example

Sectors of local economy	Freight center operations for supporting the sector
Agriculture/livestock	Storage, transshipment, support of exporting processes for specific agricultural products, e.g. cotton, fur, leather, etc.
	Storage, transshipment and support of exporting and carriage processes for fresh or frozen products, e.g. fruits, meat, vegetables, oil, fish, etc.
	Specialized distribution center for agricultural supplies, e.g. seeds, animal feeds, fertilizer
	Provision of specialized support services, e.g. veterinary check
Industry	Specialized distribution center of modules for important sector of local industry (e.g. automotive industry) or center for the preparation of relevant imports/exports
	Special facilities for the storage and distribution of chemical products
Trade	Storage/distribution center for the support of import/export of special industrial products
	Storage/distribution center for the support of import/export of consuming products
Services (e.g. 3PL, information technologies)	Logistics training center
	Research and development in logistics information technologies



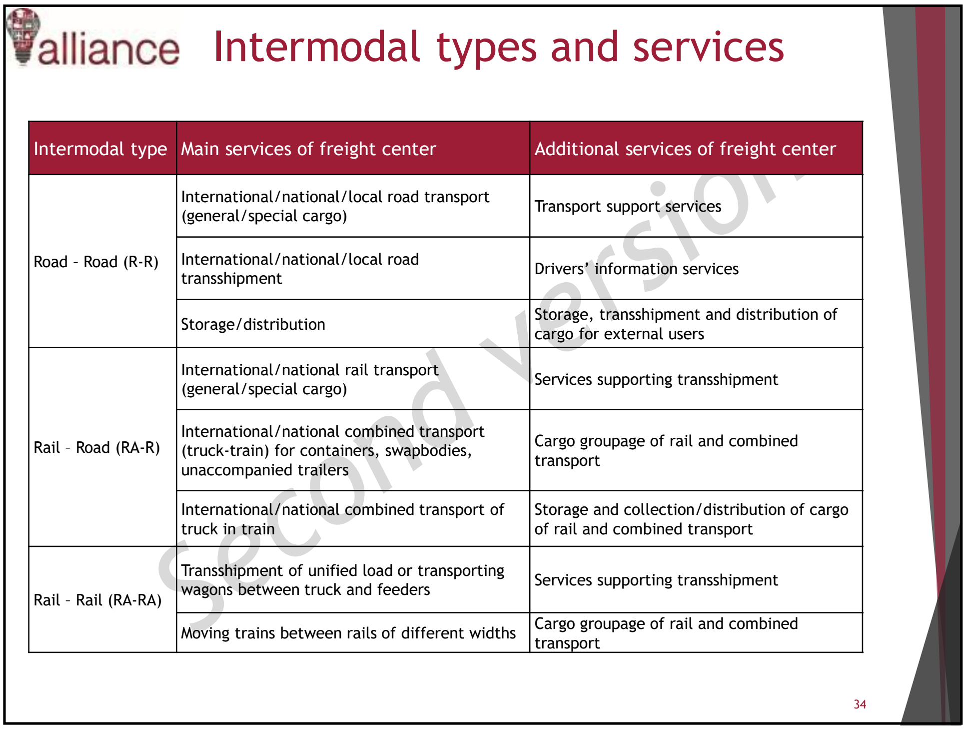
Intermodal operation of a freight center

- The combination of transportation modes at each interchange determines its intermodal operation
- Interoperation among the different modes should be taken for granted:
  - Scope of the provided operations, expressed by the range and potential of specialization of the services provided (operational scope)
  - Provided transport options, expressed by the type of intermodal nodes resulting from the various combinations of transportation modes (intermodal operation)
  - Influence scope of the interchange, expressed by the geographic role it has in relation to the provided services (geographical scope)



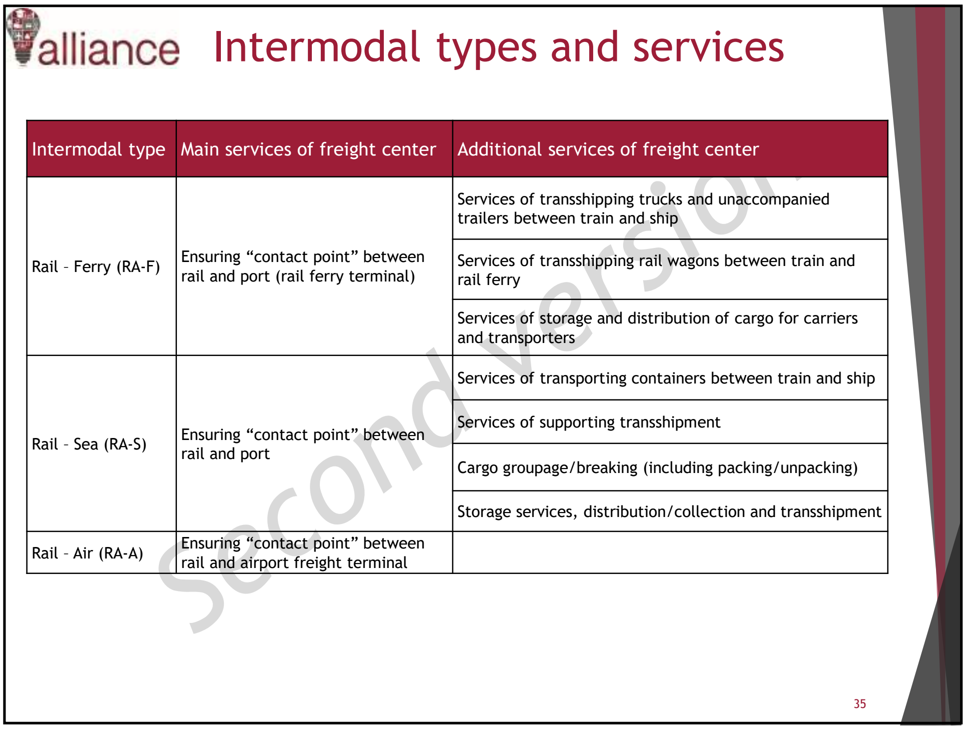
Transportation modes

- Road transport (R): trucks, combination of trailer and traction unit
- Rail transport (RA): rail wagons with unified load
- Ferry transport (F): transported trucks, containers, etc.
- Sea transport (S): container ships
- Air transport (A): freighters, passenger airplanes with potential freight transport



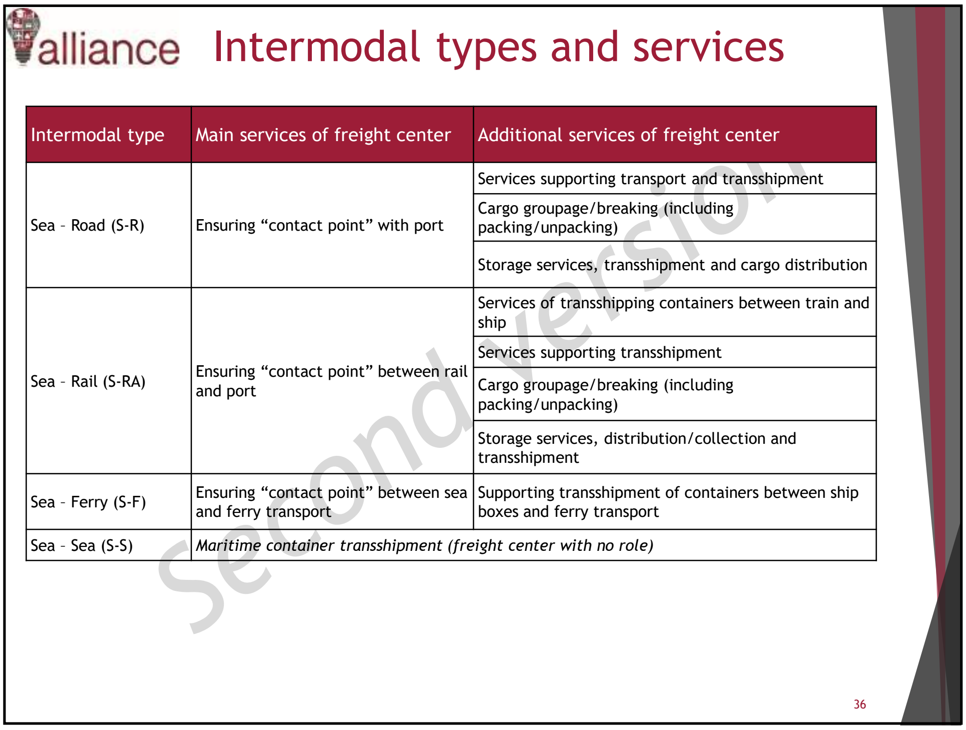
Intermodal types and services

Intermodal type	Main services of freight center	Additional services of freight center
Road - Road (R-R)	International/national/local road transport (general/special cargo)	Transport support services
	International/national/local road transshipment	Drivers' information services
	Storage/distribution	Storage, transshipment and distribution of cargo for external users
Rail - Road (RA-R)	International/national rail transport (general/special cargo)	Services supporting transshipment
	International/national combined transport (truck-train) for containers, swapbodies, unaccompanied trailers	Cargo groupage of rail and combined transport
	International/national combined transport of truck in train	Storage and collection/distribution of cargo of rail and combined transport
Rail - Rail (RA-RA)	Transshipment of unified load or transporting wagons between truck and feeders	Services supporting transshipment
	Moving trains between rails of different widths	Cargo groupage of rail and combined transport



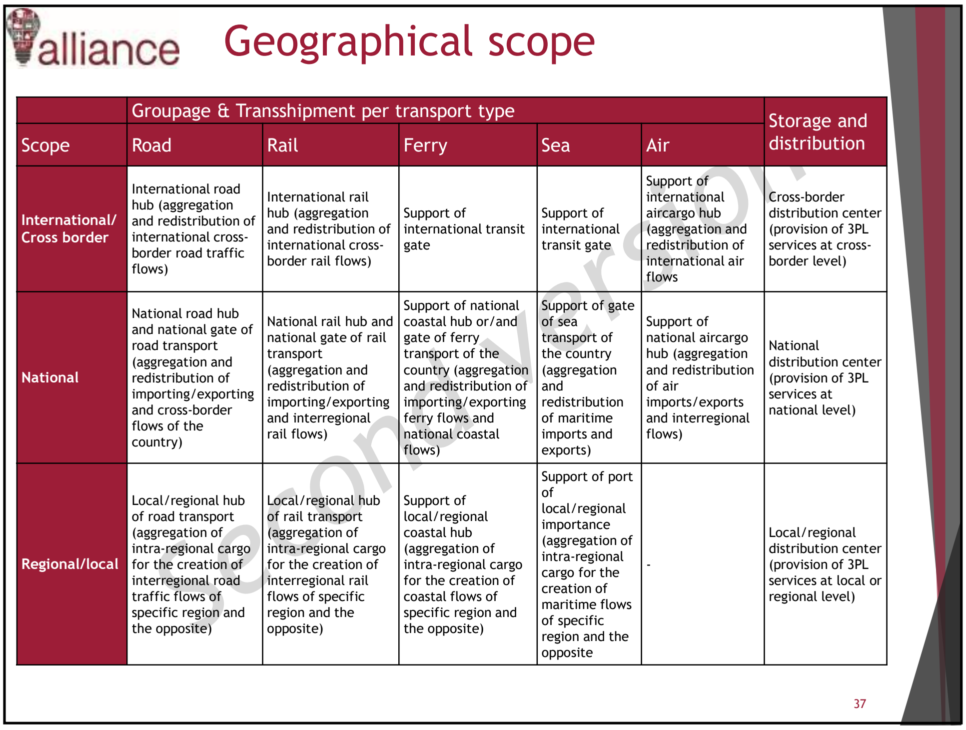
Intermodal types and services

Intermodal type	Main services of freight center	Additional services of freight center
Rail – Ferry (RA-F)	Ensuring “contact point” between rail and port (rail ferry terminal)	Services of transshipping trucks and unaccompanied trailers between train and ship
		Services of transshipping rail wagons between train and rail ferry
		Services of storage and distribution of cargo for carriers and transporters
Rail – Sea (RA-S)	Ensuring “contact point” between rail and port	Services of transporting containers between train and ship
		Services of supporting transshipment
		Cargo groupage/breaking (including packing/unpacking)
		Storage services, distribution/collection and transshipment
Rail – Air (RA-A)	Ensuring “contact point” between rail and airport freight terminal	



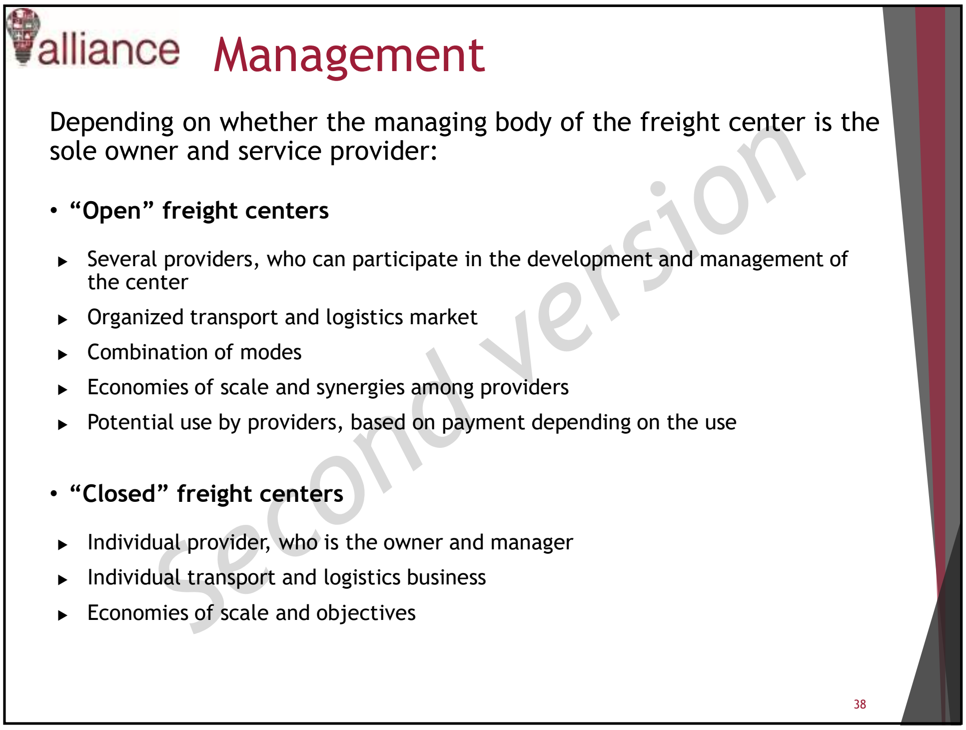
Intermodal types and services

Intermodal type	Main services of freight center	Additional services of freight center
Sea – Road (S-R)	Ensuring “contact point” with port	Services supporting transport and transshipment
		Cargo groupage/breaking (including packing/unpacking)
		Storage services, transshipment and cargo distribution
Sea – Rail (S-RA)	Ensuring “contact point” between rail and port	Services of transshipping containers between train and ship
		Services supporting transshipment
		Cargo groupage/breaking (including packing/unpacking)
		Storage services, distribution/collection and transshipment
Sea – Ferry (S-F)	Ensuring “contact point” between sea and ferry transport	Supporting transshipment of containers between ship boxes and ferry transport
Sea – Sea (S-S)	*Maritime container transshipment (freight center with no role)*	



Geographical scope

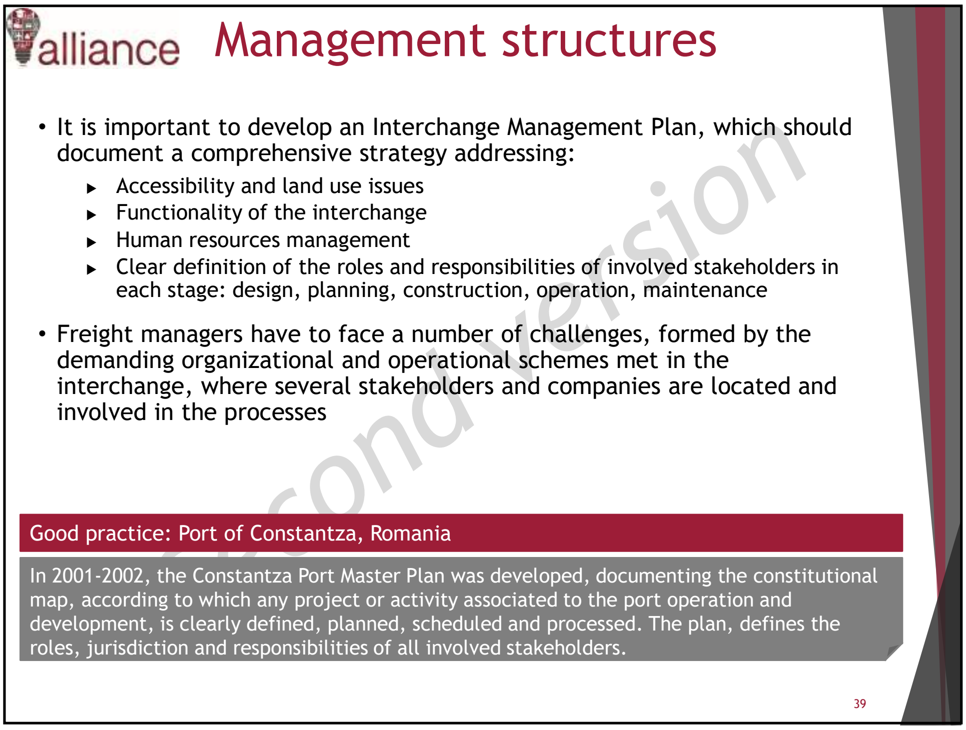
	Groupage & Transshipment per transport type					Storage and distribution
Scope	Road	Rail	Ferry	Sea	Air	
International/ Cross border	International road hub (aggregation and redistribution of international cross-border road traffic flows)	International rail hub (aggregation and redistribution of international cross-border rail flows)	Support of international transit gate	Support of international transit gate	Support of international aircargo hub (aggregation and redistribution of international air flows	Cross-border distribution center (provision of 3PL services at cross-border level)
National	National road hub and national gate of road transport (aggregation and redistribution of importing/exporting and cross-border flows of the country)	National rail hub and national gate of rail transport (aggregation and redistribution of importing/exporting and interregional rail flows)	Support of national coastal hub or/and gate of ferry transport of the country (aggregation and redistribution of importing/exporting ferry flows and national coastal flows)	Support of gate of sea transport of the country (aggregation and redistribution of maritime imports and exports)	Support of national aircargo hub (aggregation and redistribution of air imports/exports and interregional flows)	National distribution center (provision of 3PL services at national level)
Regional/local	Local/regional hub of road transport (aggregation of intra-regional cargo for the creation of interregional road traffic flows of specific region and the opposite)	Local/regional hub of rail transport (aggregation of intra-regional cargo for the creation of interregional rail flows of specific region and the opposite)	Support of local/regional coastal hub (aggregation of intra-regional cargo for the creation of coastal flows of specific region and the opposite)	Support of port of local/regional importance (aggregation of intra-regional cargo for the creation of maritime flows of specific region and the opposite	-	Local/regional distribution center (provision of 3PL services at local or regional level)



Management

Depending on whether the managing body of the freight center is the sole owner and service provider:

- **"Open" freight centers**
  - Several providers, who can participate in the development and management of the center
  - Organized transport and logistics market
  - Combination of modes
  - Economies of scale and synergies among providers
  - Potential use by providers, based on payment depending on the use
- **"Closed" freight centers**
  - Individual provider, who is the owner and manager
  - Individual transport and logistics business
  - Economies of scale and objectives

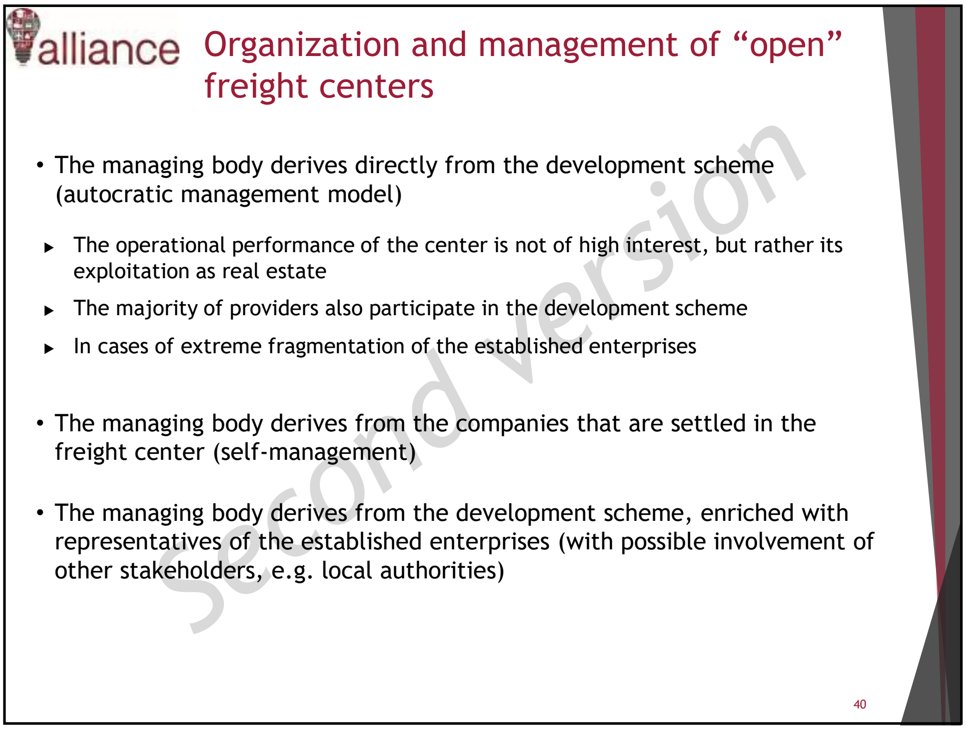


Management structures

- It is important to develop an Interchange Management Plan, which should document a comprehensive strategy addressing:
  - Accessibility and land use issues
  - Functionality of the interchange
  - Human resources management
  - Clear definition of the roles and responsibilities of involved stakeholders in each stage: design, planning, construction, operation, maintenance
- Freight managers have to face a number of challenges, formed by the demanding organizational and operational schemes met in the interchange, where several stakeholders and companies are located and involved in the processes

Good practice: Port of Constantza, Romania

In 2001-2002, the Constantza Port Master Plan was developed, documenting the constitutional map, according to which any project or activity associated to the port operation and development, is clearly defined, planned, scheduled and processed. The plan, defines the roles, jurisdiction and responsibilities of all involved stakeholders.



Organization and management of “open” freight centers

- The managing body derives directly from the development scheme (autocratic management model)
  - The operational performance of the center is not of high interest, but rather its exploitation as real estate
  - The majority of providers also participate in the development scheme
  - In cases of extreme fragmentation of the established enterprises
- The managing body derives from the companies that are settled in the freight center (self-management)
- The managing body derives from the development scheme, enriched with representatives of the established enterprises (with possible involvement of other stakeholders, e.g. local authorities)

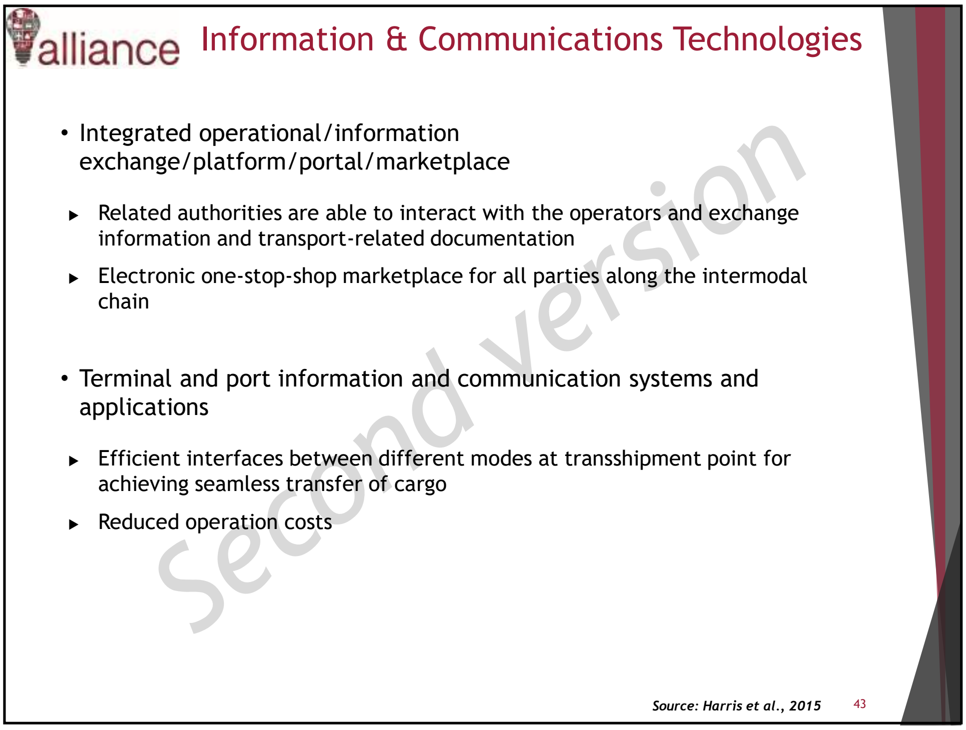
Responsibilities of the managing body

- Development and maintenance of basic infrastructure and sale/lease of real estate
- Provision of infrastructure services, e.g. electrification, water supply, waste collection, basic telecommunication infrastructure, cleaning, security, etc.
- Marketing: promotion of the services and provisions, with an emphasis on the sale/lease of land, in order to attract users/cargo
- Provision of technical support to established companies
- Provision of advisory services in the development of new freight centers
- Initiatives and development of synergies for established enterprises, e.g. shared use of internal cargo equipment, shared urban distribution
- Participation in the most profitable synergies of the established enterprises

Information & Communications Technologies

- Freight resource management systems and applications
  - Better operational efficiency
  - Reduced empty runs through better route planning
  - Improved customer satisfaction
- Freight and fleet tracking and management systems and applications
  - Operators are able to monitor and manage the cargo and vehicle, and to obtain up-to-date information
  - Improved utilization of intermodal terminal infrastructure
  - Improved security and safety processes

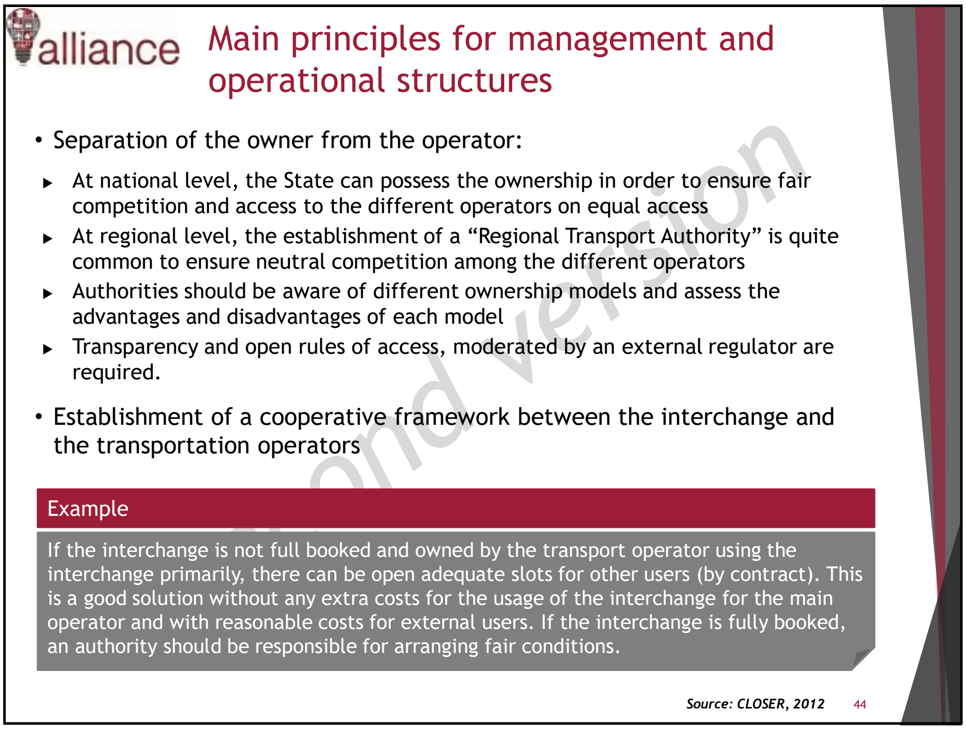
Source: Harris et al., 2015



Information & Communications Technologies

- Integrated operational/information exchange/platform/portal/marketplace
  - Related authorities are able to interact with the operators and exchange information and transport-related documentation
  - Electronic one-stop-shop marketplace for all parties along the intermodal chain
- Terminal and port information and communication systems and applications
  - Efficient interfaces between different modes at transshipment point for achieving seamless transfer of cargo
  - Reduced operation costs

Source: Harris et al., 2015



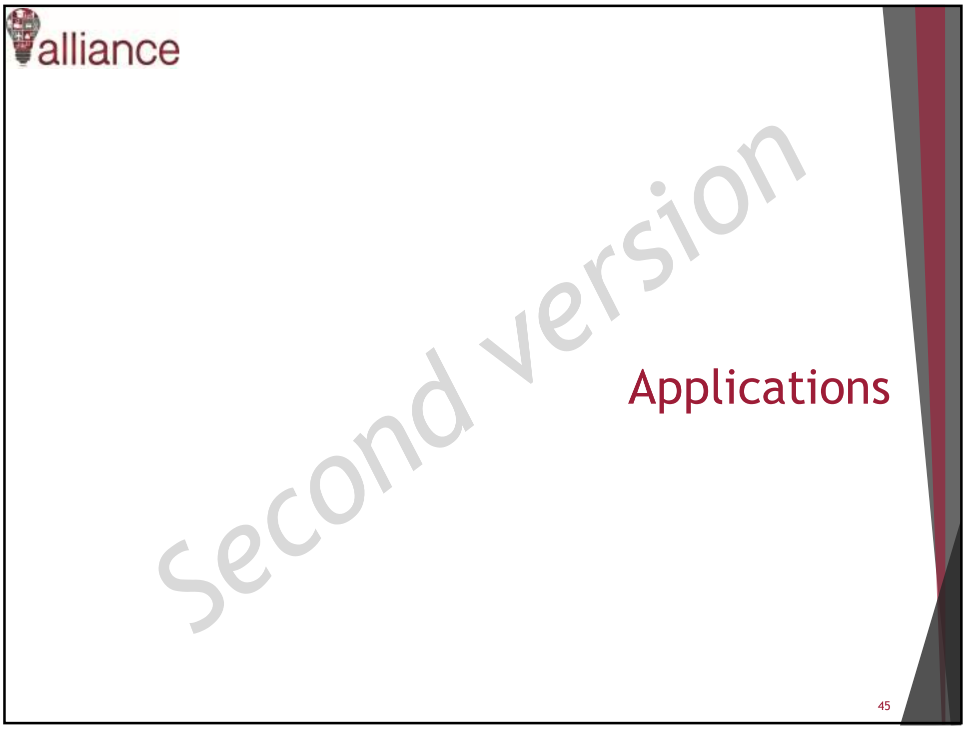
Main principles for management and operational structures

- Separation of the owner from the operator:
  - At national level, the State can possess the ownership in order to ensure fair competition and access to the different operators on equal access
  - At regional level, the establishment of a “Regional Transport Authority” is quite common to ensure neutral competition among the different operators
  - Authorities should be aware of different ownership models and assess the advantages and disadvantages of each model
  - Transparency and open rules of access, moderated by an external regulator are required.
- Establishment of a cooperative framework between the interchange and the transportation operators

Example

If the interchange is not full booked and owned by the transport operator using the interchange primarily, there can be open adequate slots for other users (by contract). This is a good solution without any extra costs for the usage of the interchange for the main operator and with reasonable costs for external users. If the interchange is fully booked, an authority should be responsible for arranging fair conditions.

Source: CLOSER, 2012



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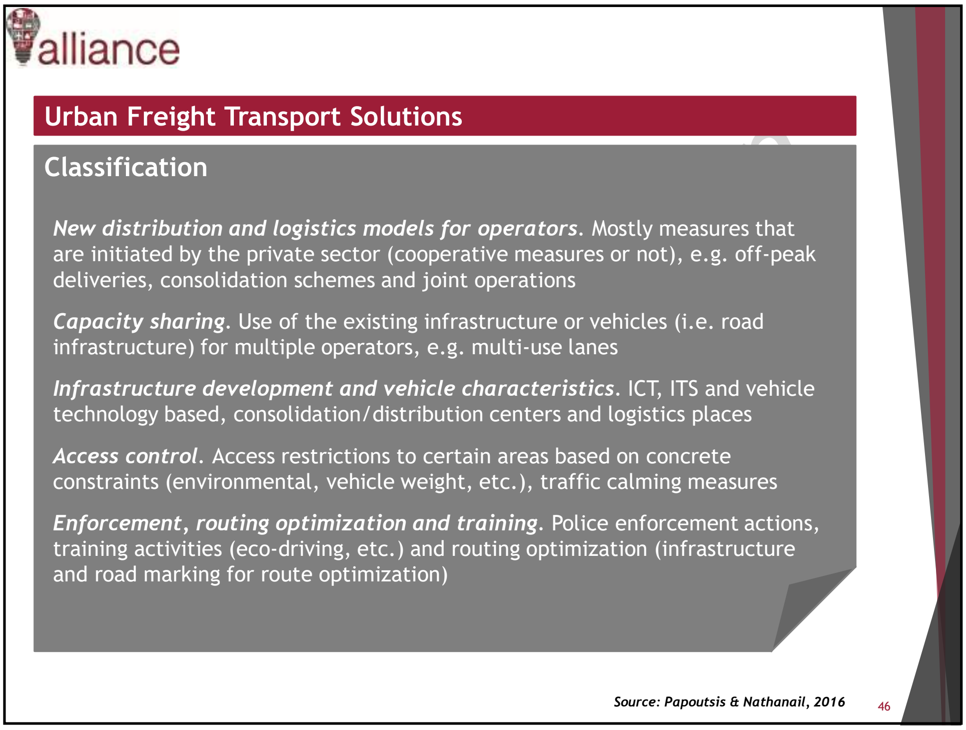
Applications



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Urban Freight Transport Solutions

Classification

New distribution and logistics models for operators. Mostly measures that are initiated by the private sector (cooperative measures or not), e.g. off-peak deliveries, consolidation schemes and joint operations

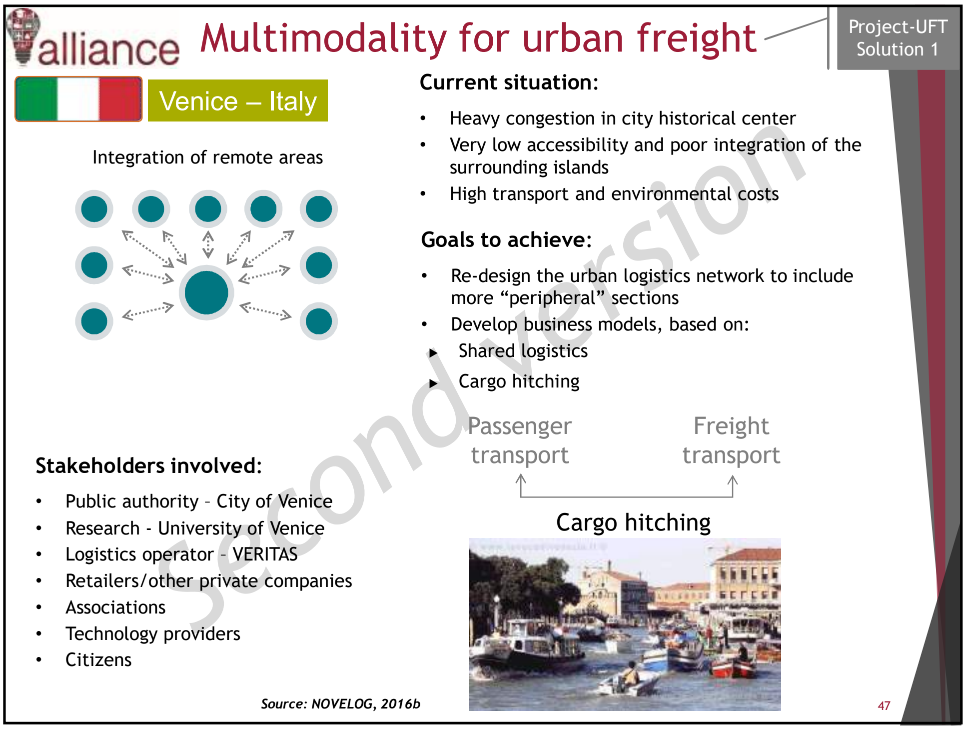
Capacity sharing. Use of the existing infrastructure or vehicles (i.e. road infrastructure) for multiple operators, e.g. multi-use lanes

Infrastructure development and vehicle characteristics. ICT, ITS and vehicle technology based, consolidation/distribution centers and logistics places

Access control. Access restrictions to certain areas based on concrete constraints (environmental, vehicle weight, etc.), traffic calming measures

Enforcement, routing optimization and training. Police enforcement actions, training activities (eco-driving, etc.) and routing optimization (infrastructure and road marking for route optimization)

Source: Papoutsis & Nathanail, 2016



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Multimodality for urban freight

Project-UFT
Solution 1

Venice – Italy

Integration of remote areas

Current situation:

- Heavy congestion in city historical center
- Very low accessibility and poor integration of the surrounding islands
- High transport and environmental costs

Goals to achieve:

- Re-design the urban logistics network to include more "peripheral" sections
- Develop business models, based on:
  - Shared logistics
  - Cargo hitching

Passenger transport

Freight transport

Cargo hitching

Stakeholders involved:

- Public authority - City of Venice
- Research - University of Venice
- Logistics operator - VERITAS
- Retailers/other private companies
- Associations
- Technology providers
- Citizens

Source: NOVELOG, 2016b

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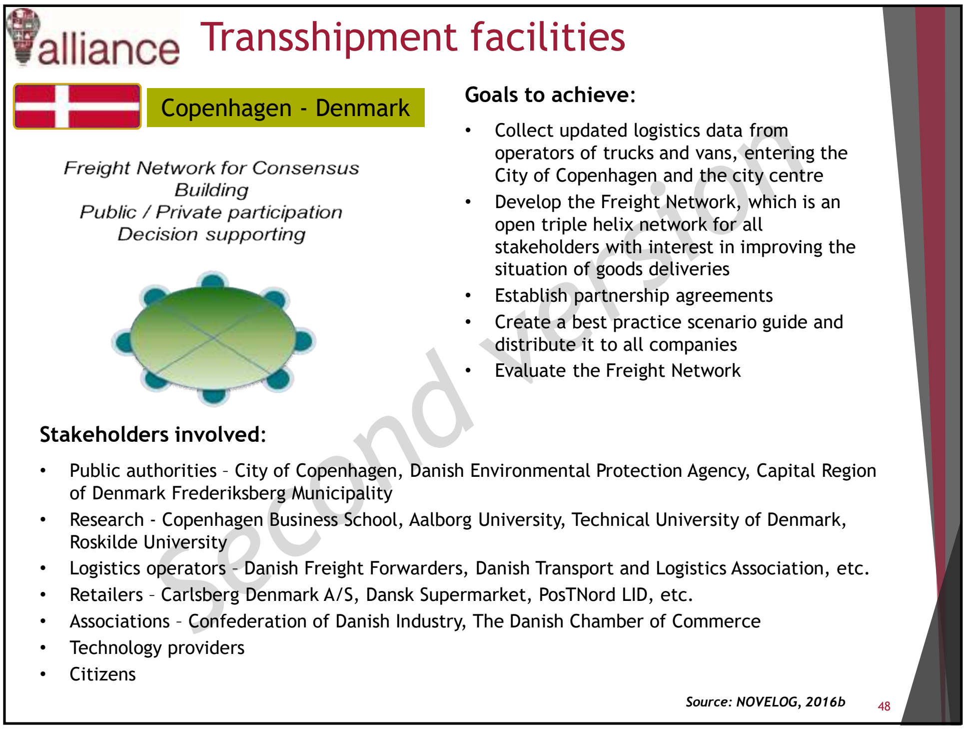

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Transshipment facilities

Copenhagen - Denmark

Freight Network for Consensus Building
Public / Private participation
Decision supporting

Goals to achieve:

- Collect updated logistics data from operators of trucks and vans, entering the City of Copenhagen and the city centre
- Develop the Freight Network, which is an open triple helix network for all stakeholders with interest in improving the situation of goods deliveries
- Establish partnership agreements
- Create a best practice scenario guide and distribute it to all companies
- Evaluate the Freight Network

Stakeholders involved:

- Public authorities – City of Copenhagen, Danish Environmental Protection Agency, Capital Region of Denmark Frederiksberg Municipality
- Research - Copenhagen Business School, Aalborg University, Technical University of Denmark, Roskilde University
- Logistics operators - Danish Freight Forwarders, Danish Transport and Logistics Association, etc.
- Retailers – Carlsberg Denmark A/S, Dansk Supermarket, PosTNord LID, etc.
- Associations – Confederation of Danish Industry, The Danish Chamber of Commerce
- Technology providers
- Citizens

Source: NOVELOG, 2016b

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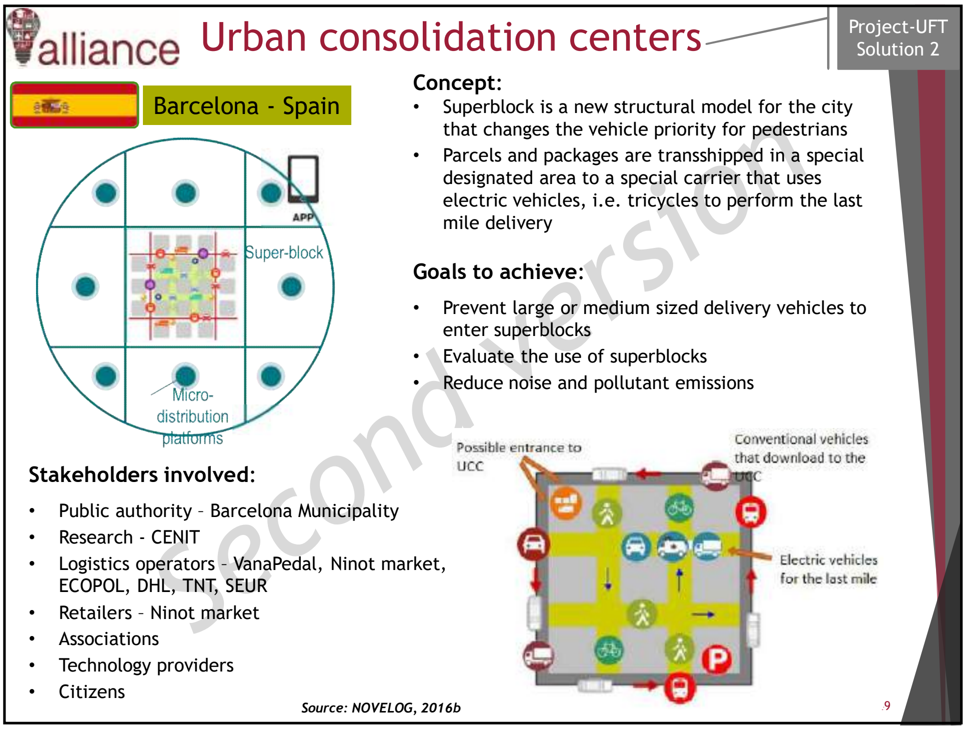


Urban consolidation centers

Project-UFT
Solution 2

Barcelona - Spain

Concept:

- Superblock is a new structural model for the city that changes the vehicle priority for pedestrians
- Parcels and packages are transshipped in a special designated area to a special carrier that uses electric vehicles, i.e. tricycles to perform the last mile delivery

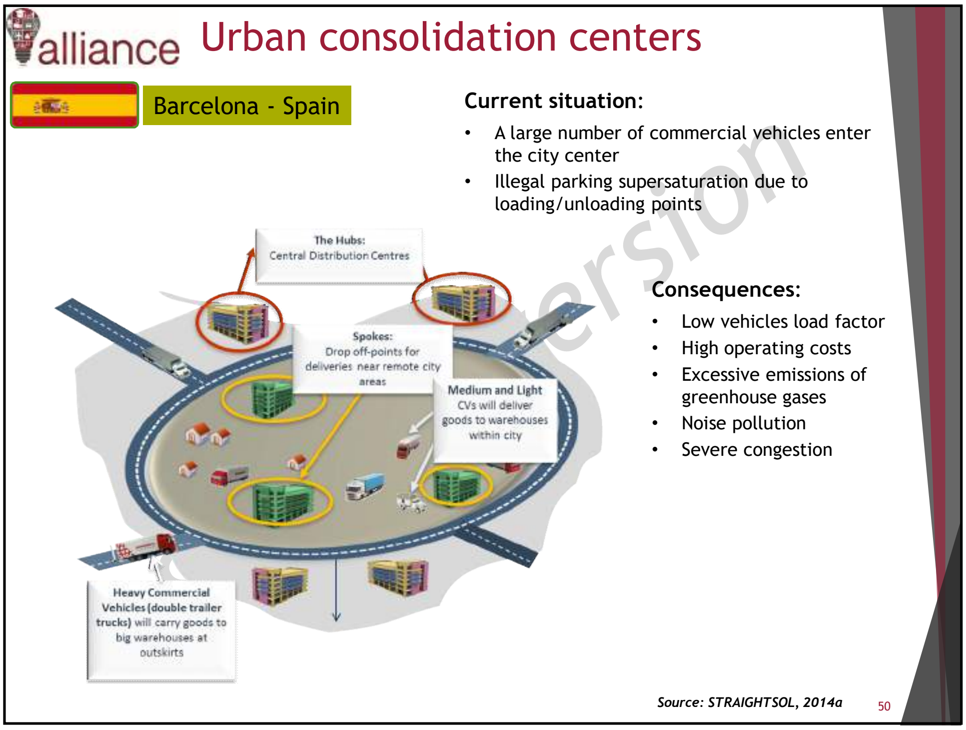
Goals to achieve:

- Prevent large or medium sized delivery vehicles to enter superblocks
- Evaluate the use of superblocks
- Reduce noise and pollutant emissions

Stakeholders involved:

- Public authority – Barcelona Municipality
- Research - CENIT
- Logistics operators – VanaPedal, Ninot market, ECOPOL, DHL, TNT, SEUR
- Retailers – Ninot market
- Associations
- Technology providers
- Citizens

Source: NOVELOG, 2016b



Urban consolidation centers

Barcelona - Spain

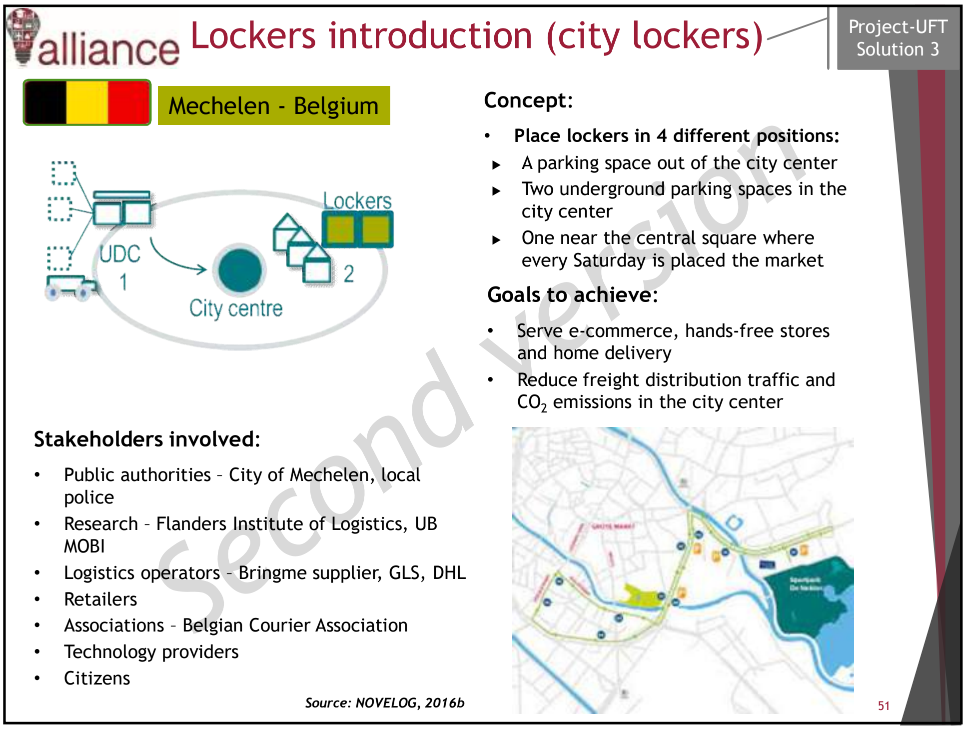
Current situation:

- A large number of commercial vehicles enter the city center
- Illegal parking supersaturation due to loading/unloading points

Consequences:

- Low vehicles load factor
- High operating costs
- Excessive emissions of greenhouse gases
- Noise pollution
- Severe congestion

Source: STRAIGHTSOL, 2014a



Lockers introduction (city lockers)

Mechelen - Belgium

Concept:

- **Place lockers in 4 different positions:**
  - A parking space out of the city center
  - Two underground parking spaces in the city center
  - One near the central square where every Saturday is placed the market

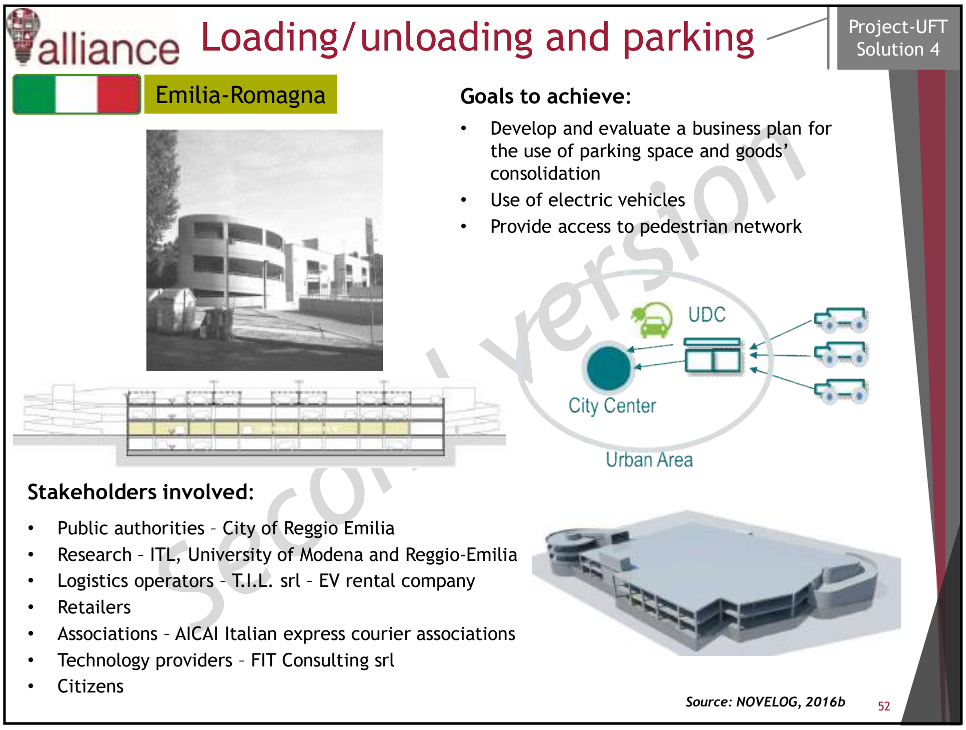
Goals to achieve:

- Serve e-commerce, hands-free stores and home delivery
- Reduce freight distribution traffic and CO_2 emissions in the city center

Stakeholders involved:

- Public authorities – City of Mechelen, local police
- Research – Flanders Institute of Logistics, UB MOBI
- Logistics operators – Bringme supplier, GLS, DHL
- Retailers
- Associations – Belgian Courier Association
- Technology providers
- Citizens

Source: NOVELOG, 2016b



Loading/unloading and parking

Emilia-Romagna

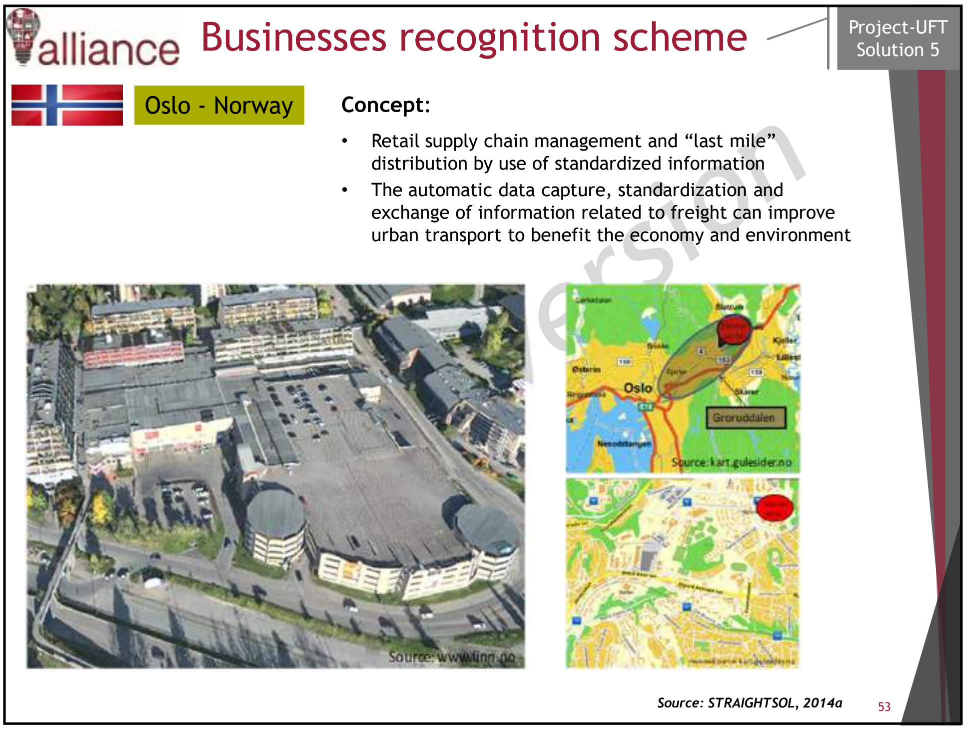
Goals to achieve:

- Develop and evaluate a business plan for the use of parking space and goods' consolidation
- Use of electric vehicles
- Provide access to pedestrian network

Stakeholders involved:

- Public authorities – City of Reggio Emilia
- Research – ITL, University of Modena and Reggio-Emilia
- Logistics operators – T.I.L. srl – EV rental company
- Retailers
- Associations – AICAI Italian express courier associations
- Technology providers – FIT Consulting srl
- Citizens

Source: NOVELOG, 2016b



Businesses recognition scheme

Oslo - Norway

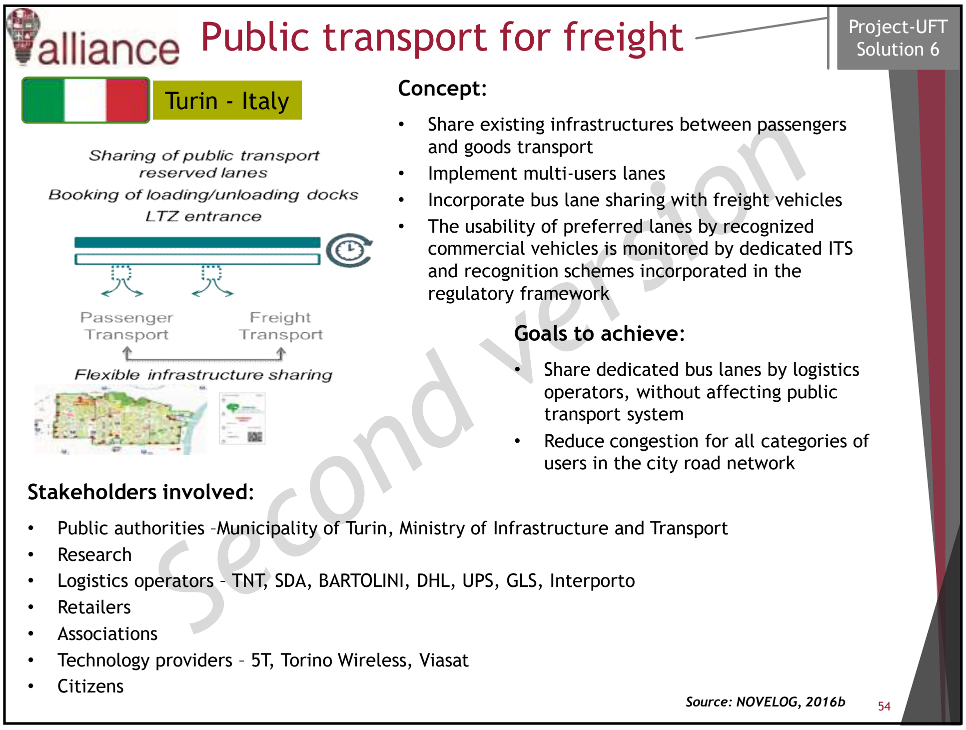
Concept:

- Retail supply chain management and "last mile" distribution by use of standardized information
- The automatic data capture, standardization and exchange of information related to freight can improve urban transport to benefit the economy and environment

Source: www.finn.no

Source: kart.gulesider.no

Source: STRAIGHTSOL, 2014a



Public transport for freight

Turin - Italy

Sharing of public transport reserved lanes

Booking of loading/unloading docks

LTZ entrance

Passenger Transport

Freight Transport

Flexible infrastructure sharing

Concept:

- Share existing infrastructures between passengers and goods transport
- Implement multi-users lanes
- Incorporate bus lane sharing with freight vehicles
- The usability of preferred lanes by recognized commercial vehicles is monitored by dedicated ITS and recognition schemes incorporated in the regulatory framework

Goals to achieve:

- Share dedicated bus lanes by logistics operators, without affecting public transport system
- Reduce congestion for all categories of users in the city road network

Stakeholders involved:

- Public authorities –Municipality of Turin, Ministry of Infrastructure and Transport
- Research
- Logistics operators – TNT, SDA, BARTOLINI, DHL, UPS, GLS, Interporto
- Retailers
- Associations
- Technology providers – 5T, Torino Wireless, Viasat
- Citizens

Source: NOVELOG, 2016b

alliance

Remote monitoring

Project-UFT
Solution 7

United Kingdom

Concept:

- Remote “bring-site” monitoring for more reactive and sustainable logistics
- Use of monitoring sensors placed in charity textile and book donation banks to provide twice-daily reports about the fill level of the banks
- Remote sensor data allow dynamic and more effective collection schedules to be devised, focusing on banks that are nearly full

-OXFAM collecting banks-

Source: smartbin.com

Objectives of OXFAM (collector and receiver of goods):

- Maximize profit, which involves a trade-off between the amount of money gained through sales of donated goods and its operating costs in doing so
- Maintain clean and tidy sites
- Improve security (reduce thefts)
- Provide adequate space in bins to allow people to donate

Source: STRAIGHTSOL, 2014a

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alliance

Case study #1

Kuehne+Nagel rail tracking and warehouse management demonstration

-Kuehne+Nagel warehouse in Sindos terminal-

The interchange

- The Kuehne-Nagel (K+N)-rail tracking and warehouse management demonstration involves the international cargo assignment from Central Europe to Greece for final, urban distribution of goods
- The transportation comprises two discrete, but successive legs:
  - 1st leg: Interurban-urban rail transport of goods from Central Europe to K+N premises in Sindos, Thessaloniki, Greece
  - 2nd leg: Urban distribution of goods (last mile delivery) by truck in Thessaloniki

-1st Leg of transportation chain-

Source: *STRAIGHTSOL, 2014a*

-Lorries performing the "last-mile" distribution-

The demonstration

- The goods are transported by rail from Sopron, Hungary to K+N's terminal, specifically a logistics centre owned by K+N in the industrial area of Thessaloniki (Sindos)
- The cargo is transported in block trains formed in Sopron, Hungary, and then reformed in other junction points (Kelebia and Belgrade) of the railway network
- In particular, the demonstration is elaborated in Thessaloniki Greater Area (including city centre and interurban area) and K+N's terminal and warehouse facilities in Sindos, 20km away from Thessaloniki
- The demonstration area is approximately 3,000 km^2 including the urban area of Thessaloniki (1,455.62 km^2) and also the industrial interurban area of Sindos (1,500 km^2) where the last-mile operations of K+N take place
- K+N's terminal, SRS (Sindos Railway Services) engages a total area of 5000 m^2

Source: STRAIGHTSOL, 2014a

alliance Geographical area characteristics

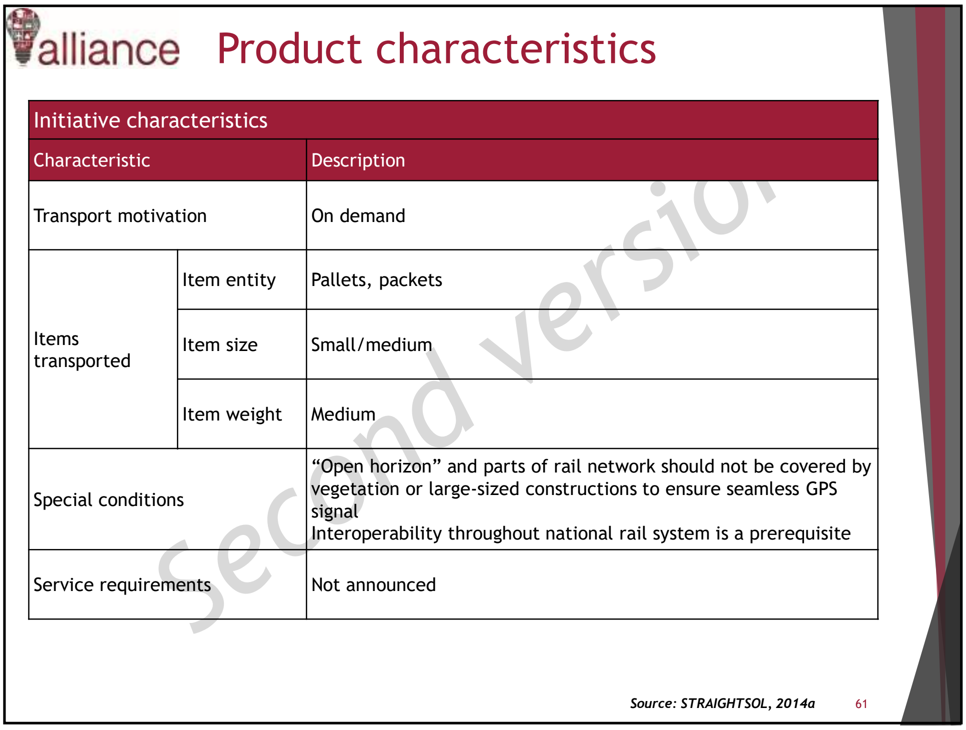
Geographical area characteristics		
Characteristic		Description
Demonstration area		International rail network, including rail freight trips that depart from Austria and end up to K+N terminal in Sindos, outside of Thessaloniki city
Urban characteristics	Size of urban area	Urban area does not correspond directly to the demonstration However, the size is medium
	Commercial density of urban area	Medium
	City homogeneity	Low
	Road network layout	Mono-centric city Not specific road network layout, but close to radial
	City type	Many types of city within urban area
Level of congestion		High
Level of compliance with regulations		Low
Restrictions applied		Restricted access to bus lanes, but not specific area access restrictions

Source: STRAIGHTSOL, 2014a

alliance Initiative characteristics

Initiative characteristics		
Characteristic		Description
Transport mode		2 transport legs: the basic one is rail wagons and impacts affect the "last-mile" distribution (trucks)
Supplementary measures and infrastructure needs		The rail network included in the demonstration area should not be covered with high, continuous vegetation "Open horizon" is needed for GPS connection success
Type of receivers		The final receivers are retailers Truck operators, who perform the 2nd leg of transport, can also be considered as receivers Citizens, who purchase from retail can also be considered indirectly as receivers
Receiver accessibility		Very limited loading bays and dedicated loading spaces lead to major traffic congestion
Stakeholders	Stakeholder participation	Logistics service provider, truck operators local rail authorities, shippers
	Stakeholder requirements	Logistics service providers, local rail authorities

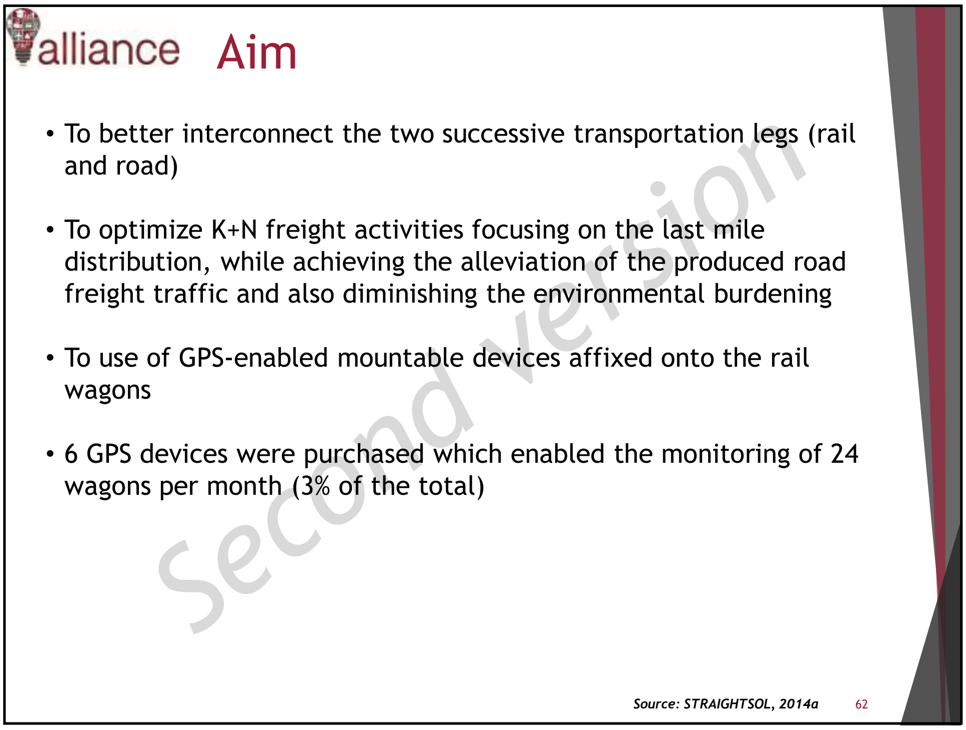
Source: STRAIGHTSOL, 2014a



Product characteristics

Initiative characteristics		
Characteristic		Description
Transport motivation		On demand
Items transported	Item entity	Pallets, packets
	Item size	Small/medium
	Item weight	Medium
Special conditions		“Open horizon” and parts of rail network should not be covered by vegetation or large-sized constructions to ensure seamless GPS signal Interoperability throughout national rail system is a prerequisite
Service requirements		Not announced

Source: STRAIGHTSOL, 2014a



Aim

- To better interconnect the two successive transportation legs (rail and road)
- To optimize K+N freight activities focusing on the last mile distribution, while achieving the alleviation of the produced road freight traffic and also diminishing the environmental burdening
- To use of GPS-enabled mountable devices affixed onto the rail wagons
- 6 GPS devices were purchased which enabled the monitoring of 24 wagons per month (3% of the total)

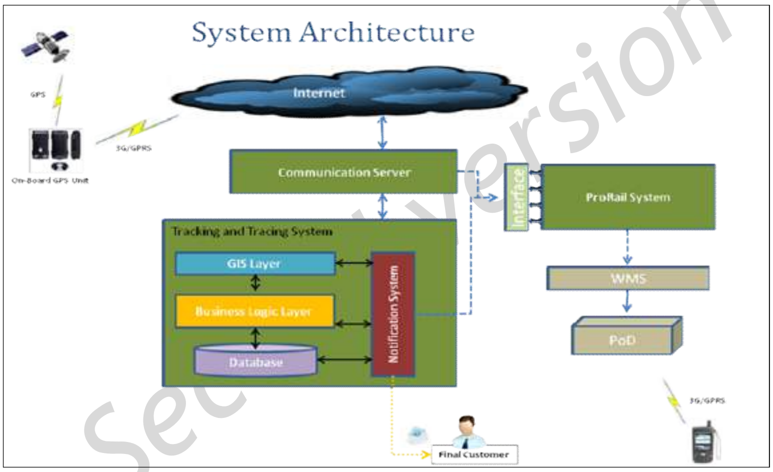
Source: STRAIGHTSOL, 2014a

Involved stakeholders

- K+N, as logistics service provider
- Customers of K+N (shippers or shipping companies and receivers of goods)
- Rail authorities, as infrastructure and equipment providers
- Truck operators, as partners of K+N implementing the task of last mile distribution
- Public, as final receivers and also consumers of the transported goods

Source: STRAIGHTSOL, 2014a

Information collection



-Integrated information system’s architecture-

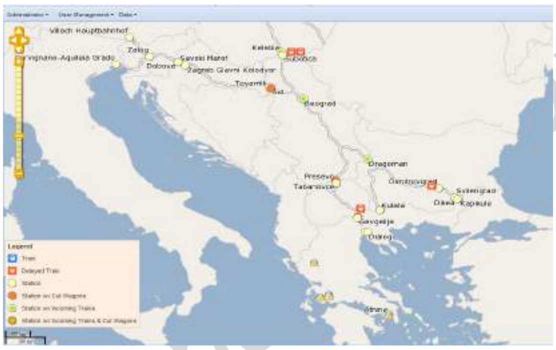
Source: STRAIGHTSOL, 2014b

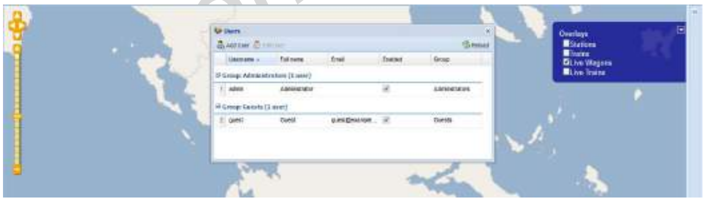
alliance Process

- The real time information on the location and status of the cargo is transmitted by the GPS devices affixed onto rail wagons
- This information is transferred via an internet platform and through the communication server it is recorded in K+N's database (ProRail system)
- The real time information is accessible both from the warehouses and everyone that is interested in the respective cargo assignment, including the final customers
- In case of emergency, K+N warehouse management system, and all involved stakeholders are notified in order to proceed to the respective corrective actions corresponding to the last mile distribution of goods
- The delivery of the freight transport commodities to the final customer is identified and reassured through the use of Personally Owned Devices (POD) interconnected to the whole information system, confirming the accomplishment of the freight assignment

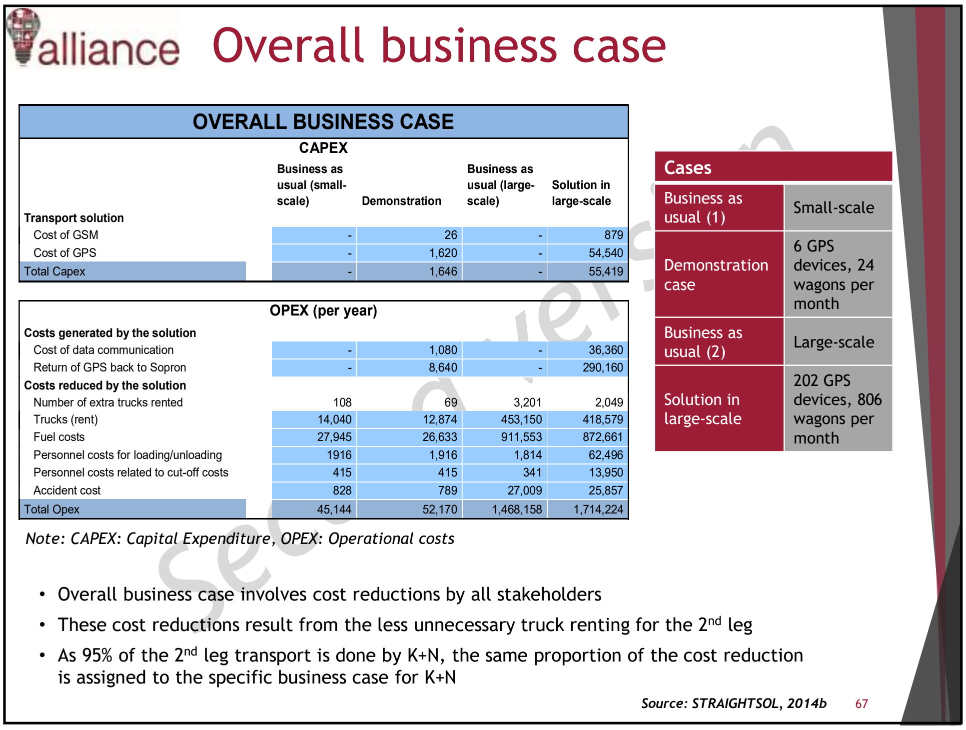
Source: STRAIGHTSOL, 2014b

alliance Tracking and tracing system





Source: STRAIGHTSOL, 2014b



Overall business case

OVERALL BUSINESS CASE

CAPEX

	Business as usual (small-scale)	Demonstration	Business as usual (large-scale)	Solution in large-scale
Transport solution				
Cost of GSM	-	26	-	879
Cost of GPS	-	1,620	-	54,540
Total Capex	-	1,646	-	55,419

OPEX (per year)

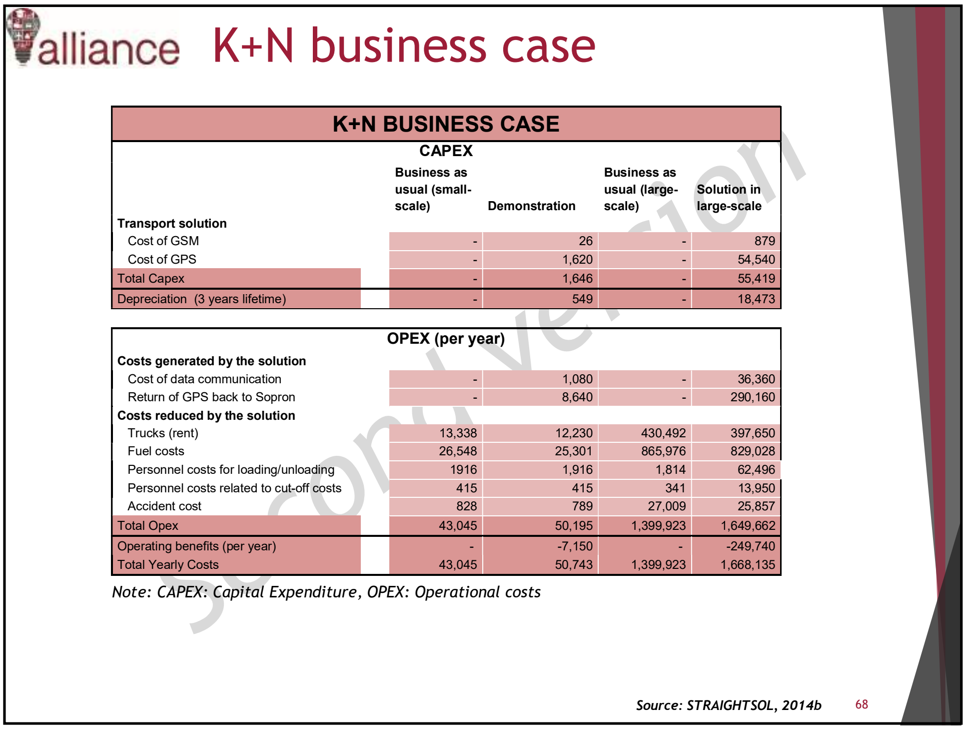
Costs generated by the solution				
Cost of data communication	-	1,080	-	36,360
Return of GPS back to Sopron	-	8,640	-	290,160
Costs reduced by the solution				
Number of extra trucks rented	108	69	3,201	2,049
Trucks (rent)	14,040	12,874	453,150	418,579
Fuel costs	27,945	26,633	911,553	872,661
Personnel costs for loading/unloading	1916	1,916	1,814	62,496
Personnel costs related to cut-off costs	415	415	341	13,950
Accident cost	828	789	27,009	25,857
Total Opex	45,144	52,170	1,468,158	1,714,224

Note: CAPEX: Capital Expenditure, OPEX: Operational costs

Cases	
Business as usual (1)	Small-scale
Demonstration case	6 GPS devices, 24 wagons per month
Business as usual (2)	Large-scale
Solution in large-scale	202 GPS devices, 806 wagons per month

- Overall business case involves cost reductions by all stakeholders
- These cost reductions result from the less unnecessary truck renting for the 2nd leg
- As 95% of the 2nd leg transport is done by K+N, the same proportion of the cost reduction is assigned to the specific business case for K+N

Source: STRAIGHTSOL, 2014b



K+N business case

K+N BUSINESS CASE

CAPEX

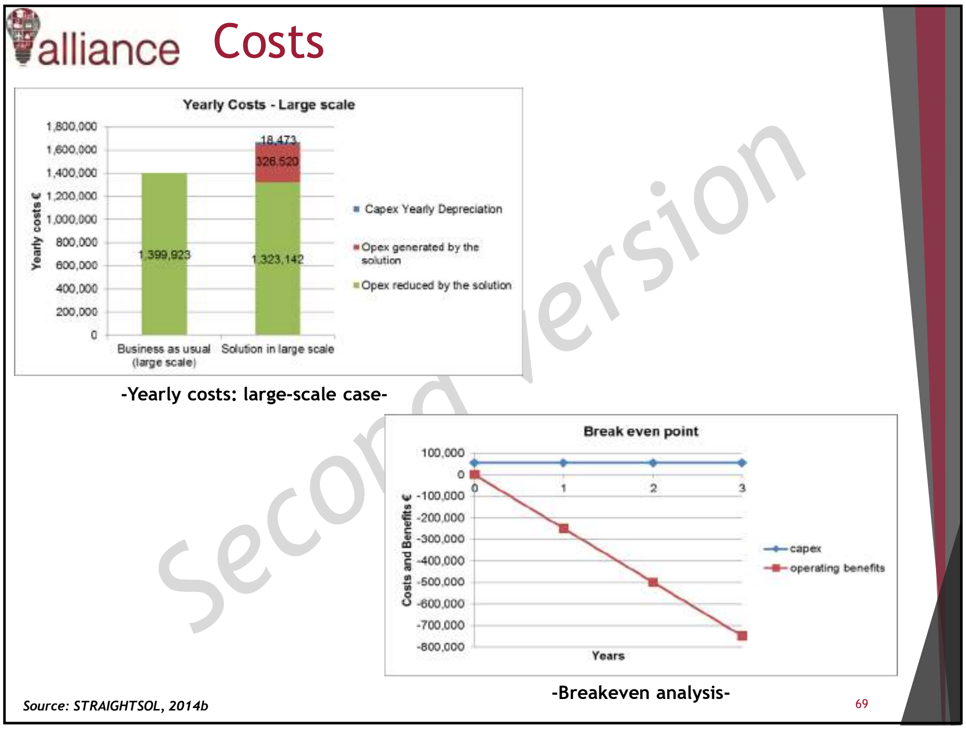
	Business as usual (small-scale)	Demonstration	Business as usual (large-scale)	Solution in large-scale
Transport solution				
Cost of GSM	-	26	-	879
Cost of GPS	-	1,620	-	54,540
Total Capex	-	1,646	-	55,419
Depreciation (3 years lifetime)	-	549	-	18,473

OPEX (per year)

Costs generated by the solution				
Cost of data communication	-	1,080	-	36,360
Return of GPS back to Sopron	-	8,640	-	290,160
Costs reduced by the solution				
Trucks (rent)	13,338	12,230	430,492	397,650
Fuel costs	26,548	25,301	865,976	829,028
Personnel costs for loading/unloading	1916	1,916	1,814	62,496
Personnel costs related to cut-off costs	415	415	341	13,950
Accident cost	828	789	27,009	25,857
Total Opex	43,045	50,195	1,399,923	1,649,662
Operating benefits (per year)	-	-7,150	-	-249,740
Total Yearly Costs	43,045	50,743	1,399,923	1,668,135

Note: CAPEX: Capital Expenditure, OPEX: Operational costs

Source: STRAIGHTSOL, 2014b

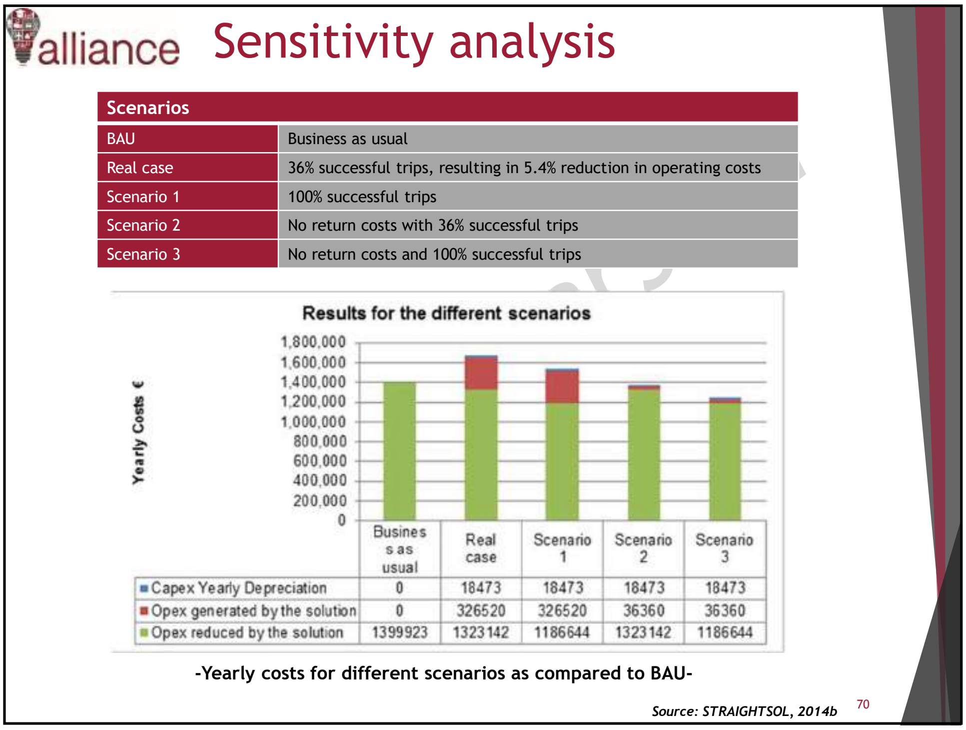


Costs

-Yearly costs: large-scale case-

-Breakeven analysis-

Source: STRAIGHTSOL, 2014b



Sensitivity analysis

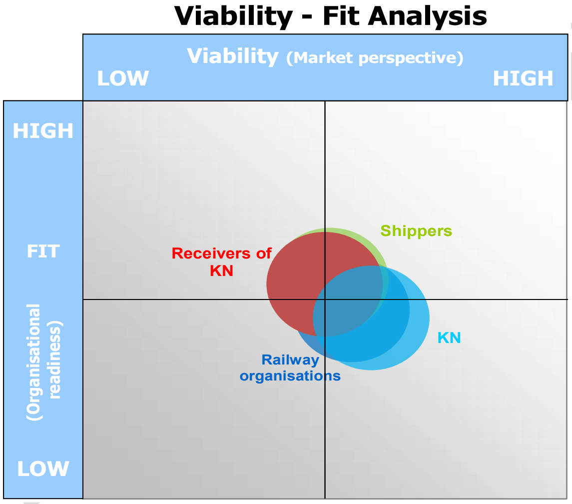
Scenarios	
BAU	Business as usual
Real case	36% successful trips, resulting in 5.4% reduction in operating costs
Scenario 1	100% successful trips
Scenario 2	No return costs with 36% successful trips
Scenario 3	No return costs and 100% successful trips

	Business as usual	Real case	Scenario 1	Scenario 2	Scenario 3
🟦 Capex Yearly Depreciation	0	18473	18473	18473	18473
🟥 Opex generated by the solution	0	326520	326520	36360	36360
🟩 Opex reduced by the solution	1399923	1323142	1186644	1323142	1186644

-Yearly costs for different scenarios as compared to BAU-

Source: STRAIGHTSOL, 2014b

Viability-Fit analysis



Note: Based on real case demonstration: 36% successful trips, GPS returned back to Sopron by airplane

Source: STRAIGHTSOL, 2014b

Viability-Fit analysis

- **Kuehne+Nagel**
  - scores positive for the market perspective, but negative for organisational readiness
  - scores positive for the market perspective, since the innovation brings an improvement to the value propositions of K+N like more automatic and accurate tracking of their goods
  - with the help of the new system K+N improves their customer contact as well which results in more customer satisfaction
- **Railway organisation**
  - scores positive for the market perspective because of exact same reasons as K+N
  - this innovation addresses a specific problem of their customers, namely renting trucks unnecessarily and not being able to inform the receivers timely
  - therefore, the innovation increases the customer satisfaction
  - however, railway organisations as well score negative for organisational fit, although not as negative as K+N

Source: STRAIGHTSOL, 2014b

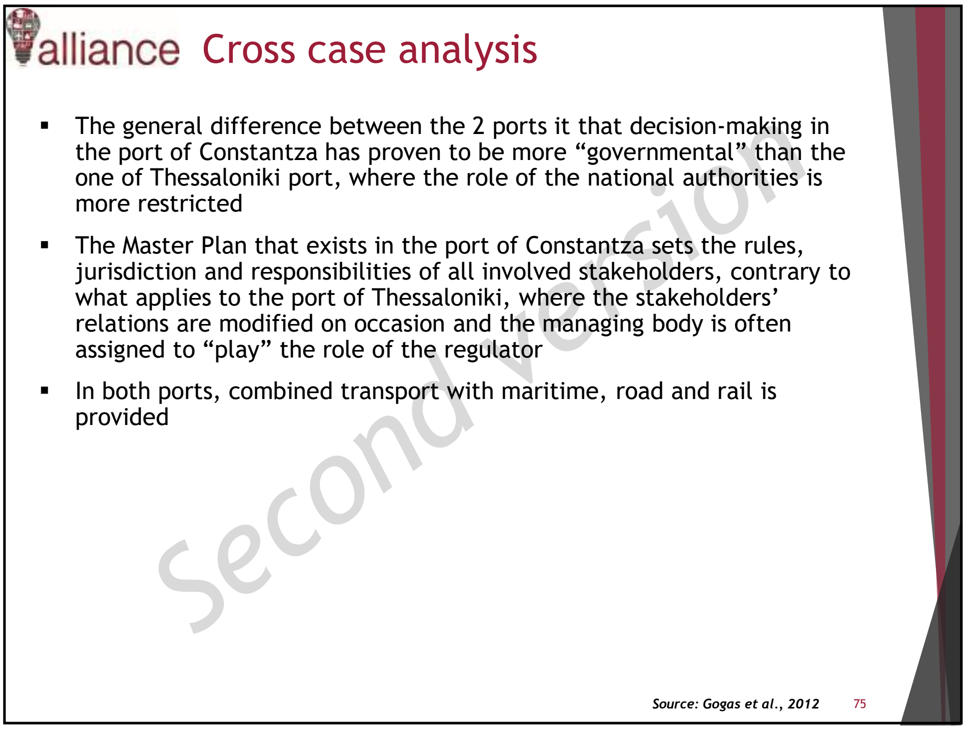
Viability-Fit analysis

- **Shippers (for the 2nd leg)**
  - score both for the market perspective and organisational fit positive, since with the innovation they avoid extra truck renting and they can keep their own customers informed about the delays
  - they experience only positive financial effects of the innovation
- **Receivers of K+N (at the end of 2nd leg)**
  - score positive for organisational aspects since with the innovation they can be timely informed about any delay of their goods and plan their activities accordingly
  - considering market perspective, receivers score neutral since the innovation does not have an impact on the customer segment and customer relations of the receivers

Source: STRAIGHTSOL, 2014b

Case study #2

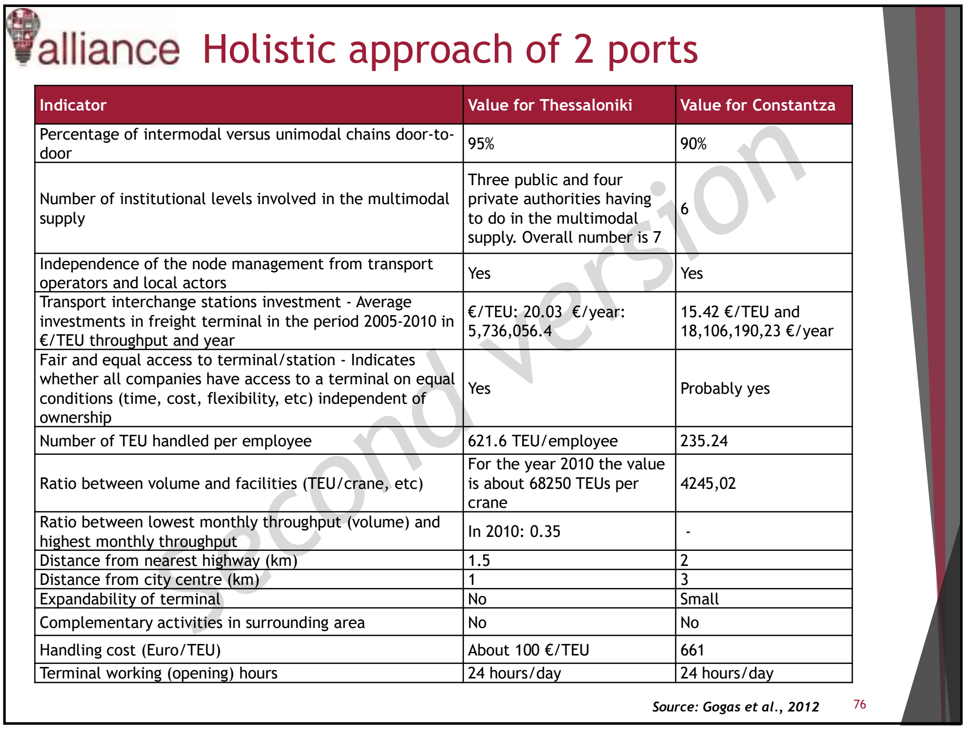
Cross-case comparison of Constantza Port, Romania and Thessaloniki Port, Greece



alliance Cross case analysis

- The general difference between the 2 ports it that decision-making in the port of Constantza has proven to be more “governmental” than the one of Thessaloniki port, where the role of the national authorities is more restricted
- The Master Plan that exists in the port of Constantza sets the rules, jurisdiction and responsibilities of all involved stakeholders, contrary to what applies to the port of Thessaloniki, where the stakeholders’ relations are modified on occasion and the managing body is often assigned to “play” the role of the regulator
- In both ports, combined transport with maritime, road and rail is provided

Source: Gogas et al., 2012



alliance Holistic approach of 2 ports

Indicator	Value for Thessaloniki	Value for Constantza
Percentage of intermodal versus unimodal chains door-to-door	95%	90%
Number of institutional levels involved in the multimodal supply	Three public and four private authorities having to do in the multimodal supply. Overall number is 7	6
Independence of the node management from transport operators and local actors	Yes	Yes
Transport interchange stations investment - Average investments in freight terminal in the period 2005-2010 in €/TEU throughput and year	€/TEU: 20.03 €/year: 5,736,056.4	15.42 €/TEU and 18,106,190,23 €/year
Fair and equal access to terminal/station - Indicates whether all companies have access to a terminal on equal conditions (time, cost, flexibility, etc) independent of ownership	Yes	Probably yes
Number of TEU handled per employee	621.6 TEU/employee	235.24
Ratio between volume and facilities (TEU/crane, etc)	For the year 2010 the value is about 68250 TEUs per crane	4245,02
Ratio between lowest monthly throughput (volume) and highest monthly throughput	In 2010: 0.35	-
Distance from nearest highway (km)	1.5	2
Distance from city centre (km)	1	3
Expandability of terminal	No	Small
Complementary activities in surrounding area	No	No
Handling cost (Euro/TEU)	About 100 €/TEU	661
Terminal working (opening) hours	24 hours/day	24 hours/day

Source: Gogas et al., 2012

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Main findings

- **Both interchanges:** interconnectivity points located at geostrategic positions of the supply chain
- **Thessaloniki port**
  - Absence of a Master Plan
  - Advanced in infrastructure and technology solutions used in the provision of services
- **Constantza port**
  - Operationally more integrated
  - The equipment and the connectors to other transportation networks need updating

Source: Gogas et al., 2012

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Guidance to further knowledge acquisition

Suggested literature

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- STRAIGHTSOL, 2014a. STRAIGHTSOL Deliverable D5.1. Demonstration assessments.
- STRAIGHTSOL, 2014b. STRAIGHTSOL Deliverable D5.3. Business models for innovative and sustainable urban-interurban transport.

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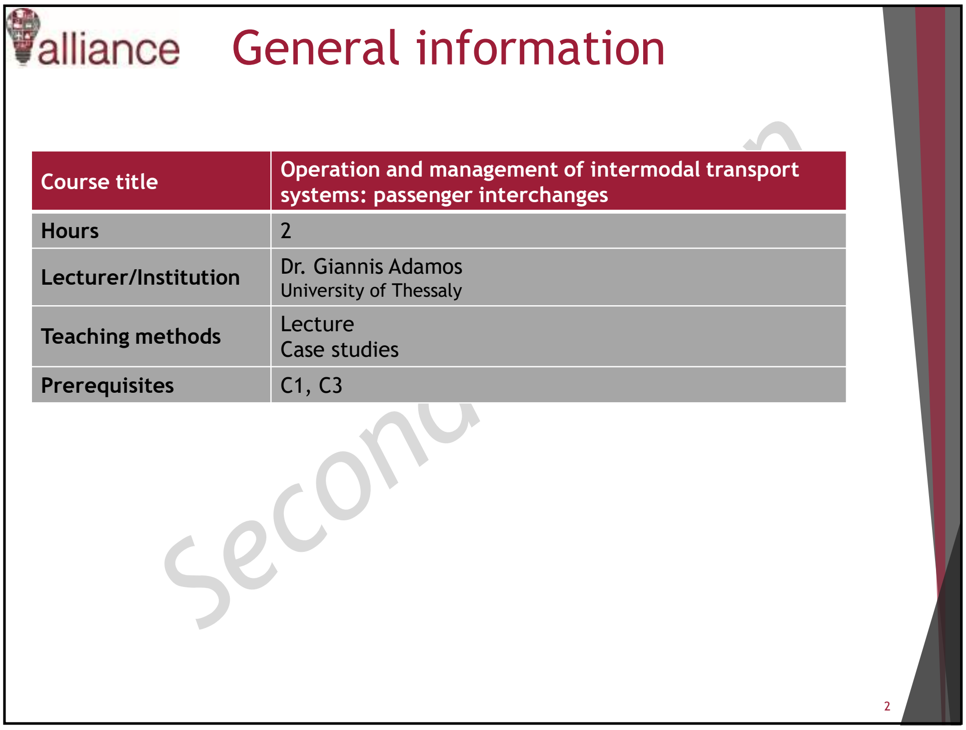
Operation and management of intermodal transport systems: passenger interchanges

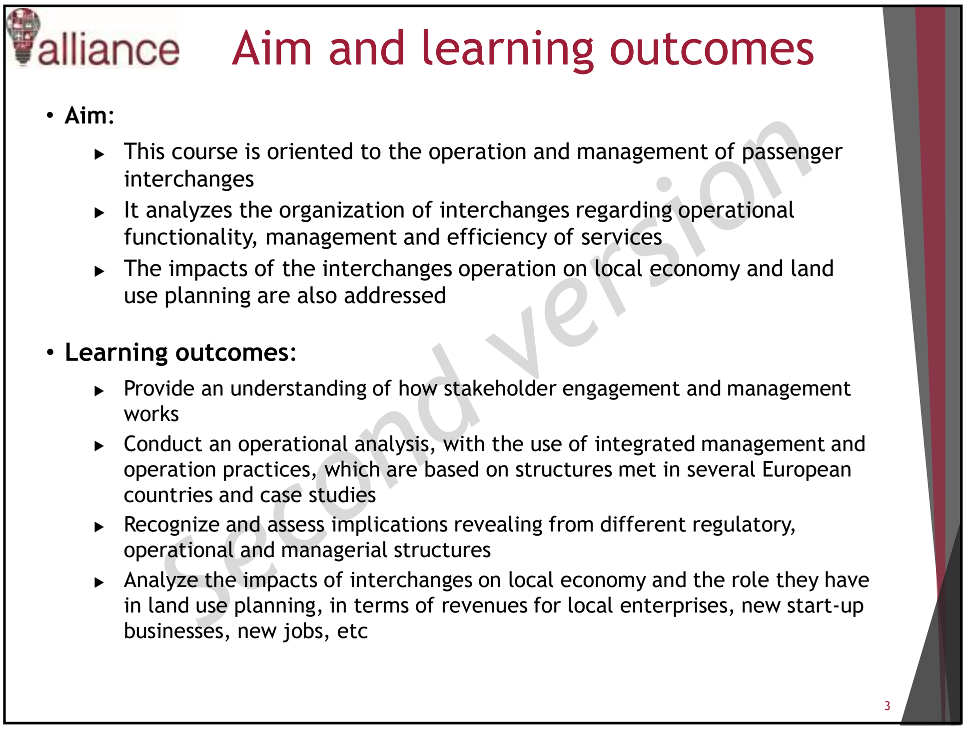
University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



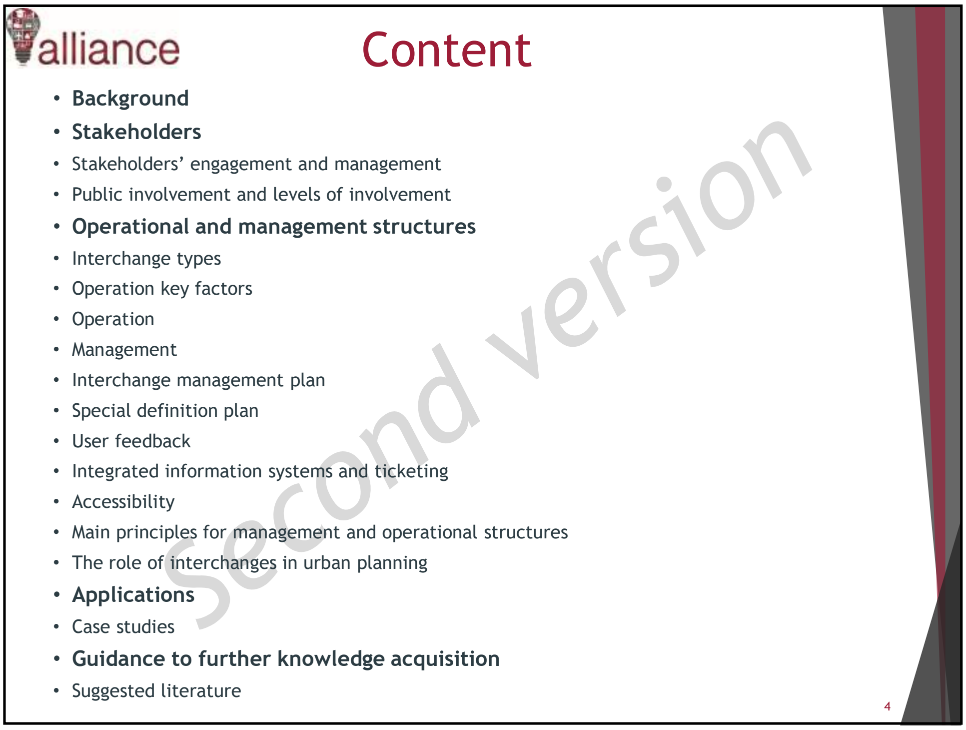
General information

Course title	Operation and management of intermodal transport systems: passenger interchanges
Hours	2
Lecturer/Institution	Dr. Giannis Adamos University of Thessaly
Teaching methods	Lecture Case studies
Prerequisites	C1, C3



Aim and learning outcomes

- **Aim:**
  - This course is oriented to the operation and management of passenger interchanges
  - It analyzes the organization of interchanges regarding operational functionality, management and efficiency of services
  - The impacts of the interchanges operation on local economy and land use planning are also addressed
- **Learning outcomes:**
  - Provide an understanding of how stakeholder engagement and management works
  - Conduct an operational analysis, with the use of integrated management and operation practices, which are based on structures met in several European countries and case studies
  - Recognize and assess implications revealing from different regulatory, operational and managerial structures
  - Analyze the impacts of interchanges on local economy and the role they have in land use planning, in terms of revenues for local enterprises, new start-up businesses, new jobs, etc



Content

- **Background**
- **Stakeholders**
- Stakeholders' engagement and management
- Public involvement and levels of involvement
- **Operational and management structures**
- Interchange types
- Operation key factors
- Operation
- Management
- Interchange management plan
- Special definition plan
- User feedback
- Integrated information systems and ticketing
- Accessibility
- Main principles for management and operational structures
- The role of interchanges in urban planning
- **Applications**
- Case studies
- **Guidance to further knowledge acquisition**
- Suggested literature

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Background

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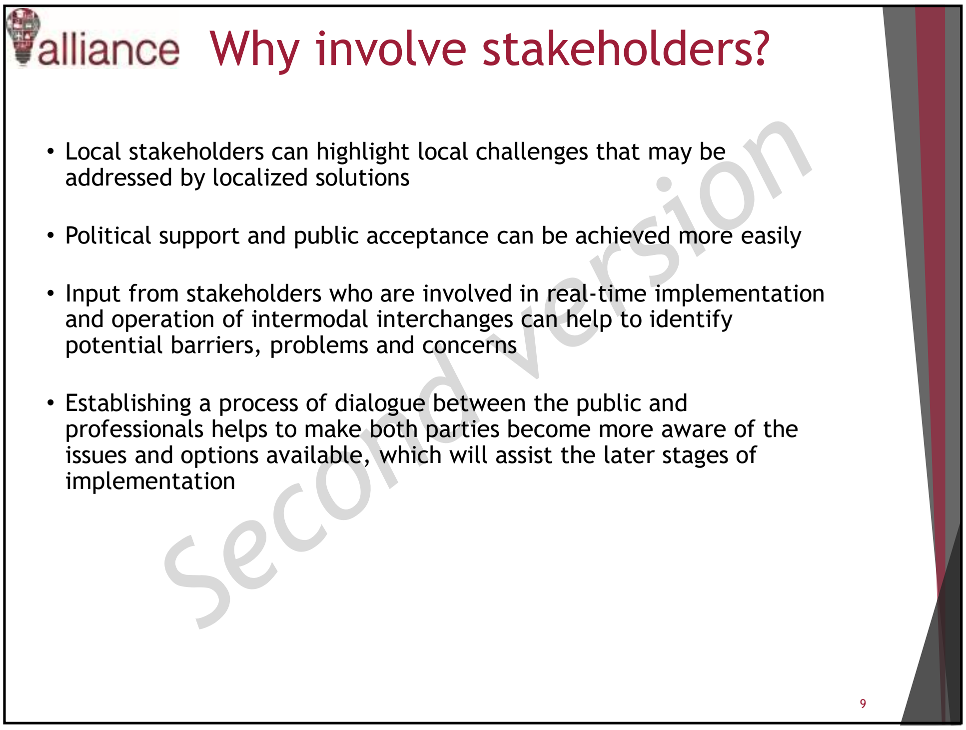
Background

- Governance and policy cover issues related to the interconnection of transportation with land planning, institutional and organization frameworks
- There are few examples of policies, regulations and guidance that incorporate the design, construction, management and operation of interchanges as a whole
- The interchange facility and its catchment area are not being considered satisfactorily in transport planning
- The roles and responsibilities of stakeholders involved in the interchange are often addressed by the regulatory framework of each mode
- Decision makers, service providers and end users are three groups of stakeholders that affect intermodal transport
- The challenge of efficient intermodal transport is to satisfy each specific group, its needs and requirements

Stakeholders

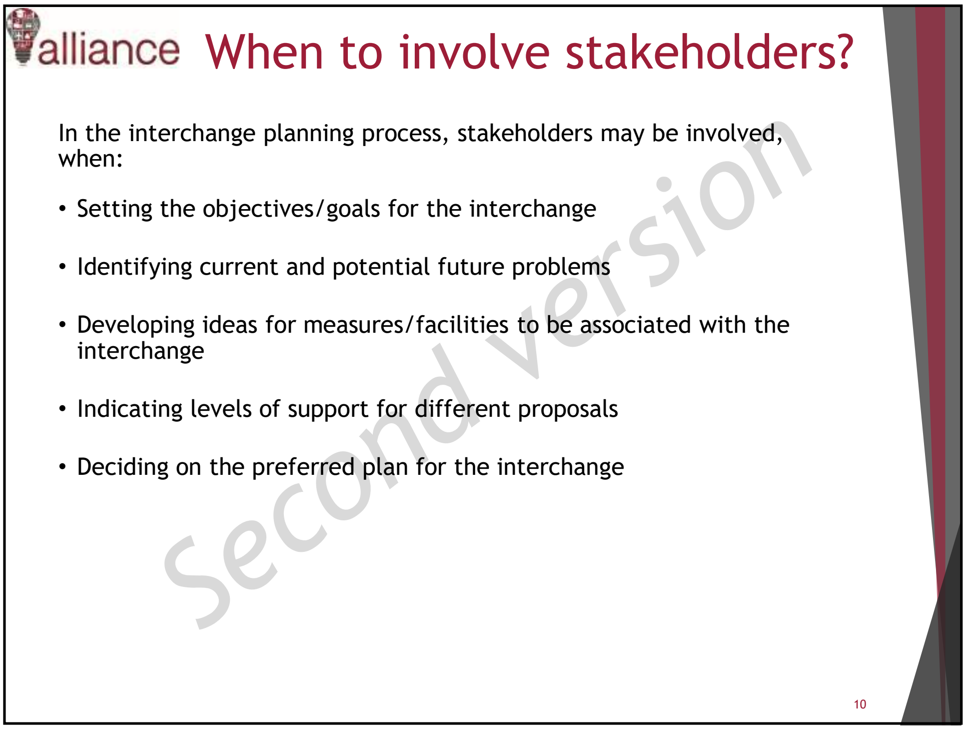
Stakeholders' engagement and management

- **Stakeholders' identification:**
    - Why involve stakeholders?
    - When to involve stakeholders?
    - Which stakeholders to involve?
- **Stakeholders' engagement:**
    - Strategy
    - Public involvement
    - Techniques for public involvement



Why involve stakeholders?

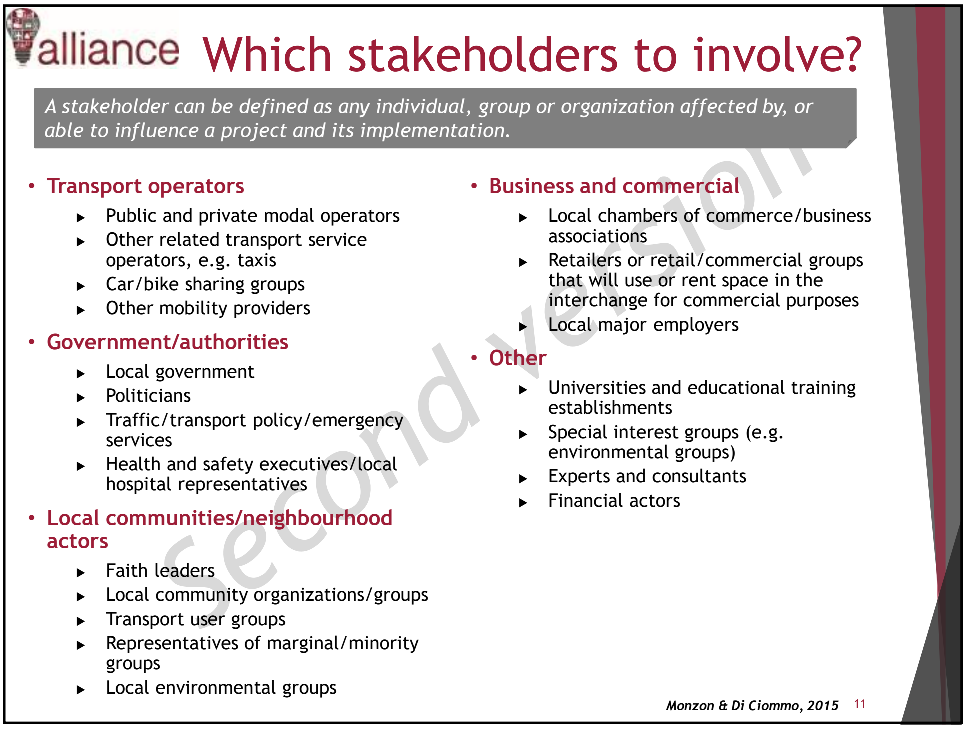
- Local stakeholders can highlight local challenges that may be addressed by localized solutions
- Political support and public acceptance can be achieved more easily
- Input from stakeholders who are involved in real-time implementation and operation of intermodal interchanges can help to identify potential barriers, problems and concerns
- Establishing a process of dialogue between the public and professionals helps to make both parties become more aware of the issues and options available, which will assist the later stages of implementation



When to involve stakeholders?

In the interchange planning process, stakeholders may be involved, when:

- Setting the objectives/goals for the interchange
- Identifying current and potential future problems
- Developing ideas for measures/facilities to be associated with the interchange
- Indicating levels of support for different proposals
- Deciding on the preferred plan for the interchange

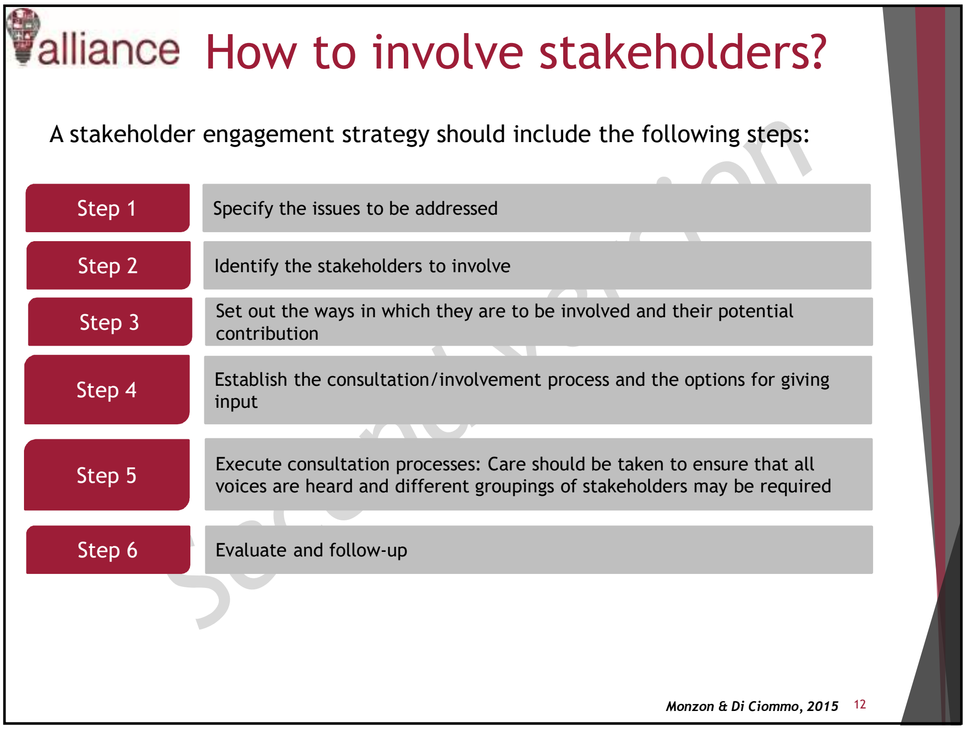


Which stakeholders to involve?

A stakeholder can be defined as any individual, group or organization affected by, or able to influence a project and its implementation.

- **Transport operators**
  - Public and private modal operators
  - Other related transport service operators, e.g. taxis
  - Car/bike sharing groups
  - Other mobility providers
- **Government/authorities**
  - Local government
  - Politicians
  - Traffic/transport policy/emergency services
  - Health and safety executives/local hospital representatives
- **Local communities/neighbourhood actors**
  - Faith leaders
  - Local community organizations/groups
  - Transport user groups
  - Representatives of marginal/minority groups
  - Local environmental groups
- **Business and commercial**
  - Local chambers of commerce/business associations
  - Retailers or retail/commercial groups that will use or rent space in the interchange for commercial purposes
  - Local major employers
- **Other**
  - Universities and educational training establishments
  - Special interest groups (e.g. environmental groups)
  - Experts and consultants
  - Financial actors

Monzon & Di Ciommo, 2015



How to involve stakeholders?

A stakeholder engagement strategy should include the following steps:

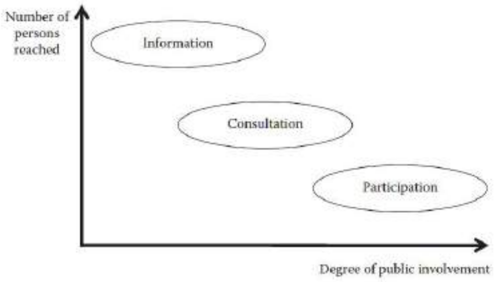
Step 1	Specify the issues to be addressed
Step 2	Identify the stakeholders to involve
Step 3	Set out the ways in which they are to be involved and their potential contribution
Step 4	Establish the consultation/involvement process and the options for giving input
Step 5	Execute consultation processes: Care should be taken to ensure that all voices are heard and different groupings of stakeholders may be required
Step 6	Evaluate and follow-up

Monzon & Di Ciommo, 2015

Public involvement

- Engaging stakeholders is an ongoing dynamic process
- Public consultation may occur when an interchange is being:
  - Planned
  - Designed and built
  - Redesigned or upgraded
- The aim is to build effective and trustful partnerships

Levels of involvement



Information	Consultation	Participation
Stakeholders are notified about the proposed implementation of a project Information is shared with stakeholders	Several ways: questionnaires, information days, leaflets and meetings Listening and learning should lead to a common understanding Targeted at particular groups	Two-way dialogue between stakeholders and professionals Direct discussions among the various parties Co-decision-making

Monzon & Di Ciommo, 2015

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Operational and management structures

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Interchange types

Characteristics	National hub: Airports and passenger/ferry ports	National city terminal	Other city or local terminals
Long-distance modes	Air, high-speed rail, conventional rail, interurban bus, ferry	High-speed rail, conventional rail, interurban bus	Conventional rail, interurban bus, ferry
Main authority levels	National/regional	National/regional/local	Local/regional
Orientation	National/international	Regional/local/city	City
Type (level) of interconnection	International/national ↔ Local/regional/national	National/regional ↔ Regional/local	Regional ↔ Local
Ownership	National authorities or their representatives, varying private influence	National/regional/local authorities or their representatives, sometimes private influence	Usually local/regional authorities, but also national, not much private influence

Source: CLOSER, 2011

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Operation key factors

- Key factors that form the operational profile of a passenger interchange and make it competitive are:
    - Location
    - Infrastructure
    - Modes
    - Services
- Small and medium sized interchanges may have a simple transport related function, involving a low number of operators
- Larger interchanges may include retail and commercial opportunities and a variety of transport modes and operators, resulting in a more complicated structure
- Good operation requires coordination among all involved stakeholders

Good practice (passengers): Berlin Central Station, Germany

There are short transfer times between long distance modes, ensured by the successful coordination between transport operators and the dynamic schedule synchronization.

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Operation

- Key types of organizations that may be responsible of operation:
    - Central government or one of its agencies
    - Regional government or one of its agencies
    - Local transport authorities
    - Public transport operators (rail, metro, light rail transit, bus)
    - Private organizations
- Smaller interchanges are often publicly owned and operated
- Larger and more complex multimodal interchanges tend to be shared between private and public ownership and management

Example: United Kingdom

Railway stations are usually managed and operated by train operating companies and bus stations by bus/coach operators. Still, a number of the larger railway stations are managed by Network Rail, and in London, bus stations are managed by London Buses.

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Management (1/2)

- Management involves the rights and responsibilities of actors at an interchange related to:
  - Maintenance
  - Finance
  - Station operations
- Management is directly associated to outputs when it comes to daily operations, but is also highly relevant for the design of interchange and its general accessibility for passengers
- Policy, governance, organization and finance are interrelated and these foster or hinder the promotion of an efficient and attractive interchange

Source: City-HUB, 2013a

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Management (2/2)

- **Success criteria for interchanges:**
  - Coordination of different modalities
  - Establishment of rights and responsibilities of stakeholders and facilitation of station maintenance and cleaning
  - Management agreements when interchanges' facilities are owned, managed or served by more than one organizations
  - Monitoring of passenger needs
  - Design of the interchange so as to minimize the potential for accidents, conflicts and collisions
  - Compliance of relevant safety and emergency standards
  - Importance of multi-modal tickets and integrated ticketing system
  - Generate revenues for renting space

Source: City-HUB, 2013a

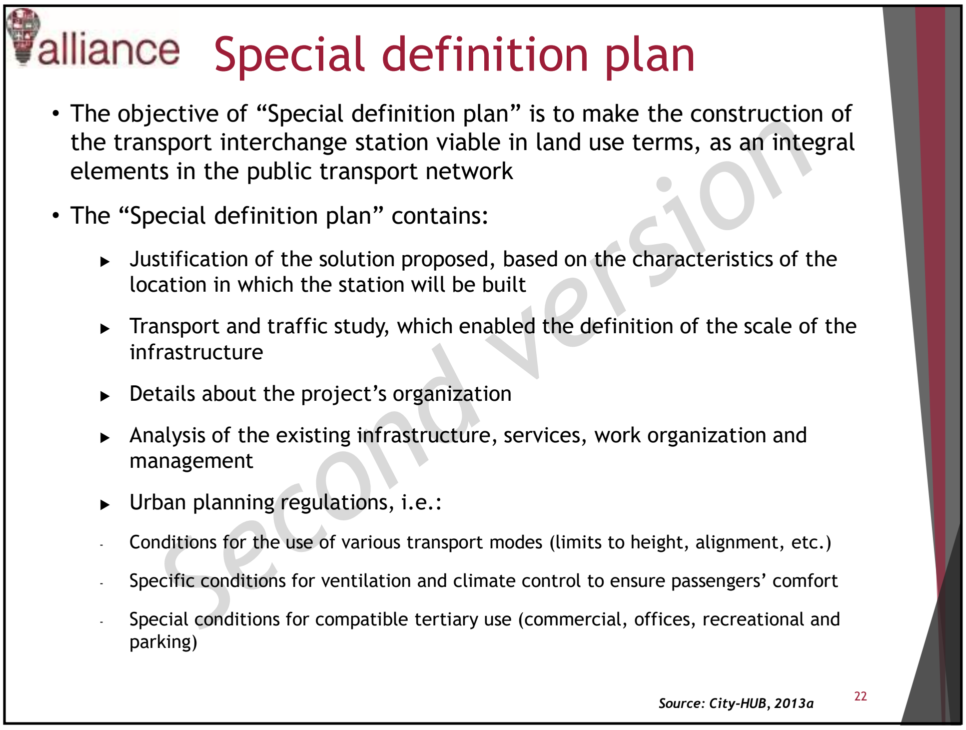
Interchange management plan

- It is important to develop an Interchange Management Plan, which should document a comprehensive strategy addressing:
  - Accessibility and land use issues
  - Functionality of the interchange
  - Human resources management
  - Clear definition of the roles and responsibilities of involved stakeholders in each stage: design, planning, construction, operation, maintenance

Good practice: Madrid, Spain

Public administrations have developed a plan for transport interchanges, addressing functionality across different modes and efficiency improvement. Agreements have been made among the regional government, the city Council and the Madrid transport authority.

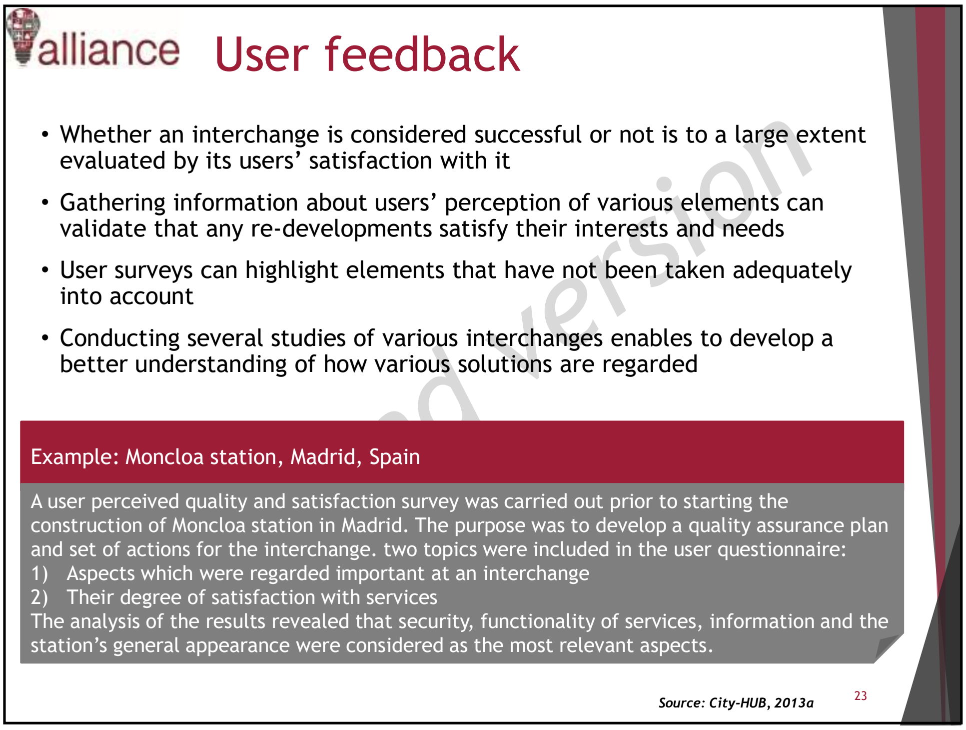
Source: City-HUB, 2013a



Special definition plan

- The objective of “Special definition plan” is to make the construction of the transport interchange station viable in land use terms, as an integral elements in the public transport network
- The “Special definition plan” contains:
  - Justification of the solution proposed, based on the characteristics of the location in which the station will be built
  - Transport and traffic study, which enabled the definition of the scale of the infrastructure
  - Details about the project’s organization
  - Analysis of the existing infrastructure, services, work organization and management
  - Urban planning regulations, i.e.:
    - Conditions for the use of various transport modes (limits to height, alignment, etc.)
    - Specific conditions for ventilation and climate control to ensure passengers’ comfort
    - Special conditions for compatible tertiary use (commercial, offices, recreational and parking)

Source: City-HUB, 2013a



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User feedback

- Whether an interchange is considered successful or not is to a large extent evaluated by its users' satisfaction with it
- Gathering information about users' perception of various elements can validate that any re-developments satisfy their interests and needs
- User surveys can highlight elements that have not been taken adequately into account
- Conducting several studies of various interchanges enables to develop a better understanding of how various solutions are regarded

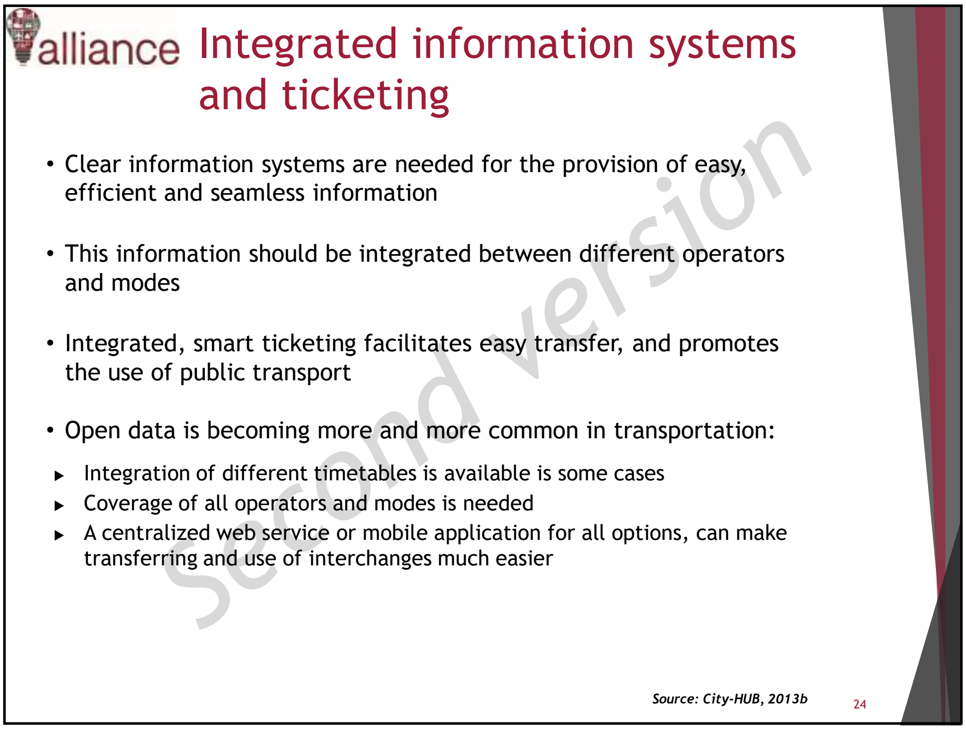
Example: Moncloa station, Madrid, Spain

A user perceived quality and satisfaction survey was carried out prior to starting the construction of Moncloa station in Madrid. The purpose was to develop a quality assurance plan and set of actions for the interchange. two topics were included in the user questionnaire:

1) Aspects which were regarded important at an interchange
2) Their degree of satisfaction with services

The analysis of the results revealed that security, functionality of services, information and the station's general appearance were considered as the most relevant aspects.

Source: City-HUB, 2013a



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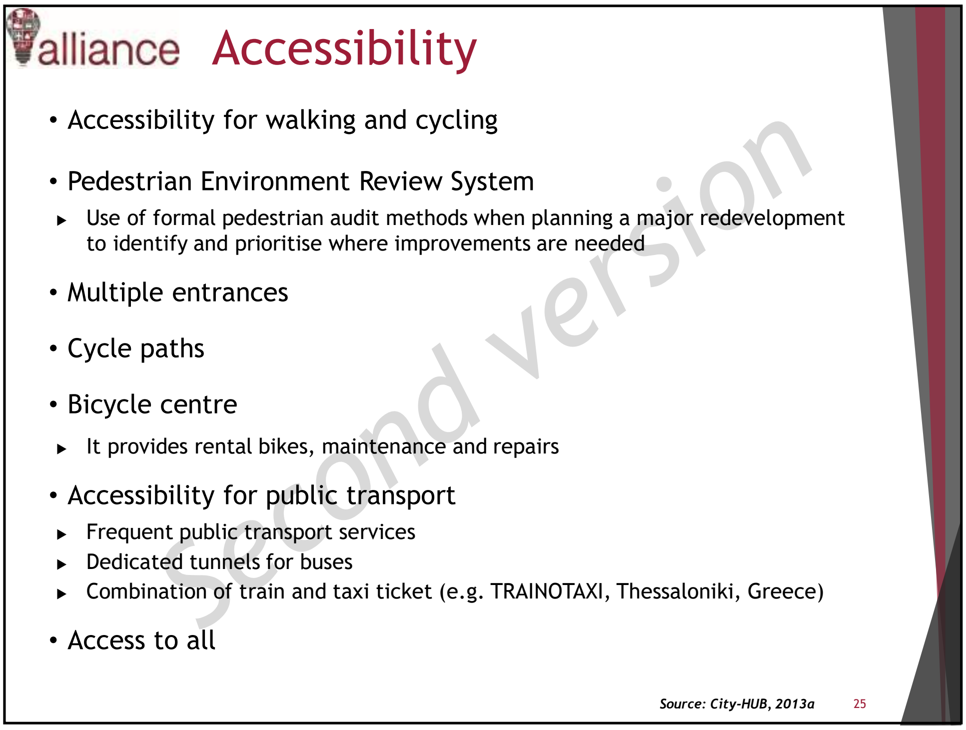
Integrated information systems and ticketing

- Clear information systems are needed for the provision of easy, efficient and seamless information
- This information should be integrated between different operators and modes
- Integrated, smart ticketing facilitates easy transfer, and promotes the use of public transport
- Open data is becoming more and more common in transportation:
  - Integration of different timetables is available is some cases
  - Coverage of all operators and modes is needed
  - A centralized web service or mobile application for all options, can make transferring and use of interchanges much easier

Source: City-HUB, 2013b



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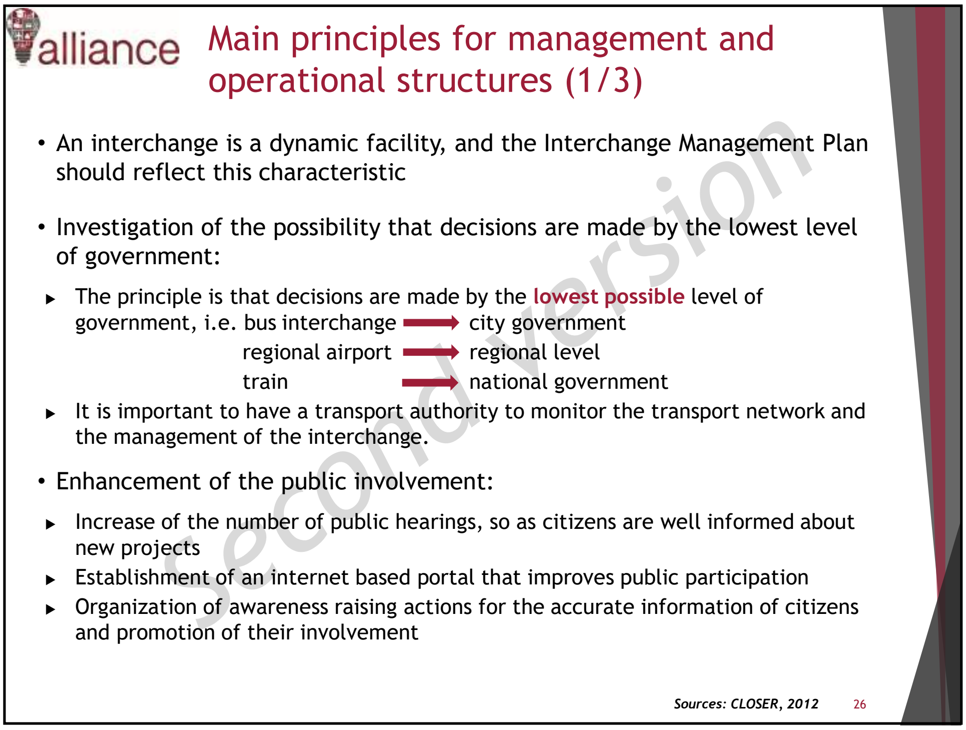
Accessibility

- Accessibility for walking and cycling
- Pedestrian Environment Review System
  - Use of formal pedestrian audit methods when planning a major redevelopment to identify and prioritise where improvements are needed
- Multiple entrances
- Cycle paths
- Bicycle centre
  - It provides rental bikes, maintenance and repairs
- Accessibility for public transport
  - Frequent public transport services
  - Dedicated tunnels for buses
  - Combination of train and taxi ticket (e.g. TRAINOTAXI, Thessaloniki, Greece)
- Access to all

Source: City-HUB, 2013a



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Main principles for management and operational structures (1/3)

- An interchange is a dynamic facility, and the Interchange Management Plan should reflect this characteristic
- Investigation of the possibility that decisions are made by the lowest level of government:
  - The principle is that decisions are made by the **lowest possible** level of government, i.e. bus interchange → city government
    regional airport → regional level
    train → national government
  - It is important to have a transport authority to monitor the transport network and the management of the interchange.
- Enhancement of the public involvement:
  - Increase of the number of public hearings, so as citizens are well informed about new projects
  - Establishment of an internet based portal that improves public participation
  - Organization of awareness raising actions for the accurate information of citizens and promotion of their involvement

Sources: CLOSER, 2012

Main principles for management and operational structures (2/3)

- Separation of the owner from the operator:
  - At national level, the State can possess the ownership in order to ensure fair competition and access to the different operators on equal access
  - At regional level, the establishment of a “Regional Transport Authority” is quite common to ensure neutral competition among the different operators
  - Authorities should be aware of different ownership models and assess the advantages and disadvantages of each model
  - Transparency and open rules of access, moderated by an external regulator are required.
- Establishment of a cooperative framework between the interchange and the transportation operators

Example

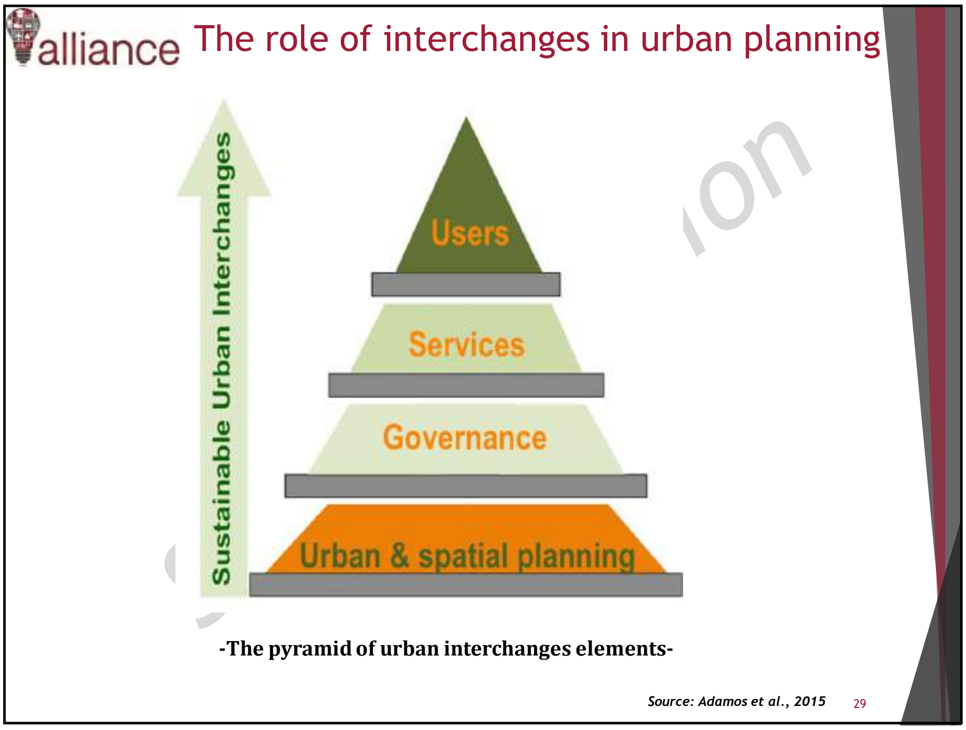
If the interchange is not fully booked and owned by the transport operator using the interchange primarily, there can be open adequate slots for other users (by contract). This is a good solution without any extra costs for the usage of the interchange for the main operator and with reasonable costs for external users. If the interchange is fully booked, an authority should be responsible for arranging fair conditions.

Source: CLOSER, 2012

Main principles for management and operational structures (3/3)

- Integration of the operations at public transport interchanges, including systems related to:
  - Travelers, i.e. information, signs, ticket sales and validation, service coordination, waiting rooms, etc.
  - Transport operators, i.e. personnel, vehicles, services
- Effective operation of the delaying services to ensure that connections are not missed

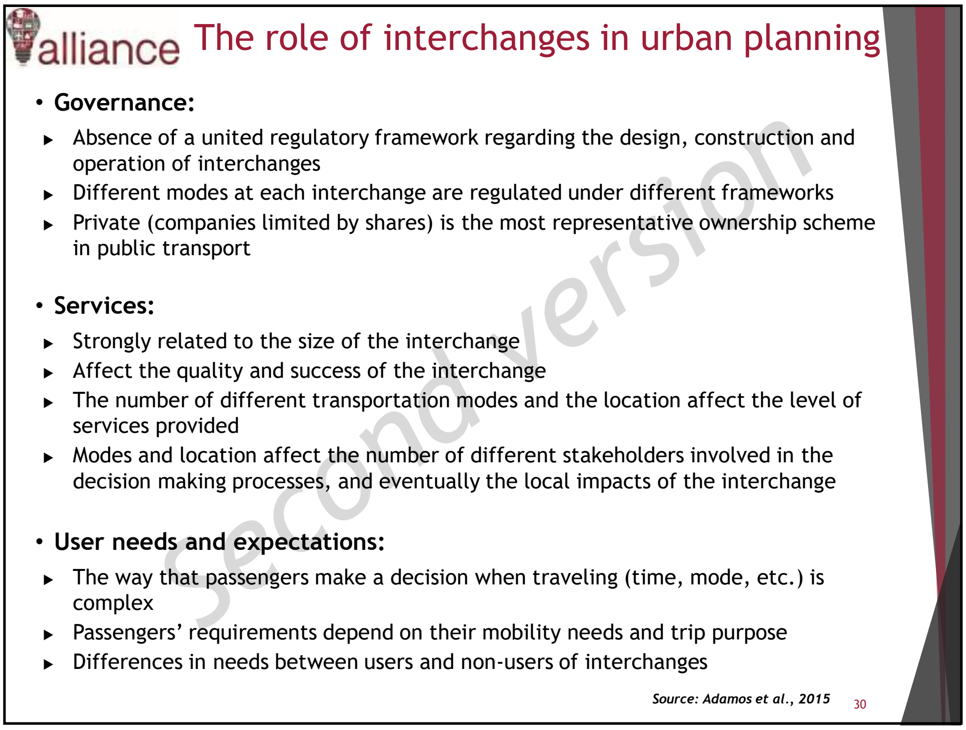
Source: CLOSER, 2012



The role of interchanges in urban planning

-The pyramid of urban interchanges elements-

Source: Adamos et al., 2015



The role of interchanges in urban planning

- **Governance:**
  - Absence of a united regulatory framework regarding the design, construction and operation of interchanges
  - Different modes at each interchange are regulated under different frameworks
  - Private (companies limited by shares) is the most representative ownership scheme in public transport

- **Services:**
  - Strongly related to the size of the interchange
  - Affect the quality and success of the interchange
  - The number of different transportation modes and the location affect the level of services provided
  - Modes and location affect the number of different stakeholders involved in the decision making processes, and eventually the local impacts of the interchange

- **User needs and expectations:**
  - The way that passengers make a decision when traveling (time, mode, etc.) is complex
  - Passengers' requirements depend on their mobility needs and trip purpose
  - Differences in needs between users and non-users of interchanges

Source: Adamos et al., 2015

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Applications

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Case study #1

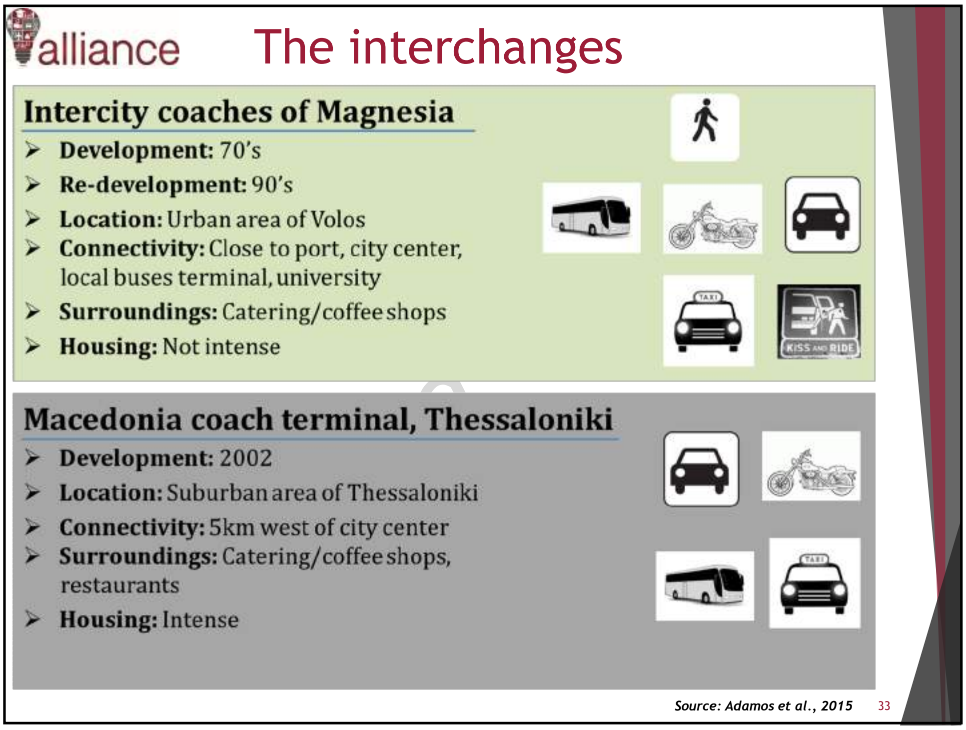
Cross-case assessment of the impacts of 4 Greek interchanges on urban development and environment

Intercity coaches of Magnesia, Volos, Greece

Macedonia coach terminal, Thessaloniki, Greece

KTEL Kifisou, Athens, Greece

New Railway of Thessaloniki, Greece



The interchanges

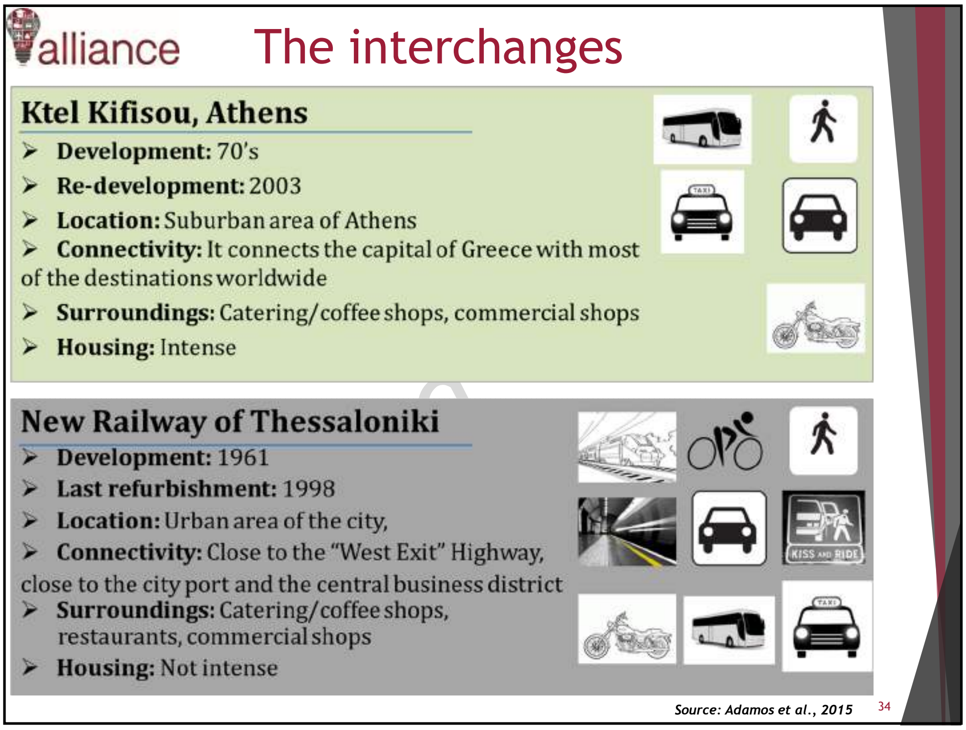
Intercity coaches of Magnesia

- **Development:** 70's
- **Re-development:** 90's
- **Location:** Urban area of Volos
- **Connectivity:** Close to port, city center, local buses terminal, university
- **Surroundings:** Catering/coffee shops
- **Housing:** Not intense

Macedonia coach terminal, Thessaloniki

- **Development:** 2002
- **Location:** Suburban area of Thessaloniki
- **Connectivity:** 5km west of city center
- **Surroundings:** Catering/coffee shops, restaurants
- **Housing:** Intense

Source: Adamos et al., 2015



The interchanges

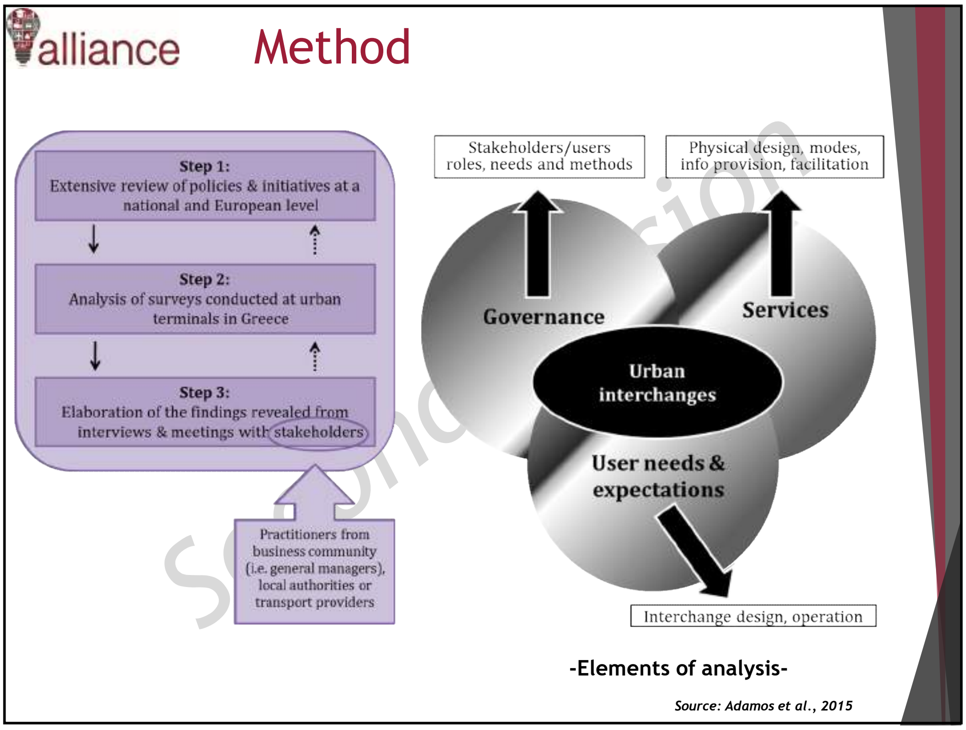
Ktel Kifisou, Athens

- **Development:** 70's
- **Re-development:** 2003
- **Location:** Suburban area of Athens
- **Connectivity:** It connects the capital of Greece with most of the destinations worldwide
- **Surroundings:** Catering/coffee shops, commercial shops
- **Housing:** Intense

New Railway of Thessaloniki

- **Development:** 1961
- **Last refurbishment:** 1998
- **Location:** Urban area of the city,
- **Connectivity:** Close to the "West Exit" Highway, close to the city port and the central business district
- **Surroundings:** Catering/coffee shops, restaurants, commercial shops
- **Housing:** Not intense

Source: Adamos et al., 2015



Method

Step 1:
Extensive review of policies & initiatives at a national and European level

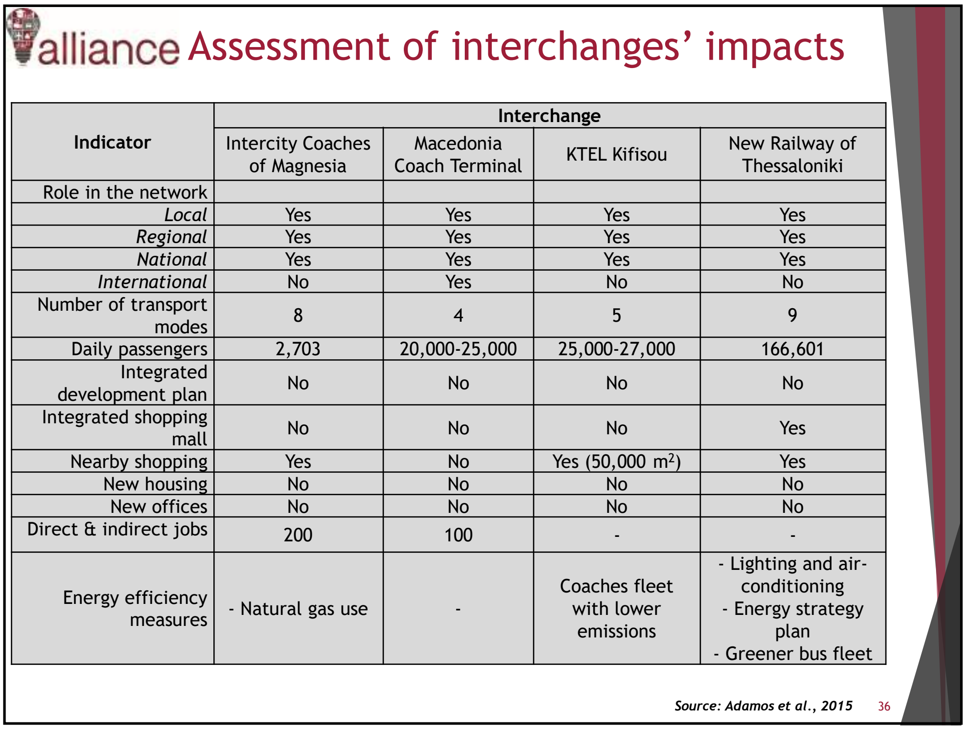
Step 2:
Analysis of surveys conducted at urban terminals in Greece

Step 3:
Elaboration of the findings revealed from interviews & meetings with stakeholders

Practitioners from business community (i.e. general managers), local authorities or transport providers

-Elements of analysis-

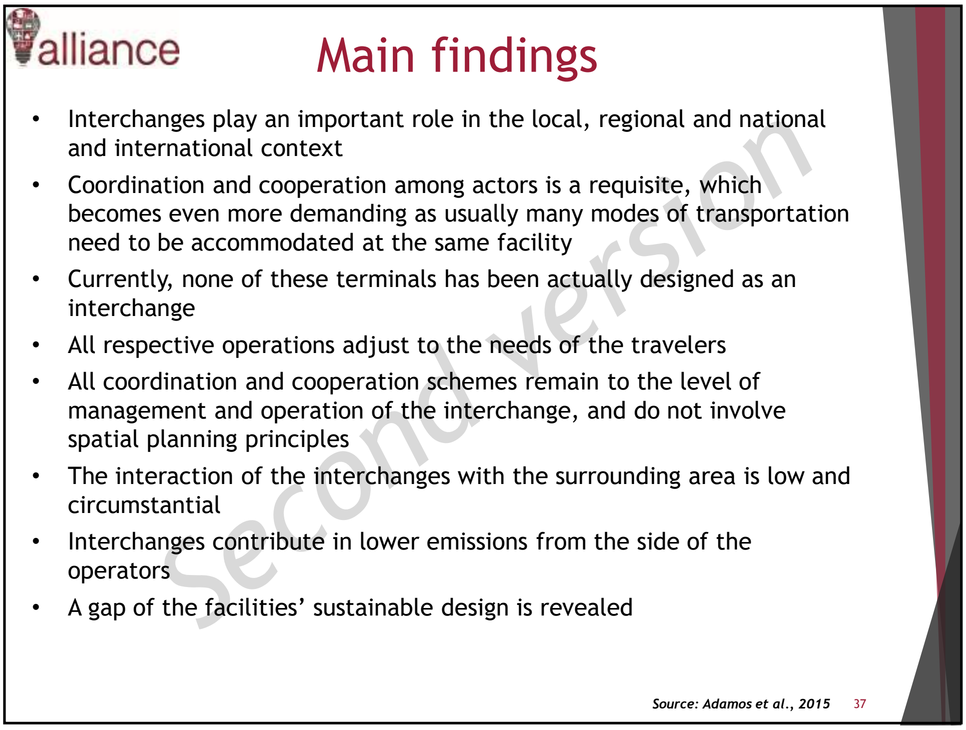
Source: Adamos et al., 2015



Assessment of interchanges' impacts

Indicator	Interchange			
	Intercity Coaches of Magnesia	Macedonia Coach Terminal	KTEL Kifisou	New Railway of Thessaloniki
Role in the network				
Local	Yes	Yes	Yes	Yes
Regional	Yes	Yes	Yes	Yes
National	Yes	Yes	Yes	Yes
International	No	Yes	No	No
Number of transport modes	8	4	5	9
Daily passengers	2,703	20,000-25,000	25,000-27,000	166,601
Integrated development plan	No	No	No	No
Integrated shopping mall	No	No	No	Yes
Nearby shopping	Yes	No	Yes (50,000 m^2)	Yes
New housing	No	No	No	No
New offices	No	No	No	No
Direct & indirect jobs	200	100	-	-
Energy efficiency measures	- Natural gas use	-	Coaches fleet with lower emissions	- Lighting and air-conditioning - Energy strategy plan - Greener bus fleet

Source: Adamos et al., 2015



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Main findings

- Interchanges play an important role in the local, regional and national and international context
- Coordination and cooperation among actors is a requisite, which becomes even more demanding as usually many modes of transportation need to be accommodated at the same facility
- Currently, none of these terminals has been actually designed as an interchange
- All respective operations adjust to the needs of the travelers
- All coordination and cooperation schemes remain to the level of management and operation of the interchange, and do not involve spatial planning principles
- The interaction of the interchanges with the surrounding area is low and circumstantial
- Interchanges contribute in lower emissions from the side of the operators
- A gap of the facilities' sustainable design is revealed

Source: Adamos et al., 2015

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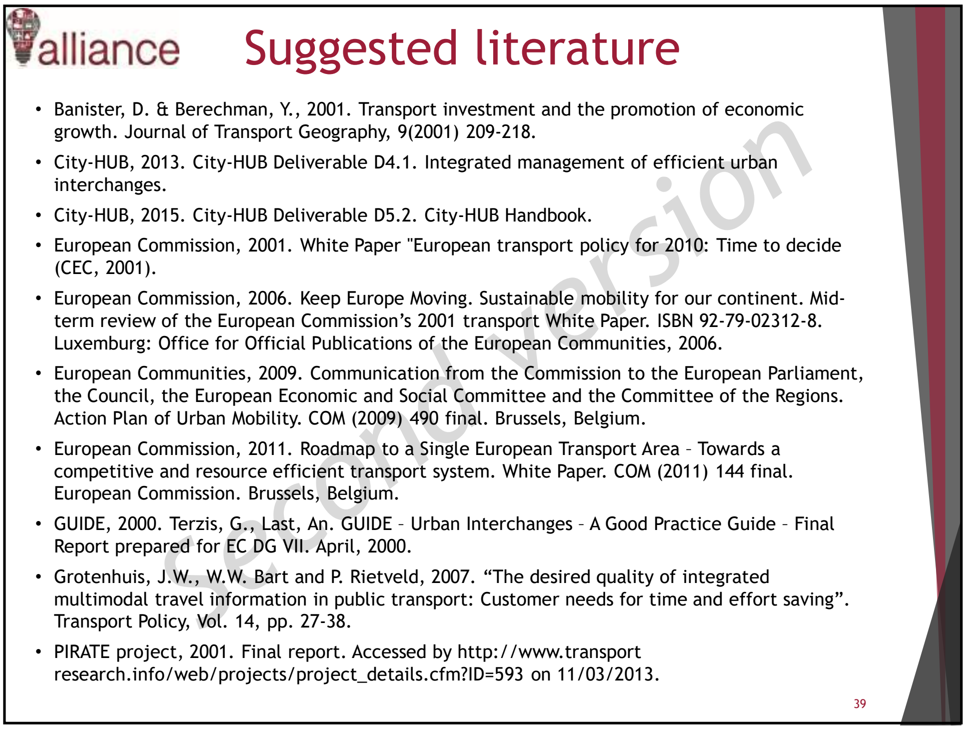
Guidance to further knowledge acquisition



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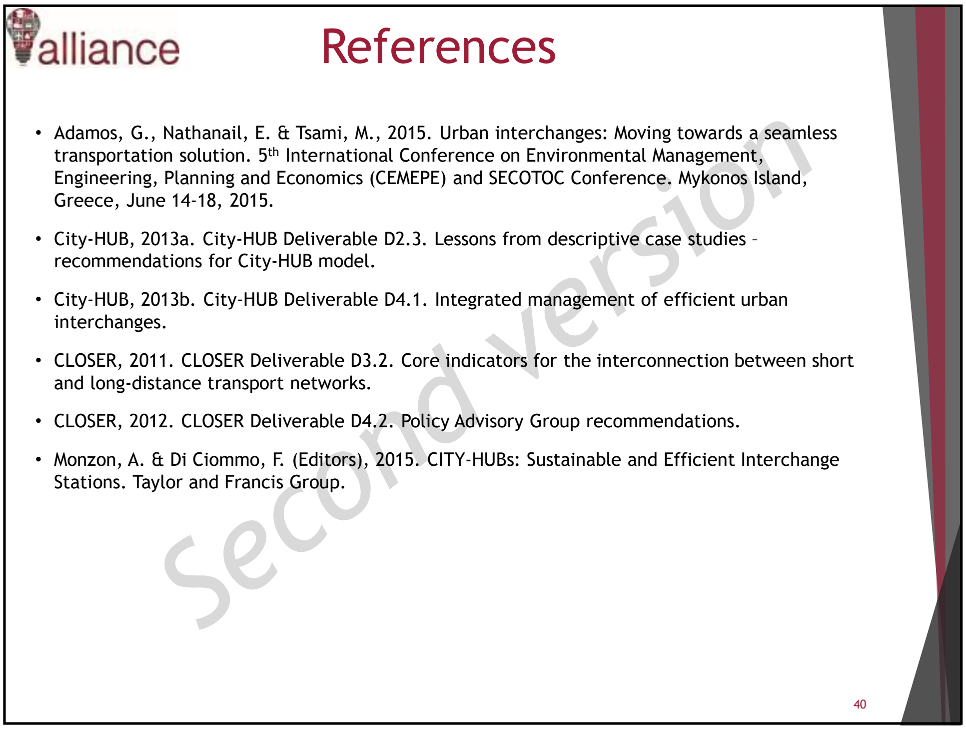

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Optimization of intermodal transport systems

Assoc. Professor Eftihia Nathanail
University of Thessaly (UTH), Greece

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General information

Course title	C5. Optimization of intermodal transport systems
Hours	3
Lecturer/Institution	**Prof. Eftihia Nathanail** University of Thessaly enath@uth.gr
Teaching methods	Lecture
Prerequisites	-

Aim and learning outcomes

- **Aim:**
  - The aim of this course is to introduce students with the principle of optimization, and the mathematical models that are built to facilitate decisions, in the context of reaching the optimum taking into account applying restrictions
- **Learning outcomes:**
  - Identifying variables and relationships that govern in an optimization problem.
  - Develop mathematical formulations that take into account the optimization of the objective function, safeguarding the satisfaction of constraints and limitations.
  - Use computer programs that solve optimization problems.

Content

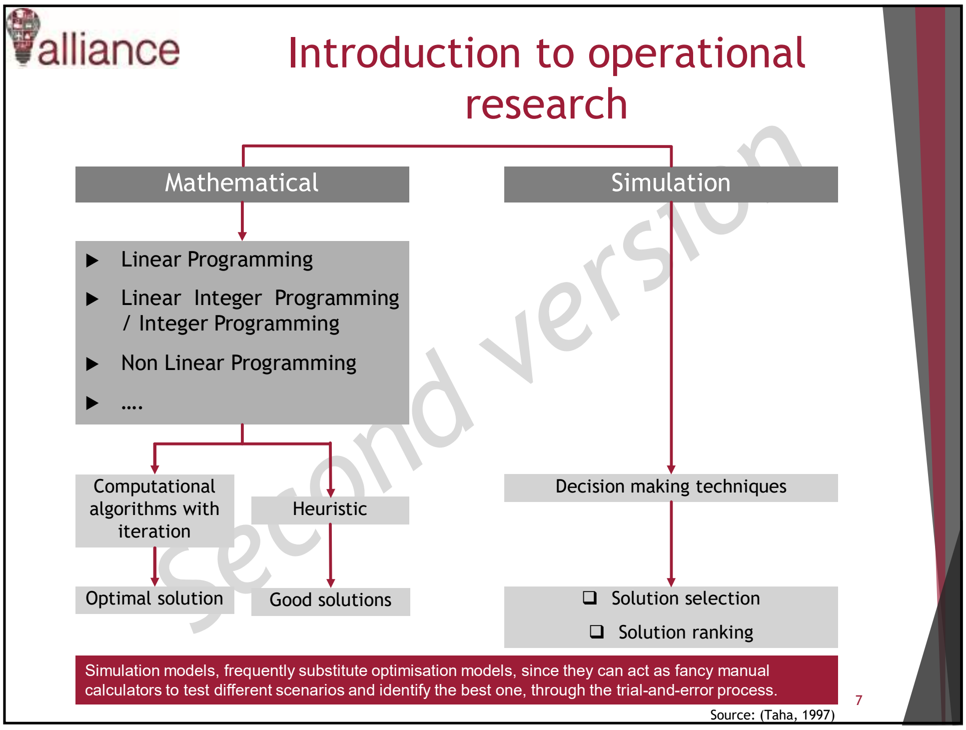
- Basic concepts
- Basic elements
- Optimization Rules
- Optimization Techniques
- Software and applications
- Guidance to further knowledge acquisition

Basic concepts

Introduction to operational research

- Scope of Operational / Operations Research is to define and solve practical problems in order to achieve the objectives with the best possible way.
- For this purpose, initially the problem is formulated as a mathematical model, and then this mathematical model is solved with mathematical programming techniques (Mathematical Programming).
- Mathematical model is a mathematical system of relations between different decision variables that expresses (with some inevitable removal) the essence of the problem.
- Generally each mathematical model consists of:
  - a function of efficiency, called objective function, and should be maximized or minimized depending on the case, and
  - constraints that describe the limits within which the objective function should be optimized (maximized or minimized)

Source: (Hillier & Lieberman, 2001)



Introduction to operational research

Mathematical

- Linear Programming
- Linear Integer Programming / Integer Programming
- Non Linear Programming
- ….

Computational algorithms with iteration → Optimal solution

Heuristic → Good solutions

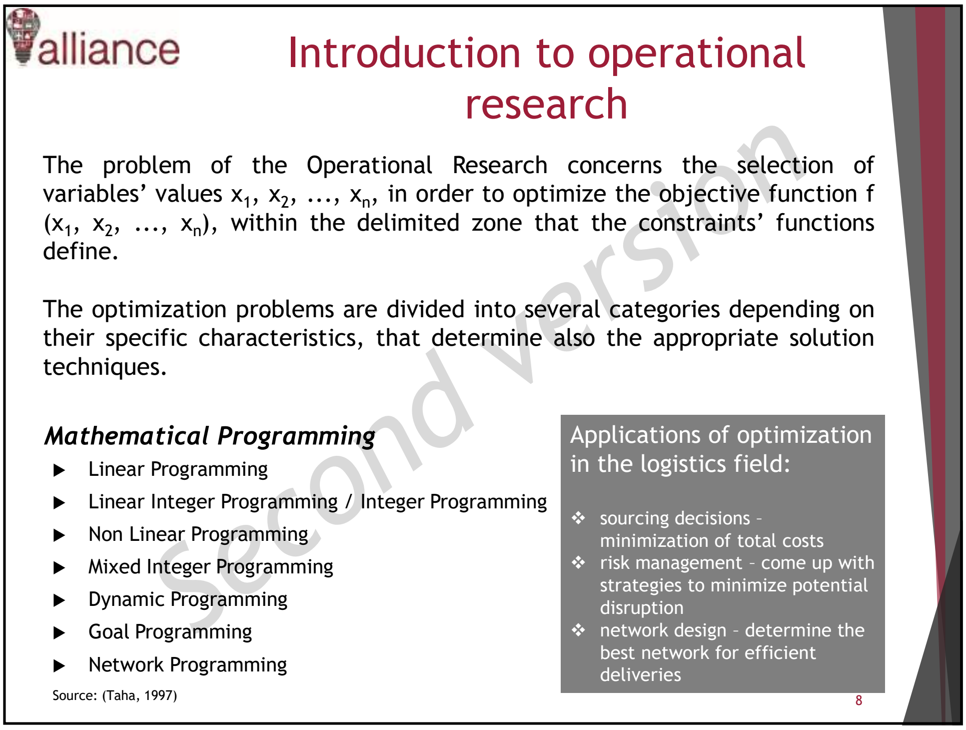
Simulation

Decision making techniques

- ☐ Solution selection
- ☐ Solution ranking

Simulation models, frequently substitute optimisation models, since they can act as fancy manual calculators to test different scenarios and identify the best one, through the trial-and-error process.

Source: (Taha, 1997)



Introduction to operational research

The problem of the Operational Research concerns the selection of variables' values x_1, x_2, …, x_n, in order to optimize the objective function f (x_1, x_2, …, x_n), within the delimited zone that the constraints' functions define.

The optimization problems are divided into several categories depending on their specific characteristics, that determine also the appropriate solution techniques.

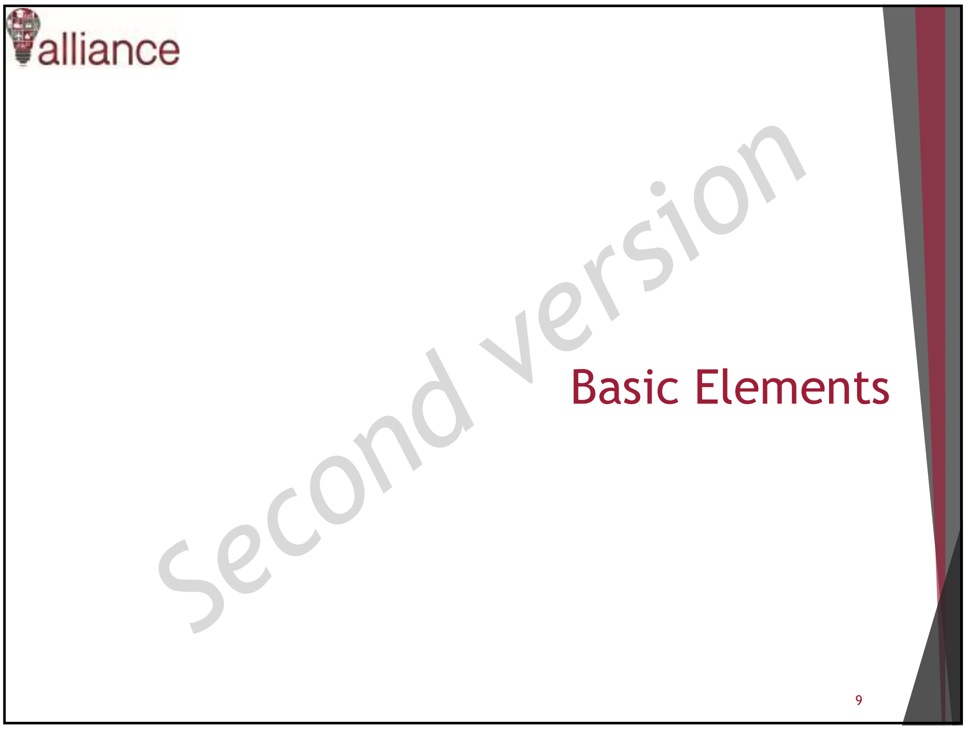
Mathematical Programming

- Linear Programming
- Linear Integer Programming / Integer Programming
- Non Linear Programming
- Mixed Integer Programming
- Dynamic Programming
- Goal Programming
- Network Programming

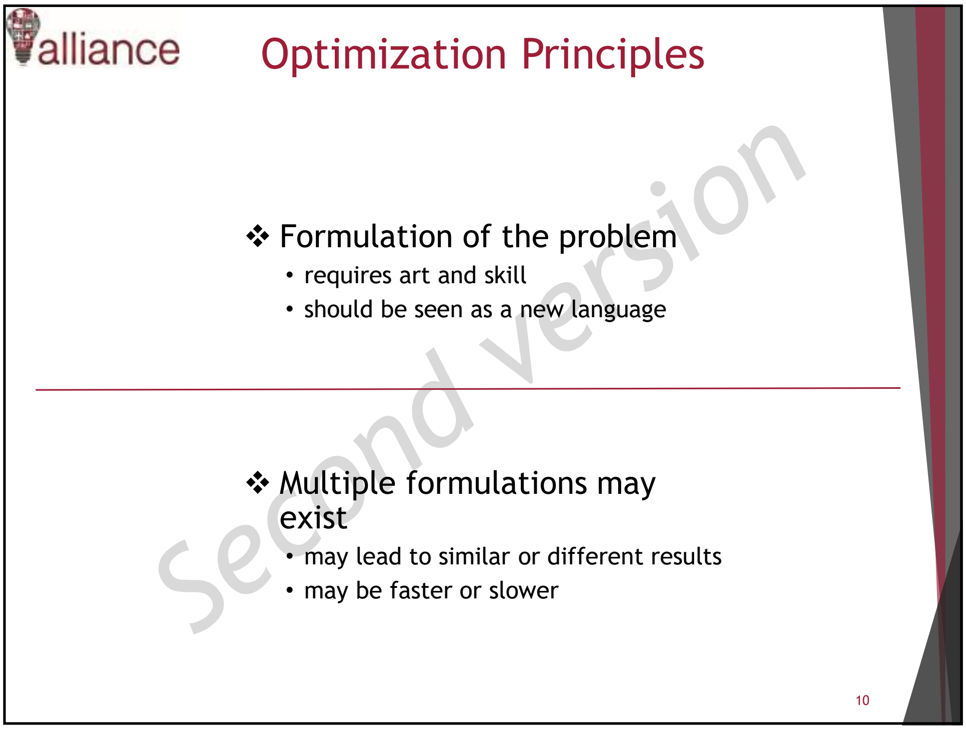
Source: (Taha, 1997)

Applications of optimization in the logistics field:

- ❖ sourcing decisions - minimization of total costs
- ❖ risk management - come up with strategies to minimize potential disruption
- ❖ network design - determine the best network for efficient deliveries



Basic Elements



Optimization Principles

- ❖ Formulation of the problem
  - requires art and skill
  - should be seen as a new language

- ❖ Multiple formulations may exist
  - may lead to similar or different results
  - may be faster or slower

Optimization elements

- What do we know?

Data: Demand prices, costs, ability / capacity, people needed

- *small letters at the beginning of the alphabet*
- *known from scratch or can be calculated*

- What do we have to decide?

Decision variables

- *production volumes, storage, shipments between plants and distribution centers, quantities of raw materials, number of employees, etc*
- *capital letters at the end of the alphabet*

Auxiliary variables (also decision variables)

Optimization elements

- What is the goal?

Objective function

- *Minimization or maximization problem*
- *total shipping cost, total cost of production and storage, total number of shifts and personnel, loss of profits*

- What are the limits to achieve it?

Constraints

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Optimization elements

Indices

- *used for numbering (e.g. demand points, candidate positions, scenarios, time periods, route paths, facilities)*
- *i ϵ I, j ϵ J, k ϵ K (middle of the alphabet)*

Parameters

- *used in the objective function and constraints*
- *may change from run to run*

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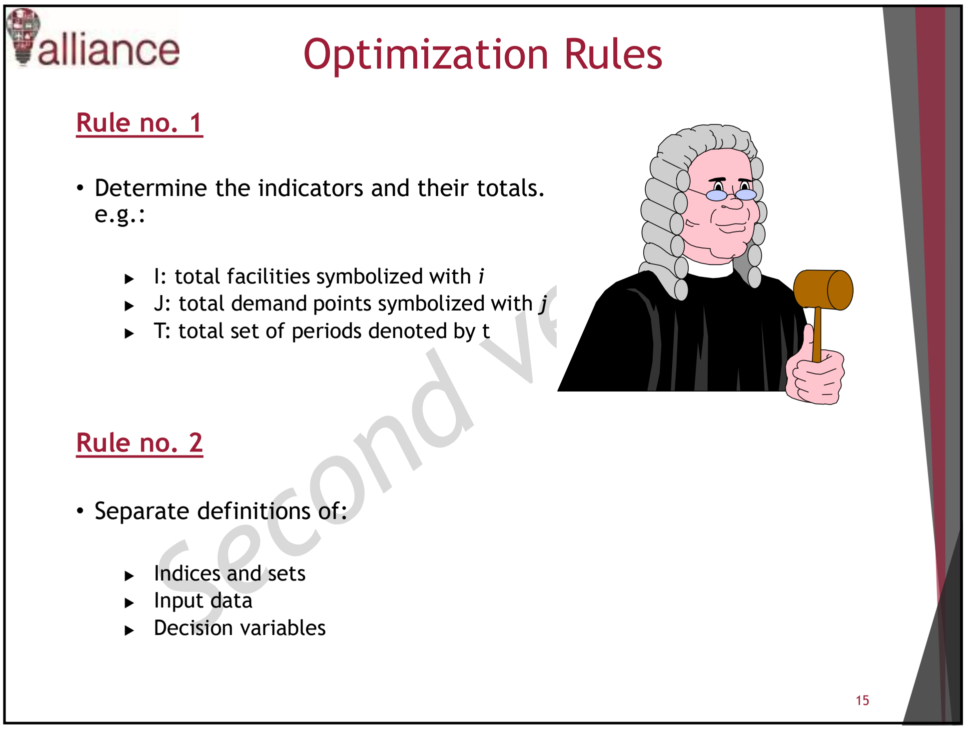
Optimization Rules

source: (Daskin, 2010)



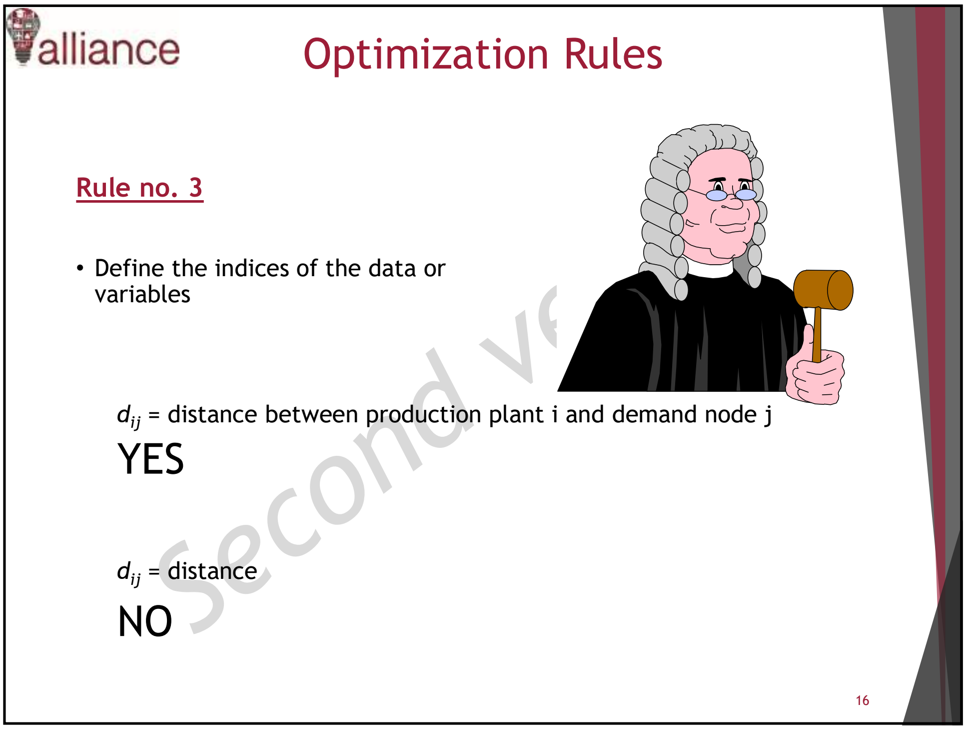
Optimization Rules

Rule no. 1

- Determine the indicators and their totals. e.g.:
  - I: total facilities symbolized with *i*
  - J: total demand points symbolized with *j*
  - T: total set of periods denoted by t

Rule no. 2

- Separate definitions of:
  - Indices and sets
  - Input data
  - Decision variables



Optimization Rules

Rule no. 3

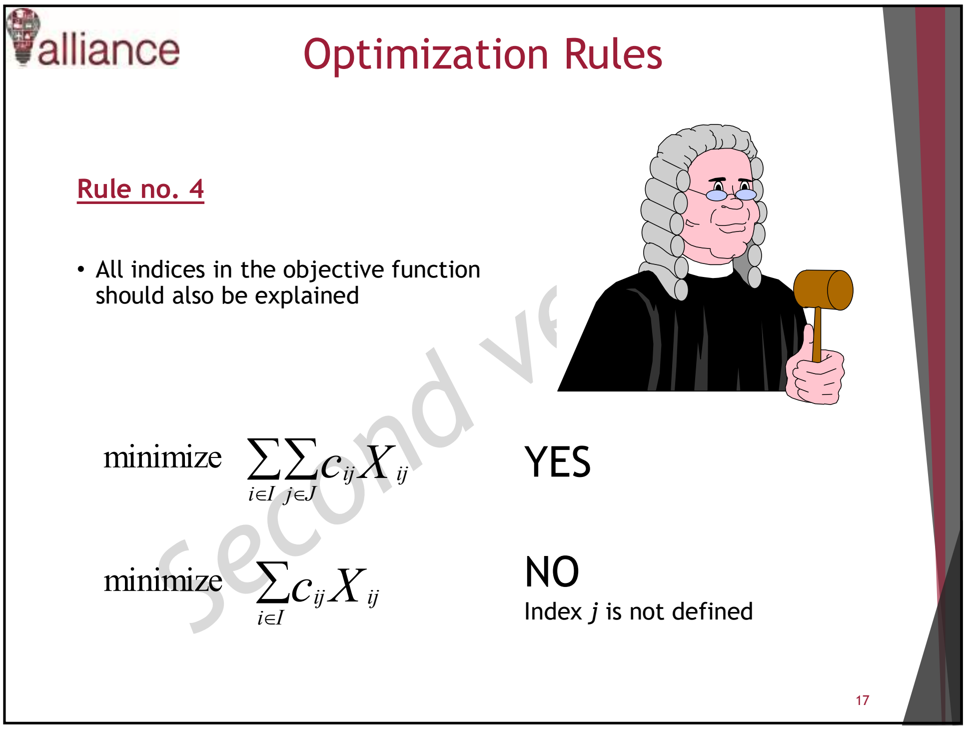
- Define the indices of the data or variables

d_{ij} = distance between production plant i and demand node j

YES

d_{ij} = distance

NO



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Optimization Rules

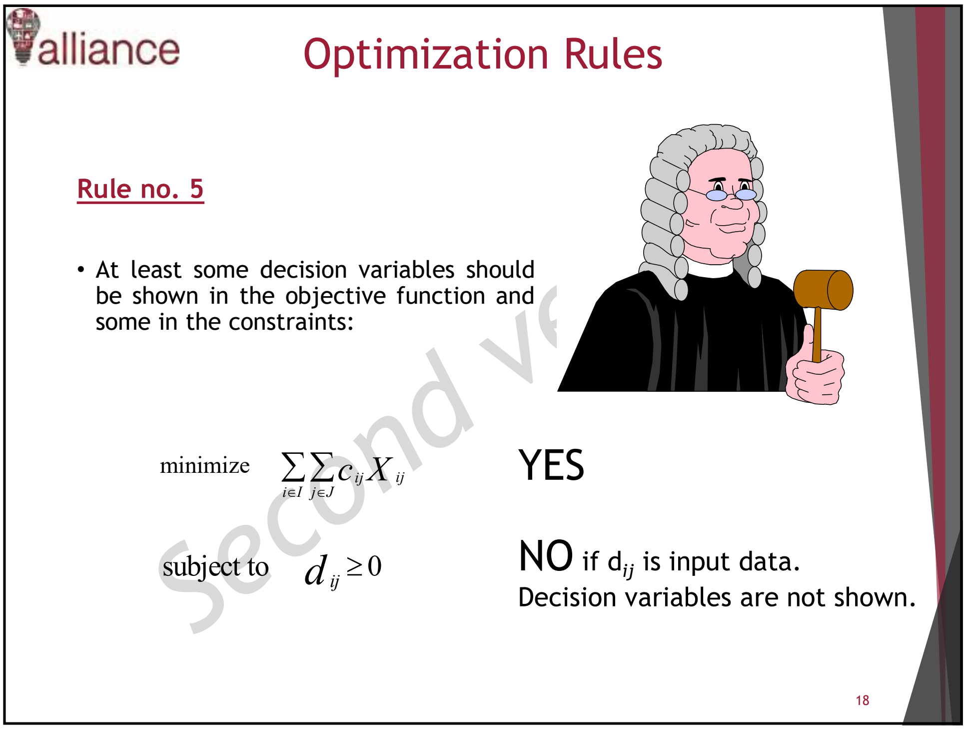
Rule no. 4

- All indices in the objective function should also be explained

minimize $\sum_{i \in I} \sum_{j \in J} c_{ij} X_{ij}$ YES

minimize $\sum_{i \in I} c_{ij} X_{ij}$ NO

Index *j* is not defined



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Optimization Rules

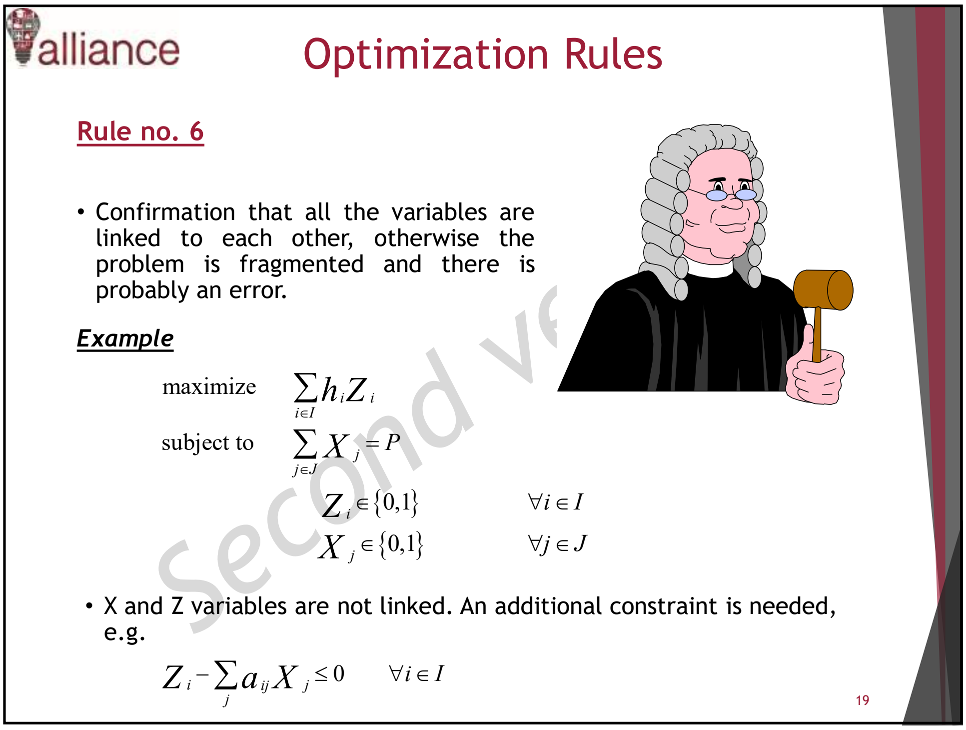
Rule no. 5

- At least some decision variables should be shown in the objective function and some in the constraints:

minimize $\sum_{i \in I} \sum_{j \in J} c_{ij} X_{ij}$ YES

subject to $d_{ij} \geq 0$ NO if d_{ij} is input data.

Decision variables are not shown.



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Optimization Rules

Rule no. 6

- Confirmation that all the variables are linked to each other, otherwise the problem is fragmented and there is probably an error.

Example

$$\text{maximize} \quad \sum_{i \in I} h_i Z_i$$

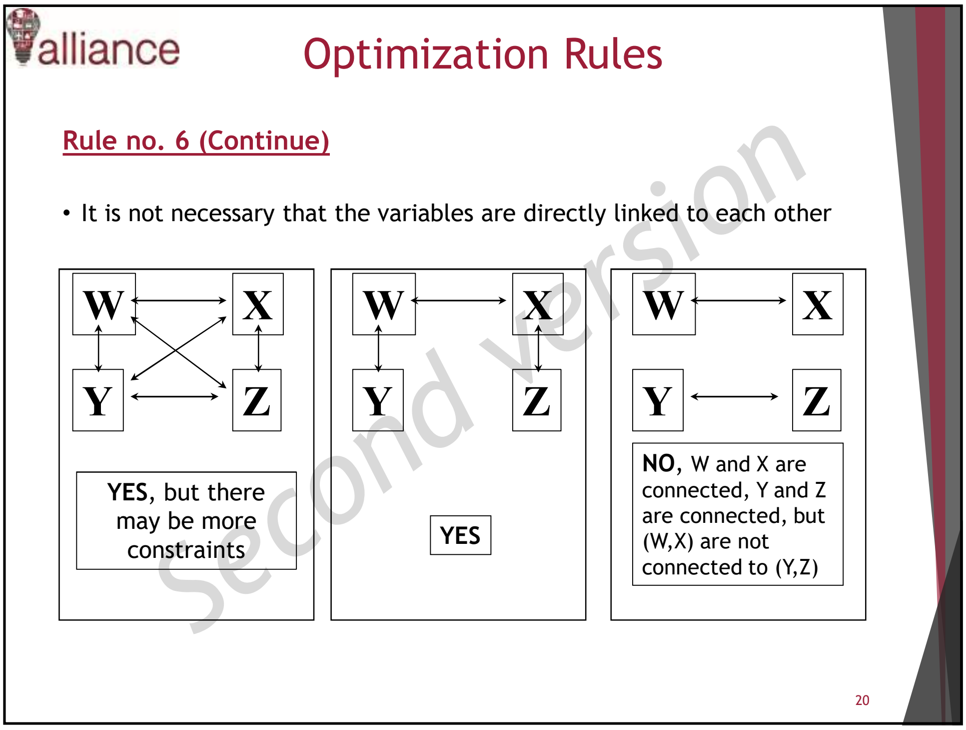
$$\text{subject to} \quad \sum_{j \in J} X_j = P$$

$$Z_i \in \{0,1\} \qquad \forall i \in I$$

$$X_j \in \{0,1\} \qquad \forall j \in J$$

- X and Z variables are not linked. An additional constraint is needed, e.g.

$$Z_i - \sum_j a_{ij} X_j \leq 0 \qquad \forall i \in I$$



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Optimization Rules

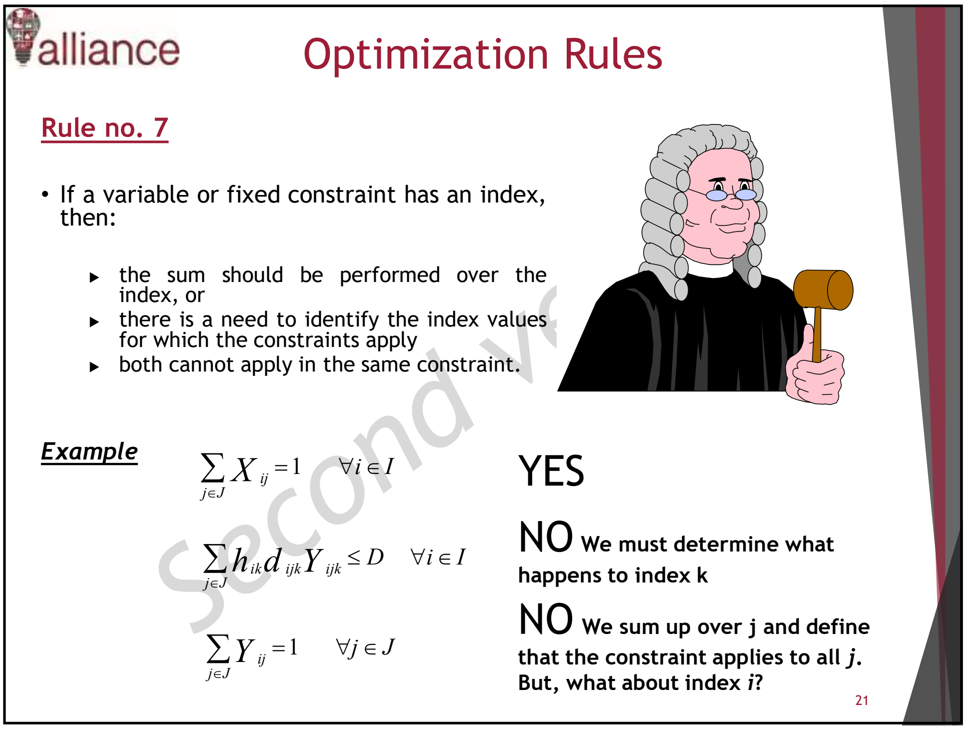
Rule no. 6 (Continue)

- It is not necessary that the variables are directly linked to each other

YES, but there may be more constraints

YES

NO, W and X are connected, Y and Z are connected, but (W,X) are not connected to (Y,Z)



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Optimization Rules

Rule no. 7

- If a variable or fixed constraint has an index, then:
  - the sum should be performed over the index, or
  - there is a need to identify the index values for which the constraints apply
  - both cannot apply in the same constraint.

Example

$$\sum_{j\in J} X_{ij} = 1 \quad \forall i \in I$$

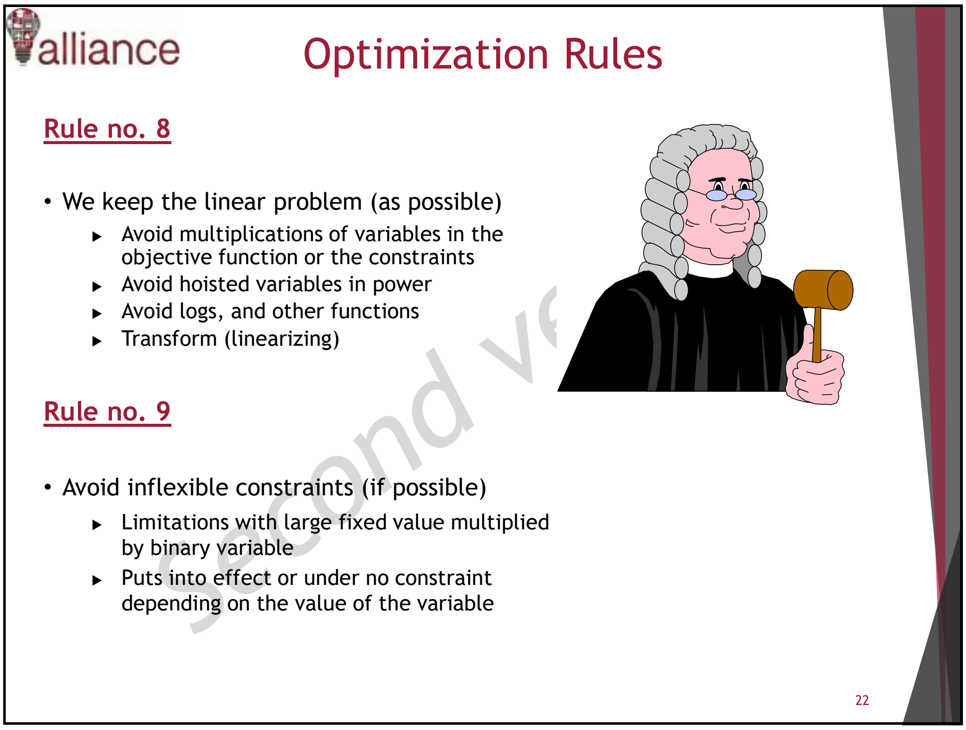
YES

$$\sum_{j\in J} h_{ik} d_{ijk} Y_{ijk} \le D \quad \forall i \in I$$

NO **We must determine what happens to index k**

$$\sum_{j\in J} Y_{ij} = 1 \quad \forall j \in J$$

NO **We sum up over j and define that the constraint applies to all *j*. But, what about index *i*?**



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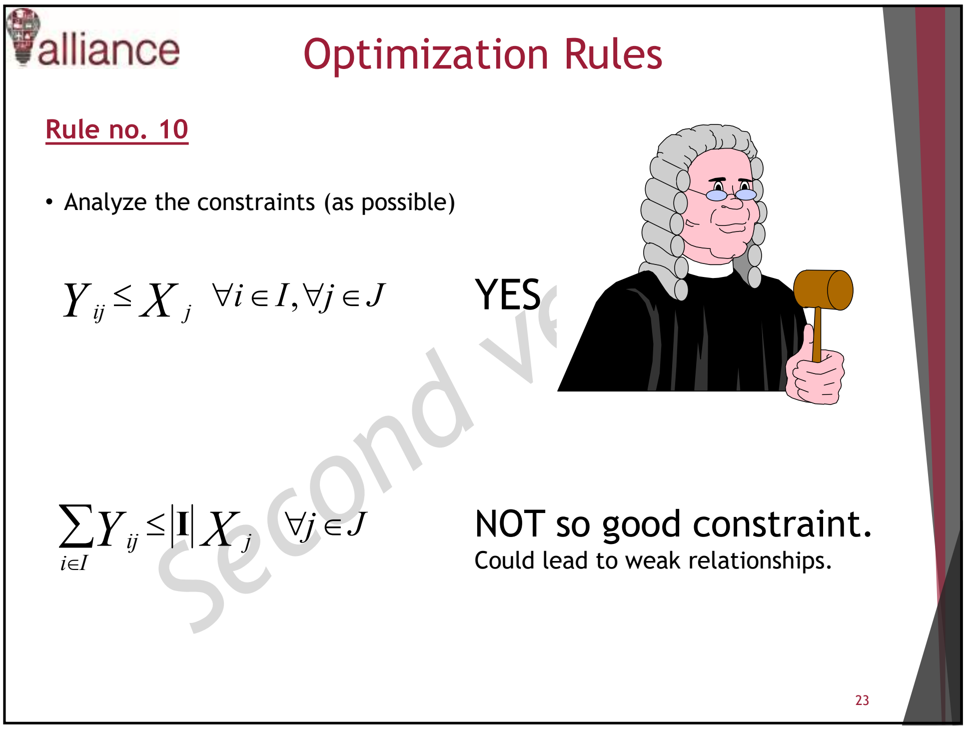
Optimization Rules

Rule no. 8

- We keep the linear problem (as possible)
  - Avoid multiplications of variables in the objective function or the constraints
  - Avoid hoisted variables in power
  - Avoid logs, and other functions
  - Transform (linearizing)

Rule no. 9

- Avoid inflexible constraints (if possible)
  - Limitations with large fixed value multiplied by binary variable
  - Puts into effect or under no constraint depending on the value of the variable



Optimization Rules

Rule no. 10

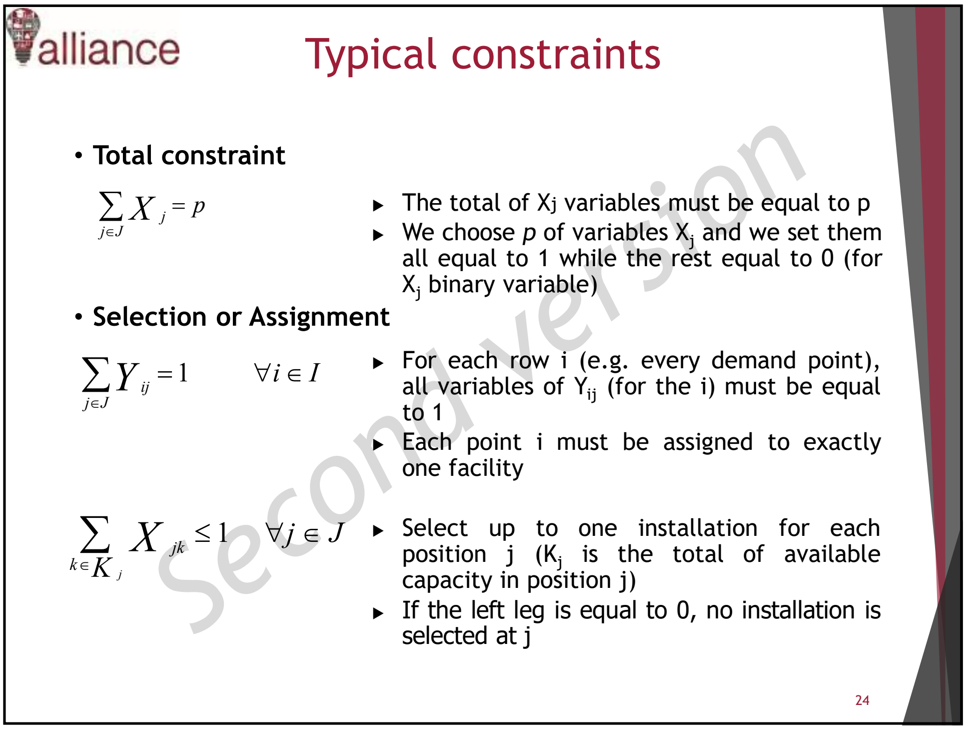
- Analyze the constraints (as possible)

$$Y_{ij} \le X_j \quad \forall i \in I, \forall j \in J$$

YES

$$\sum_{i \in I} Y_{ij} \le |\mathbf{I}| X_j \quad \forall j \in J$$

NOT so good constraint.
Could lead to weak relationships.



Typical constraints

- **Total constraint**

$$\sum_{j \in J} X_j = p$$

- The total of Xj variables must be equal to p
- We choose *p* of variables X_j and we set them all equal to 1 while the rest equal to 0 (for X_j binary variable)

- **Selection or Assignment**

$$\sum_{j \in J} Y_{ij} = 1 \qquad \forall i \in I$$

- For each row i (e.g. every demand point), all variables of Y_{ij} (for the i) must be equal to 1
- Each point i must be assigned to exactly one facility

$$\sum_{k \in K_j} X_{jk} \le 1 \quad \forall j \in J$$

- Select up to one installation for each position j (K_j is the total of available capacity in position j)
- If the left leg is equal to 0, no installation is selected at j

Typical constraints

- **Supply constraints**

$$\sum_{j\in J} X_{ij} \le S_i \qquad \forall i \in I$$

where

$$X_{ij} = \text{flow from i to j}$$

- The total outgoing flow from the i must be less than or equal to the supply i (S_i)
- In the X_{ij}, i is used as supply and j as demand

- **Demand constraints**

$$\sum_{i\in I} X_{ij} \ge D_j \quad \forall j \in J$$

where

$$X_{ij} = \text{flow from i to j}$$

- The overall outgoing flow to the j must be higher or equal to the demand at the point j (D_j)
- In the X_{ij}, i is used as supply and j as demand

Typical constraints

- **Connection of constraints**

$$Y_{ij} \le X_j \quad \forall i \in I, \forall j \in J$$

- X_j should be at least as much as Y_{ij}, or
- Y_{ij} should not be higher than X_j for all i and j
- We can not assign demand i to facility (Y_{ij} = 1) unless there is a facility in j (X_j = 1)

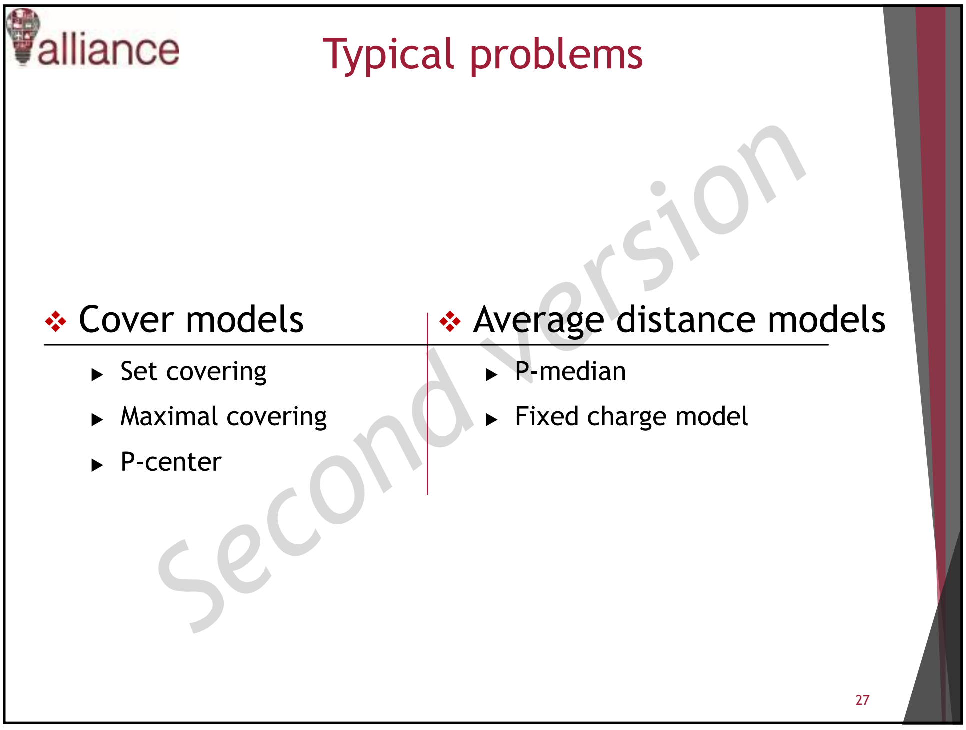
$$Z_i - \sum_{j\in J} a_{ij} X_j \le 0 \qquad \forall i \in I$$

- The i is considered not to have been covered (Z_i = 1) unless there is at least one facility sited, able to meet demand in i $\left(\sum_{j\in J} a_{ij} X_j \ge 1 \right)$

- **Maximum constraints**

$$W \ge \sum_{j\in J} d_{ij} Y_{ij} \quad \forall i \in I$$

- The W must be higher than the largest value of the right part of the inequality for all i
- The right side of the inequality indicates the distance between the point i and the facility assigned
- Used in P-center problem where minimizing the W under this and other constraints



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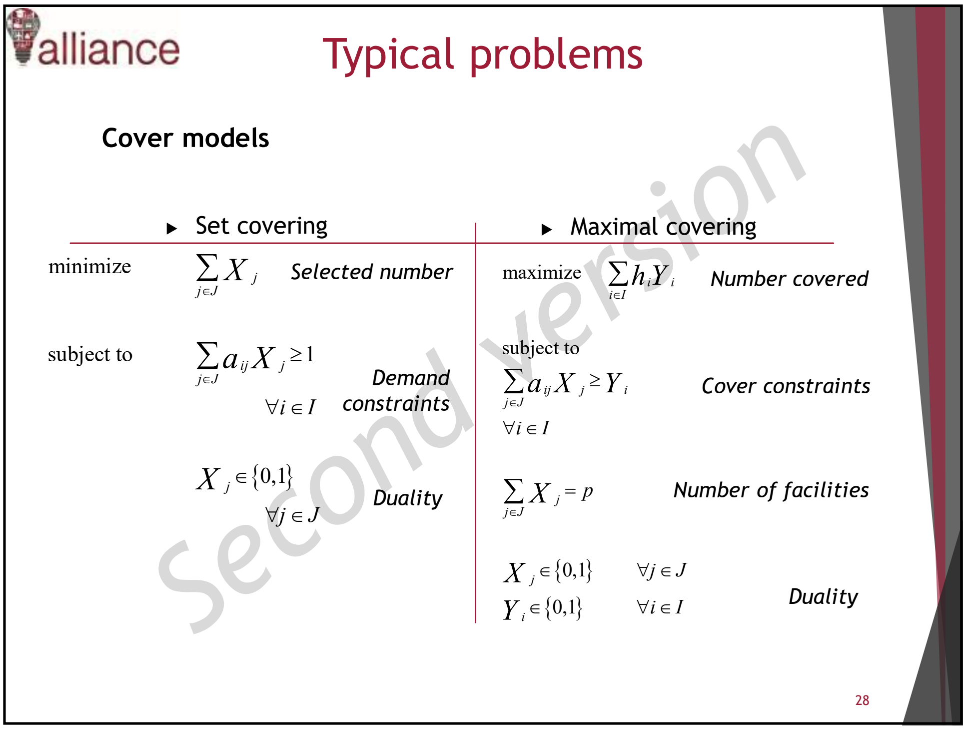
Typical problems

- ❖ Cover models
  - Set covering
  - Maximal covering
  - P-center
- ❖ Average distance models
  - P-median
  - Fixed charge model



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Typical problems

Cover models

- Set covering

minimize $\sum_{j \in J} X_j$ *Selected number*

subject to $\sum_{j \in J} a_{ij} X_j \geq 1 \quad \forall i \in I$ *Demand constraints*

$X_j \in \{0,1\} \quad \forall j \in J$ *Duality*

- Maximal covering

maximize $\sum_{i \in I} h_i Y_i$ *Number covered*

subject to $\sum_{j \in J} a_{ij} X_j \geq Y_i \quad \forall i \in I$ *Cover constraints*

$\sum_{j \in J} X_j = p$ *Number of facilities*

$X_j \in \{0,1\} \quad \forall j \in J$

$Y_i \in \{0,1\} \quad \forall i \in I$ *Duality*

Typical problems

Cover models

- P-center

minimize W — *Maximum distance*

subject to $\sum_{j\in J} Y_{ij} = 1 \quad \forall i \in I$ — *Assignment constraints*

$\sum_{j\in J} X_j = p$ — *Total constraints*

$Y_{ij} - X_j \leq 0 \quad \forall i \in I, \forall j \in J$ — *Connection constraints*

$W \geq \sum_{j\in J} d_{ij} Y_{ij} \quad \forall i \in I$ — *Maximum value constraints*

$X_j \in \{0,1\} \quad \forall j \in J$

$Y_{ij} \in \{0,1\} \quad \forall i \in I, \forall j \in J$ — *Duality*

Typical problems

Average distance models

- P-median

minimize $\sum_{i\in I}\sum_{j\in J} h_i d_{ij} Y_{ij}$ — *Weighted distance in demand*

subject to $\sum_{j\in J} Y_{ij} = 1 \quad \forall i \in I$ — *Assignment constraints*

$\sum_{j\in J} X_j = p$ — *Total constraints*

$Y_{ij} - X_j \leq 0 \quad \forall i \in I, \forall j \in J$ — *Connectivity constraints*

$X_j \in \{0,1\} \quad \forall j \in J$

$Y_{ij} \in \{0,1\} \quad \forall i \in I, \forall j \in J$ — *Duality*

- Fixed charge model

minimize $\sum_{j\in J} f_j X_j + \beta \sum_{i\in I}\sum_{j\in J} h_i d_{ij} Y_{ij}$ — *Fixed and operating costs*

subject to $\sum_{j\in J} Y_{ij} = 1 \quad \forall i \in I$ — *Assignment constraints*

$\sum_{j\in J} X_j = p$ — *Total constraints*

$Y_{ij} - X_j \leq 0 \quad \forall i \in I, \forall j \in J$ — *Connectivity constraints*

$X_j \in \{0,1\} \quad \forall j \in J$

$Y_{ij} \in \{0,1\} \quad \forall i \in I, \forall j \in J$ — *Duality*

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Optimization Techniques

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Linear Programming (LP)

Linear Programming: the area of mathematical programming which is the most widely applied

Setting up the model

- ❑ Variables

  $x_1, x_2, x_3, \ldots, x_n$

- ❑ Objective function (linear)

  MAX $Z = f(x) = c_1x_1 + c_2x_2 + c_3x_3 + \ldots + c_nx_n$

- ❑ Constraints

$$\alpha_{11}x_1 + \alpha_{12}x_2 + \alpha_{13}x_3 + \ldots + \alpha_{1n}x_n \leq b_1$$

$$\alpha_{21}x_1 + \alpha_{22}x_2 + \alpha_{23}x_3 + \ldots + \alpha_{2n}x_n \leq b_2$$

…

$$\alpha_{m1}x_1 + \alpha_{m2}x_2 + \alpha_{m3}x_3 + \ldots + \alpha_{mn}x_n \leq b_m$$

$x_1 \geq 0,\ x_2 \geq 0,\ x_3 \geq 0,\ \ldots,\ x_n \geq 0$ (non-negativity)

Linear Programming (LP)

Alternative set up of the model (vectors and matrices)

- Objective function

  MAX Z = f (x) = c x

- Constraints

  $a\ x \leq b$

  $x \geq 0$

c: 1 x n vector series
a: m x n matrix with elements a_{ij}
b: m x 1 column vector with b_i elements

Example (LP)

- The problem

A retailer will buy 200 containers of white appliances which may be purchased and transported from facility 1 and facility 2. Itineraries from both facilities are done on a combination of truck and rail. Each facility requires a certain time to the railway station. Determine the amount of containers to be purchased from each facility in order to maximize the profit.

Facility	1	2
Truck travel time to railway (hours)	9	6
Raw material requirements per container of white appliances (tons)	12	16
Profit per container (00 €)	350	300

Available
1566 hours truck travel time
2880 tons raw material for production of white appliances

Steps for the development of a linear optimization model

Step 1: Understanding of the problem

Step 2: Determination of decision variables

X_1= number of containers from facility 1

X_2= number of containers from facility 2

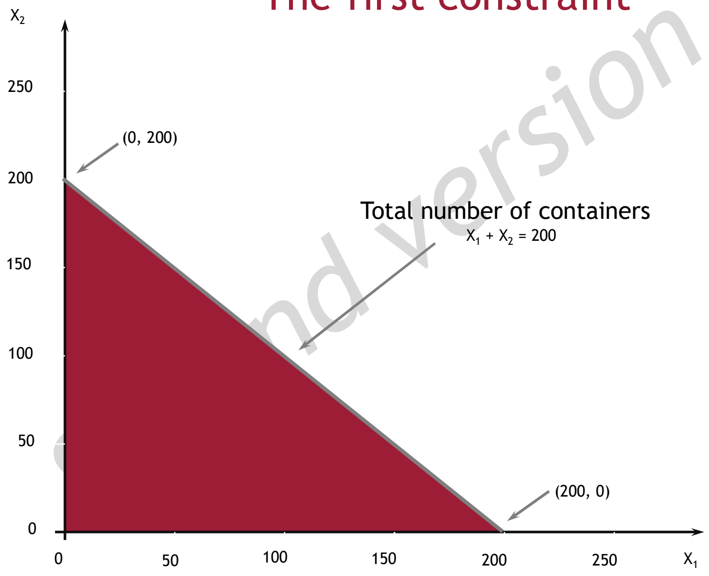
Step 3: Configuration of the objective function as a linear combination of the decision variables

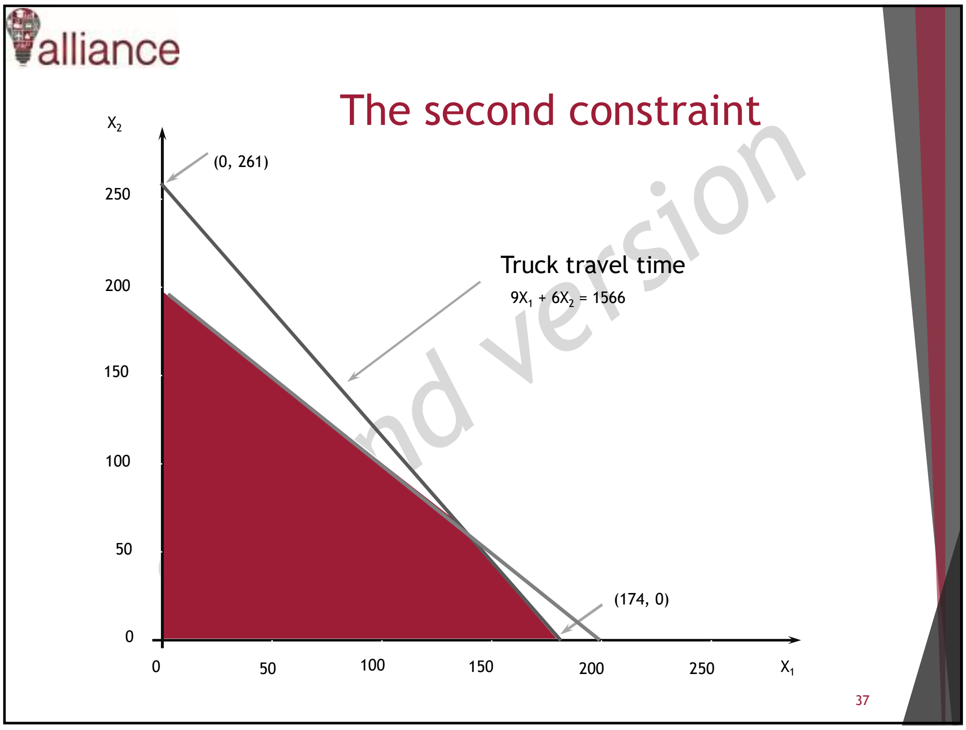
$$\text{MAX } \{350X_1 + 300X_2\}$$

Step 4: Definition of constraints as a linear combination of the decision variables

$X_1 + X_2 \leq 200$	} total number of containers
$9X_1 + 6X_2 \leq 1566$	} truck travel time (hours)
$12X_1 + 16X_2 \leq 2880$	} raw material (tons)
$X_1 \geq 0$	}Non-negativity constraints
$X_2 \geq 0$	}Non-negativity constraints

The first constraint

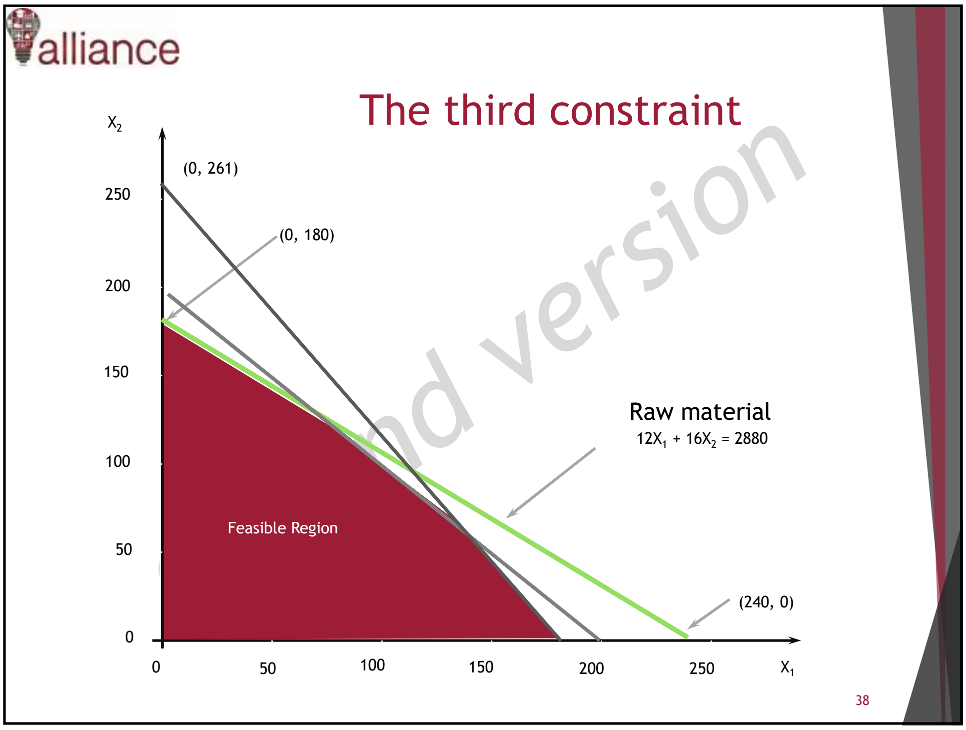




The second constraint

Truck travel time

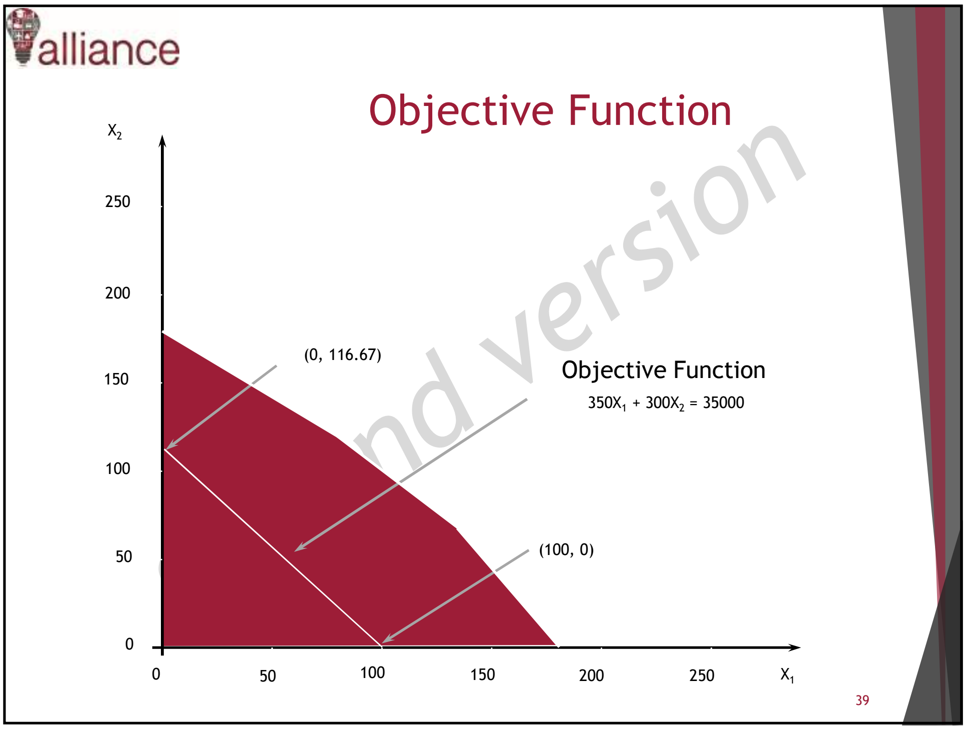
$9X_1 + 6X_2 = 1566$



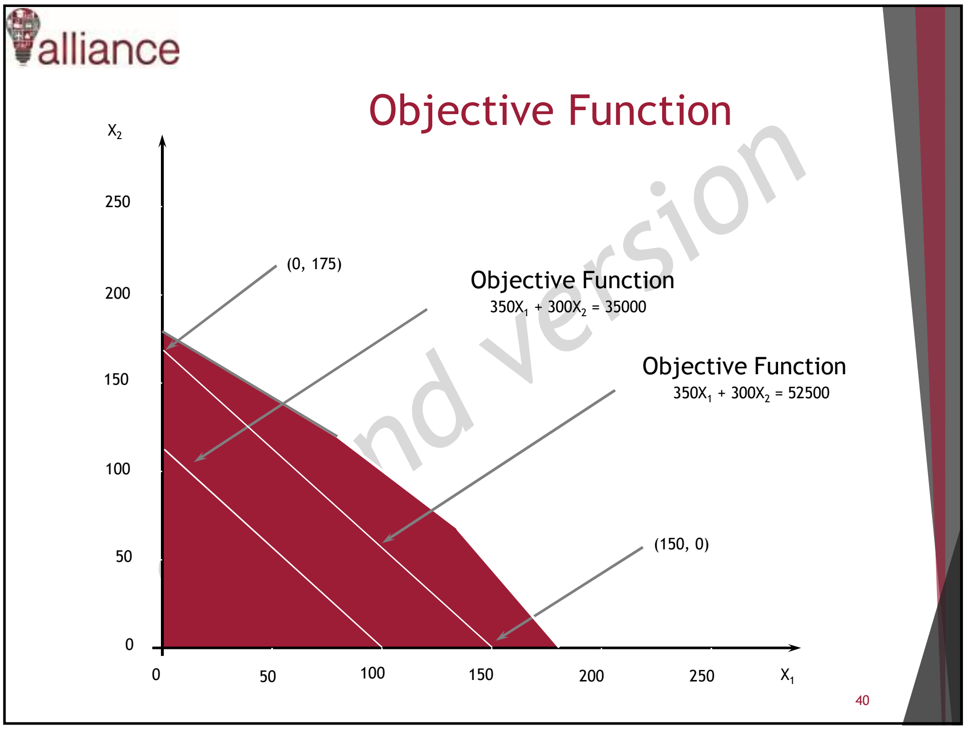
The third constraint

Raw material

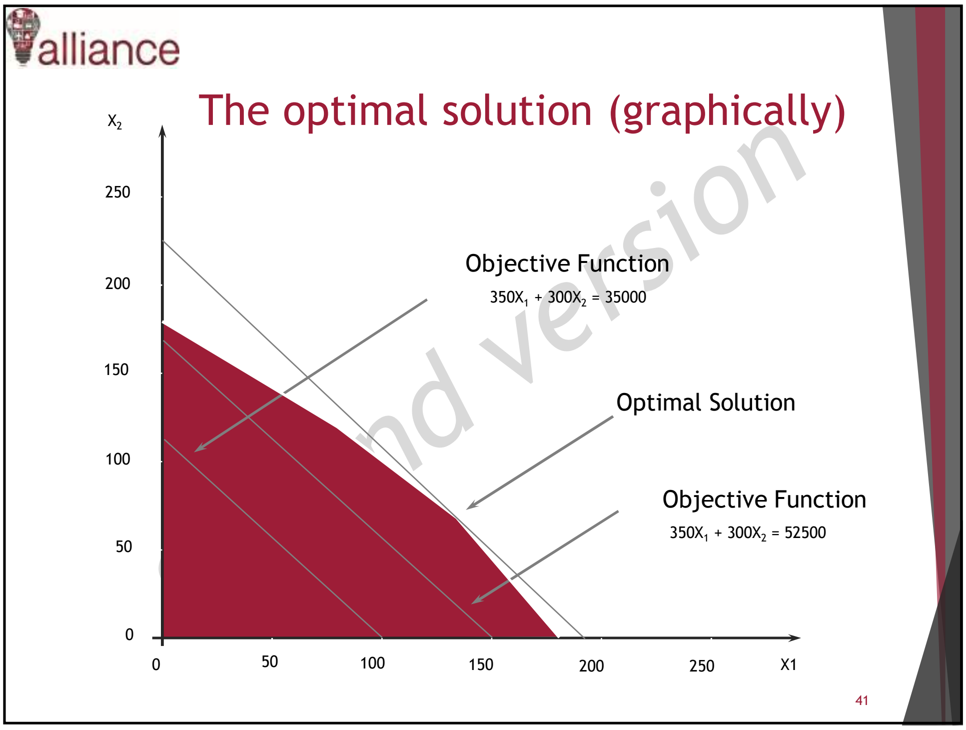
$12X_1 + 16X_2 = 2880$



Objective Function



Objective Function



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The optimal solution (graphically)

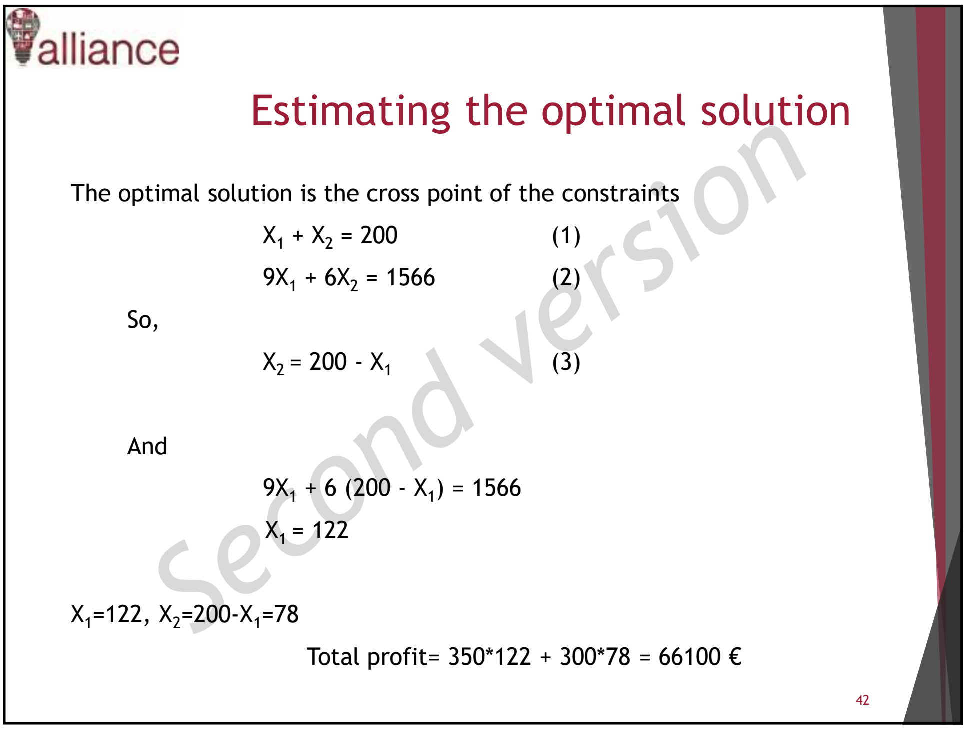
Objective Function

$350X_1 + 300X_2 = 35000$

Optimal Solution

Objective Function

$350X_1 + 300X_2 = 52500$



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Estimating the optimal solution

The optimal solution is the cross point of the constraints

$X_1 + X_2 = 200$ (1)

$9X_1 + 6X_2 = 1566$ (2)

So,

$X_2 = 200 - X_1$ (3)

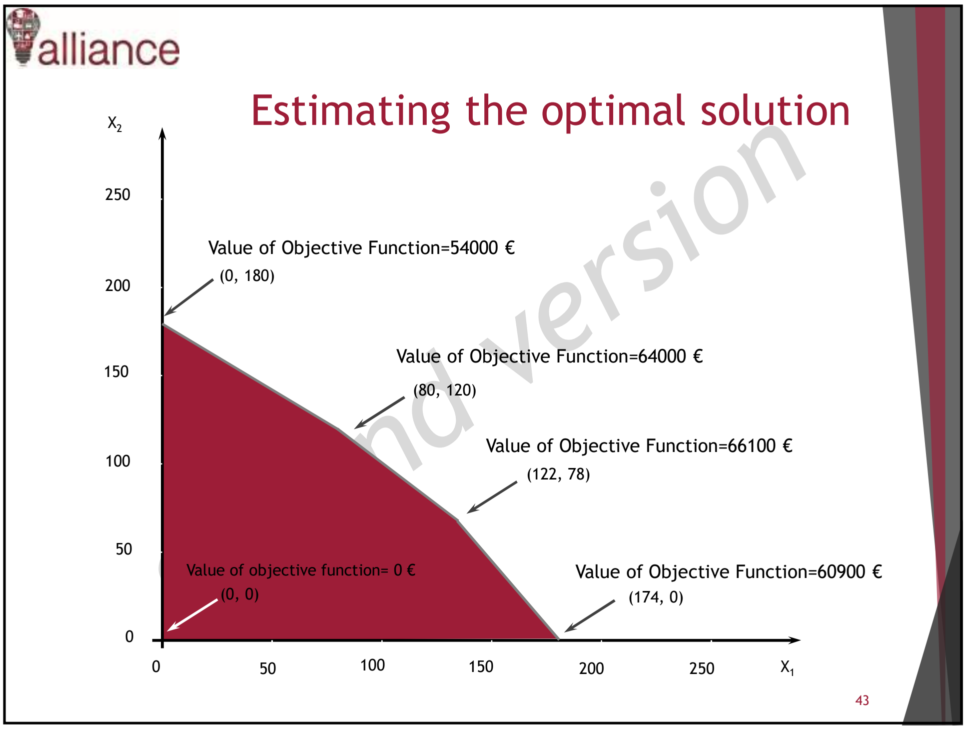
And

$9X_1 + 6\ (200 - X_1) = 1566$

$X_1 = 122$

$X_1=122,\ X_2=200-X_1=78$

Total profit= 350*122 + 300*78 = 66100 €



Estimating the optimal solution

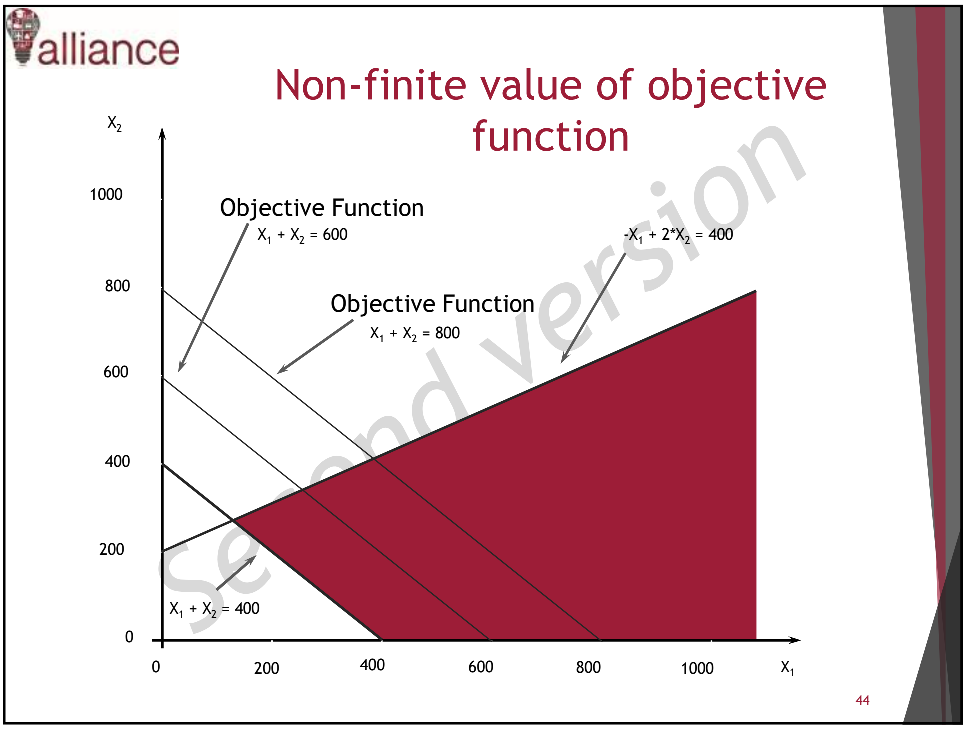
Value of Objective Function=54000 €
(0, 180)

Value of Objective Function=64000 €
(80, 120)

Value of Objective Function=66100 €
(122, 78)

Value of objective function= 0 €
(0, 0)

Value of Objective Function=60900 €
(174, 0)



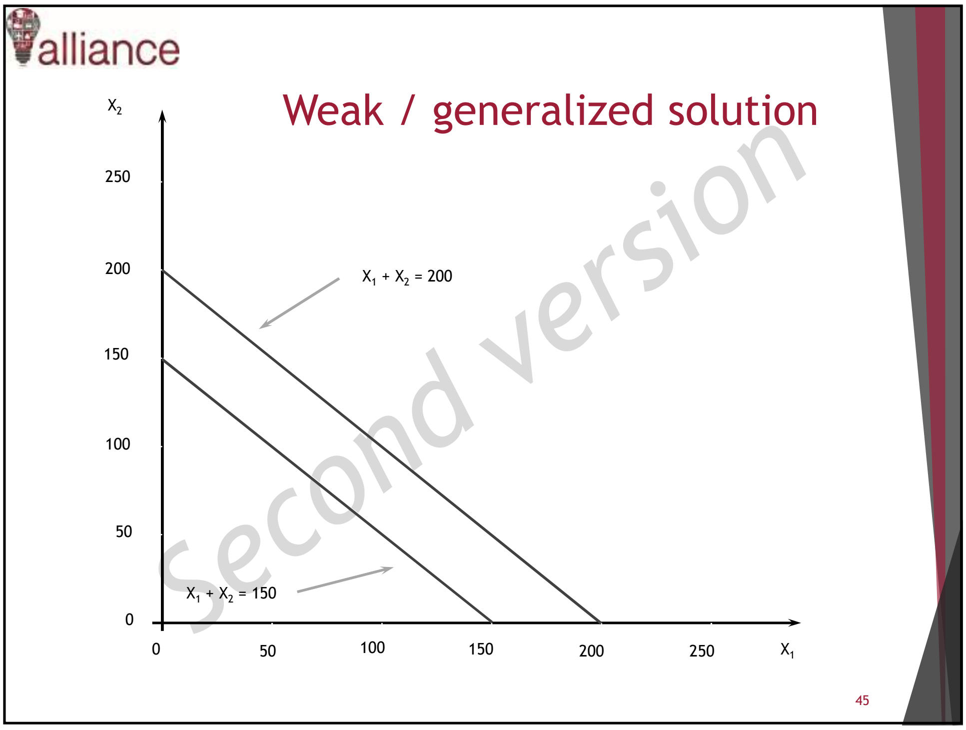
Non-finite value of objective function

Objective Function
$X_1 + X_2 = 600$

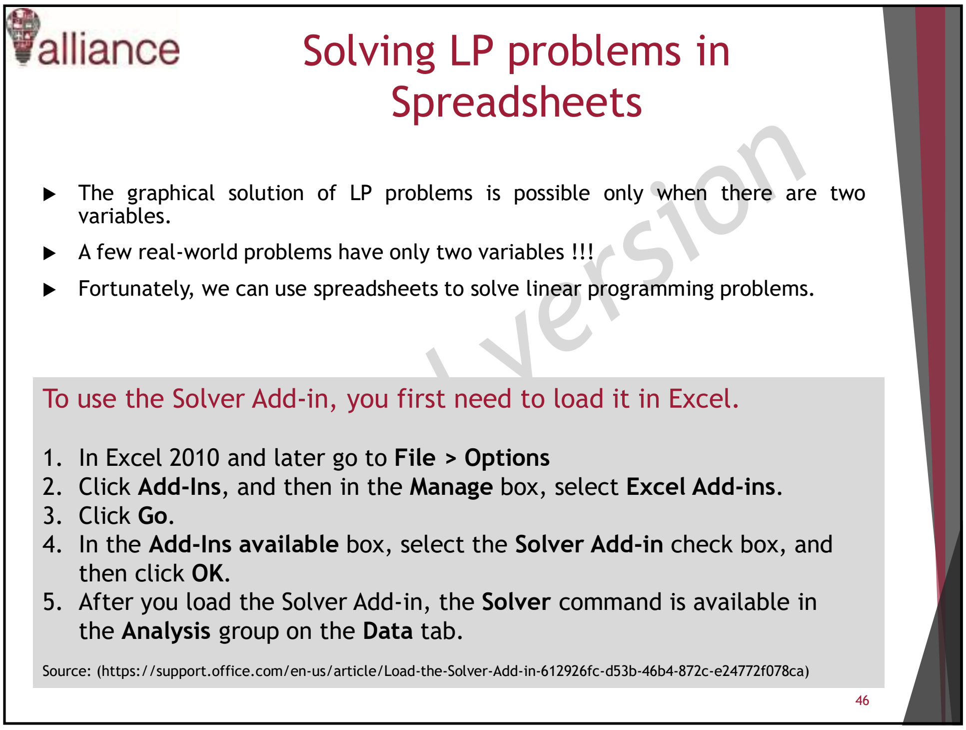
Objective Function
$X_1 + X_2 = 800$

$-X_1 + 2*X_2 = 400$

$X_1 + X_2 = 400$



Weak / generalized solution



Solving LP problems in Spreadsheets

- The graphical solution of LP problems is possible only when there are two variables.
- A few real-world problems have only two variables !!!
- Fortunately, we can use spreadsheets to solve linear programming problems.

To use the Solver Add-in, you first need to load it in Excel.

1. In Excel 2010 and later go to **File** > **Options**
2. Click **Add-Ins**, and then in the **Manage** box, select **Excel Add-ins**.
3. Click **Go**.
4. In the **Add-Ins available** box, select the **Solver Add-in** check box, and then click **OK**.
5. After you load the Solver Add-in, the **Solver** command is available in the **Analysis** group on the **Data** tab.

Source: (https://support.office.com/en-us/article/Load-the-Solver-Add-in-612926fc-d53b-46b4-872c-e24772f078ca)

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Solving LP problems in Spreadsheets

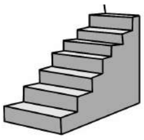
The steps of applying a linear programming model in a spreadsheet

Step 1: Organize the model data in the spreadsheet

Step 2: Keep separate cells in the spreadsheet that will represent each variable of the model

Step 3: Create a connection to a cell in the spreadsheet that corresponds to the objective function

Step 4: For any constraint, create a connection to a separate cell in the spreadsheet that corresponds to the right part (left-hand side) of the constraint



Source: (Ragsdale, 1998)

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Linear Programming (LP)

- ❑ The problem (the same as before)

A retailer will buy 200 containers of white appliances which may be purchased and transported from facility 1 and facility 2. Itineraries from both facilities are done on a combination of truck and rail. Each facility requires a certain time to the railway station. Determine the amount of containers to be purchased from each facility in order to maximize the profit.

Facility	1	2
Truck travel time to railway (hours)	9	6
Raw material requirements per container of white appliances (tons)	12	16
Profit per container (00 €)	350	300

Available
1566 hours truck travel time
2880 tons raw material for production of white appliances

$MAX: 350X_1 + 300X_2$ } *Profit*

$1X_1 + 1X_2 \leq 200$ } *Containers*

$9X_1 + 6X_2 \leq 1566$ } *Truck travel time*

$12X_1 + 16X_2 \leq 2880$ } *raw material per container*

$X_1, X_2 \geq 0$ } *Non-negativity constraints*

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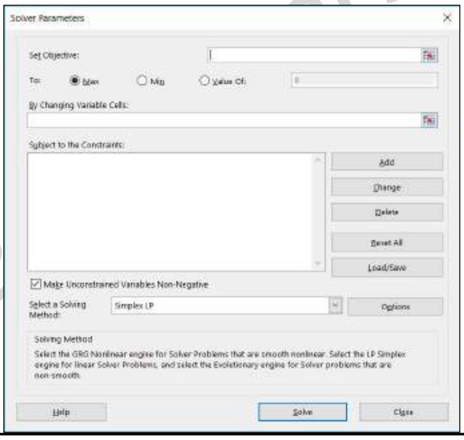
Set the problem in Solver

- Set Objective: insert the cell that corresponds to the objective function
- To: select the type of optimization (maximization or minimization)
- By Changing Cells: insert the cells corresponding to the decision variables
- Subject to the Constraints: insert the model constraints



Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

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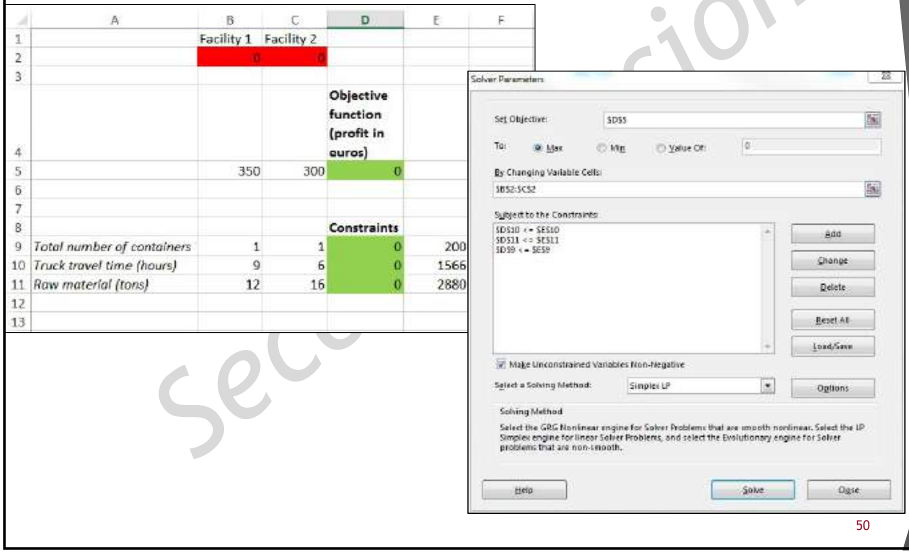
Enter data



	A	B	C	D	E	F
1		Facility 1	Facility 2			
2		0	0			
3						
4				**Objective function (profit in euros)**		
5		350	300	0		
6						
7						
8				**Constraints**		
9	*Total number of containers*	1	1	0	200	
10	*Truck travel time (hours)*	9	6	0	1566	
11	*Raw material (tons)*	12	16	0	2880	
12						
13						

Solver Parameters

Set Objective: $D$5

To: ● Max ○ Min ○ Value Of: 0

By Changing Variable Cells: $B$2:$C$2

Subject to the Constraints:
$D$10 <= $E$10
$D$11 <= $E$11
$D$9 <= $E$9

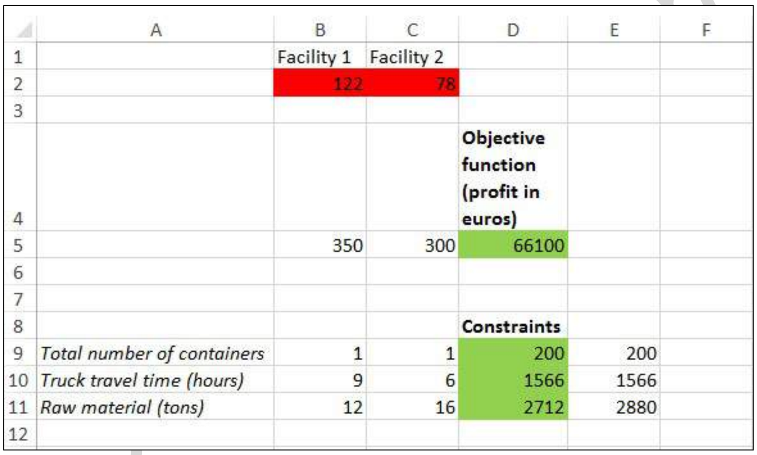
☑ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Output



	A	B	C	D	E	F
1		Facility 1	Facility 2			
2		122	78			
3						
4				**Objective function (profit in euros)**		
5		350	300	66100		
6						
7						
8				**Constraints**		
9	*Total number of containers*	1	1	200	200	
10	*Truck travel time (hours)*	9	6	1566	1566	
11	*Raw material (tons)*	12	16	2712	2880	
12						

Linear Programming

A Logistics problem

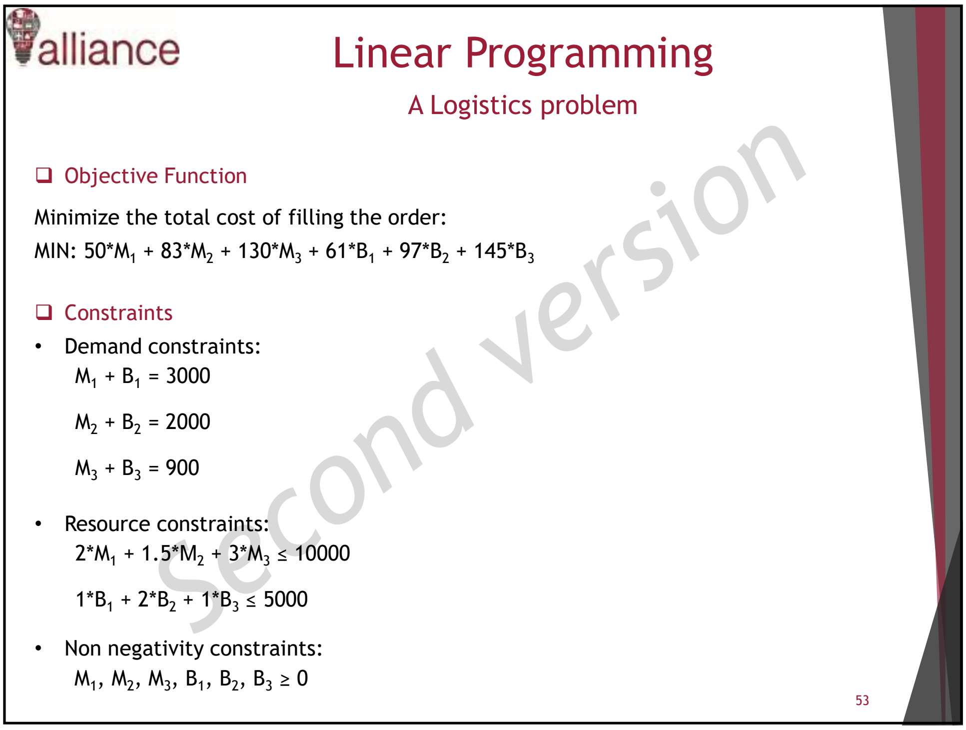
- **The problem**

A retailer needs 3000 pieces of product 1, 2000 pieces of product 2 and 900 pieces of product 3. He may buy products from a nearby producer (M), who can ship the products on LTL truck (shared vehicles) and the cost per piece is 50 euros for product 1, 83 for product 2 and 130 for product 3. The required personhours for each piece of product for the nearby producer is 2 hours for product 1, 1.5 hours for product 2 and 3 hours for product 3 and the total available resourses are 10000 hours. He can also buy products from a producer (B) from another city, who uses his own truck (FTL) and the cost per piece increases to 61 euros for product 1, 97 for product 2 and 145 for product 3. The required personhours for each piece of product for this producer is 1 hour for product 1, 2 hours for product 2 and 1 hour for product 3 and the total available resourses are 5000 hours.

How many pieces of each product should the retailer purchase from each producer to minimize his total cost?

- **Decision Variables**

M_1 = pieces of product 1 from producer M
M_2 = pieces of product 2 from producer M
M_3 = pieces of product 3 from producer M
B_1 = pieces of product 1 from producer B
B_2 = pieces of product 2 from producer B
B_3 = pieces of product 3 from producer B



Linear Programming

A Logistics problem

❑ Objective Function

Minimize the total cost of filling the order:

MIN: $50*M_1 + 83*M_2 + 130*M_3 + 61*B_1 + 97*B_2 + 145*B_3$

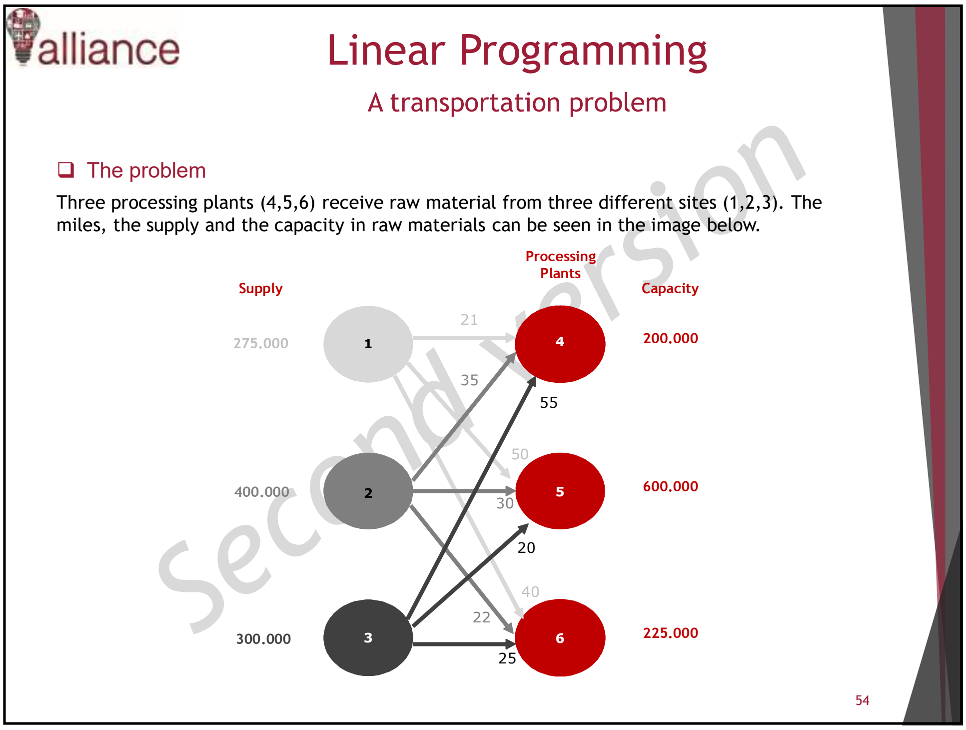
❑ Constraints

- Demand constraints:
  $M_1 + B_1 = 3000$

  $M_2 + B_2 = 2000$

  $M_3 + B_3 = 900$
- Resource constraints:
  $2*M_1 + 1.5*M_2 + 3*M_3 \leq 10000$

  $1*B_1 + 2*B_2 + 1*B_3 \leq 5000$
- Non negativity constraints:
  $M_1, M_2, M_3, B_1, B_2, B_3 \geq 0$

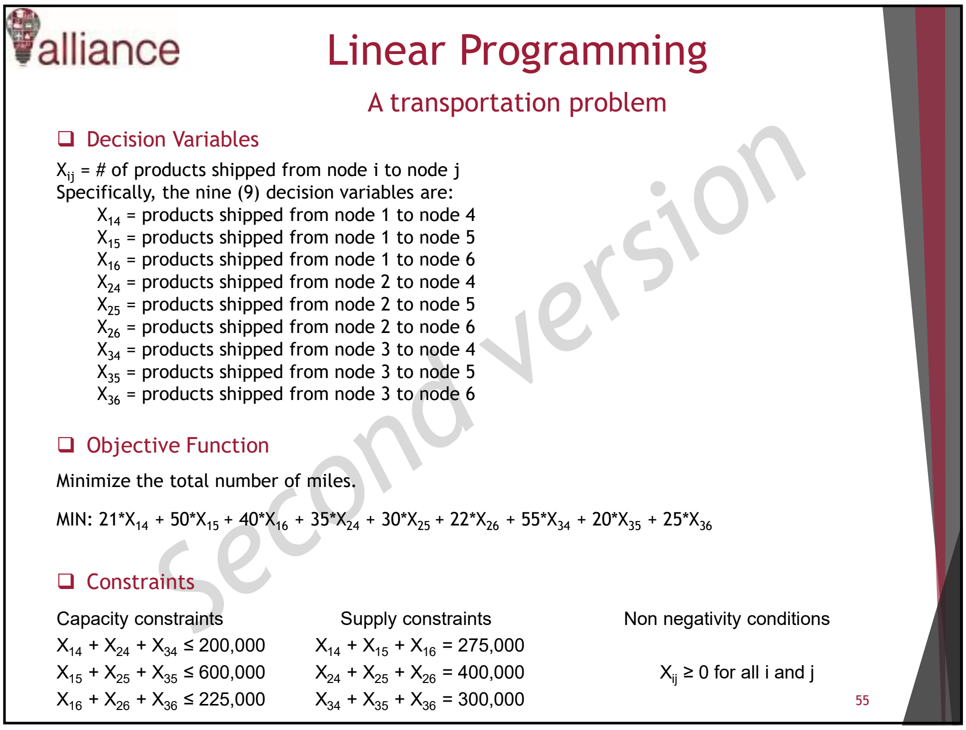


Linear Programming

A transportation problem

❑ The problem

Three processing plants (4,5,6) receive raw material from three different sites (1,2,3). The miles, the supply and the capacity in raw materials can be seen in the image below.



Linear Programming

A transportation problem

❑ Decision Variables

X_{ij} = # of products shipped from node i to node j
Specifically, the nine (9) decision variables are:

- X_{14} = products shipped from node 1 to node 4
- X_{15} = products shipped from node 1 to node 5
- X_{16} = products shipped from node 1 to node 6
- X_{24} = products shipped from node 2 to node 4
- X_{25} = products shipped from node 2 to node 5
- X_{26} = products shipped from node 2 to node 6
- X_{34} = products shipped from node 3 to node 4
- X_{35} = products shipped from node 3 to node 5
- X_{36} = products shipped from node 3 to node 6

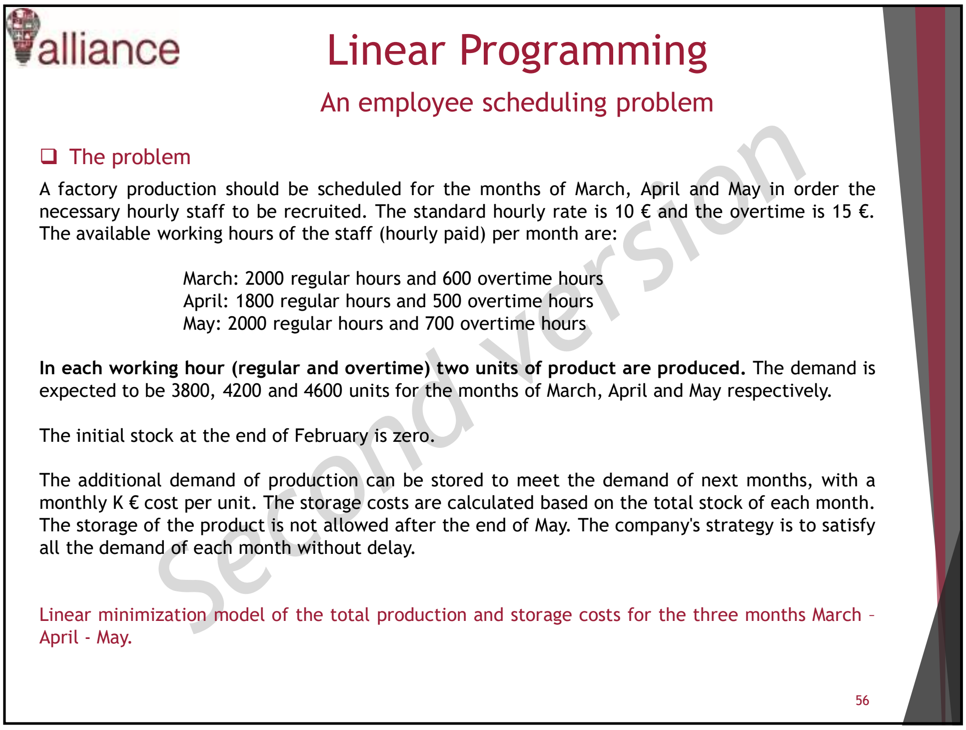
❑ Objective Function

Minimize the total number of miles.

MIN: $21*X_{14} + 50*X_{15} + 40*X_{16} + 35*X_{24} + 30*X_{25} + 22*X_{26} + 55*X_{34} + 20*X_{35} + 25*X_{36}$

❑ Constraints

Capacity constraints	Supply constraints	Non negativity conditions
$X_{14} + X_{24} + X_{34} \leq 200{,}000$	$X_{14} + X_{15} + X_{16} = 275{,}000$	
$X_{15} + X_{25} + X_{35} \leq 600{,}000$	$X_{24} + X_{25} + X_{26} = 400{,}000$	$X_{ij} \geq 0$ for all i and j
$X_{16} + X_{26} + X_{36} \leq 225{,}000$	$X_{34} + X_{35} + X_{36} = 300{,}000$	



Linear Programming

An employee scheduling problem

❑ The problem

A factory production should be scheduled for the months of March, April and May in order the necessary hourly staff to be recruited. The standard hourly rate is 10 € and the overtime is 15 €. The available working hours of the staff (hourly paid) per month are:

March: 2000 regular hours and 600 overtime hours
April: 1800 regular hours and 500 overtime hours
May: 2000 regular hours and 700 overtime hours

In each working hour (regular and overtime) two units of product are produced. The demand is expected to be 3800, 4200 and 4600 units for the months of March, April and May respectively.

The initial stock at the end of February is zero.

The additional demand of production can be stored to meet the demand of next months, with a monthly K € cost per unit. The storage costs are calculated based on the total stock of each month. The storage of the product is not allowed after the end of May. The company's strategy is to satisfy all the demand of each month without delay.

Linear minimization model of the total production and storage costs for the three months March – April - May.

Linear Programming

An employee scheduling problem

❑ Decision Variables

X_{3K}: Regular hours in March
X_{4K}: Regular hours in April
X_{5K}: Regular hours in May

X_{3Y}: Overtime in March
X_{4Y}: Overtime in April
X_{5Y}: Overtime in May

- Storage at the end of March: $2^*X_{3K} + 2^*X_{3Y} - 3800$
- Storage at the end of April: $2^*X_{3K} + 2^*X_{3Y} + 2^*X_{4K} + 2^*X_{4Y} - 3800 - 4200$
- Storage at the end of May: Zero $2^*(X_{3K} + X_{3Y} + X_{4K} + X_{4Y} + X_{5K} + X_{5Y}) = 3800 + 4200 + 4600$

❑ Objective function

MIN: $10\ (X_{3K} + X_{4K} + X_{5K}) + 15\ (X_{3Y} + X_{4Y} + X_{5Y}) + K\ (2^*X_{3K} + 2^*X_{3Y} - 3800) + K\ (2^*X_{3K} + 2^*X_{3Y} + 2^*X_{4K} + 2^*X_{4Y} - 3800 - 4200)$

❑ Constraints

Available regular hours & overtime

$X_{3K} \leq 2000 \quad X_{3Y} \leq 600$
$X_{4K} \leq 1800 \quad X_{4Y} \leq 500$
$X_{5K} \leq 2000 \quad X_{5Y} \leq 700$

$2^*X_{3K} + 2^*X_{3Y} \geq 3800$
$2^*X_{3K} + 2^*X_{3Y} + 2^*X_{4K} + 2^*X_{4Y} \geq 8000$
$2^*X_{3K} + 2^*X_{3Y} + 2^*X_{4K} + 2^*X_{4Y} + X_{5K} + 2^*X_{5Y} = 12600$
Fulfil demand without delay
Storage March - April: ≥ 0
Storage May: zero

Non negativity constraints

$X_{3K}, X_{3Y}, X_{4K}, X_{4Y}, X_{5K}, X_{5Y} \geq 0$

Linear Programming

A production planning problem

❑ The problem

An engineering company manufactures two special products in three laboratories. From the total capacity of each laboratory, only a percentage of 4%, 12% and 18%, respectively, is available for the production of the two specific products.

The capacity percentages of every laboratory that are required for the production rate of one unit per min are 1%, 0% and 3% for the first product and 0%, 2% and 2% for the second product in laboratories 1,2 and 3 respectively.
The net profit from the production of each product unit is 3 € for the first product and 5 € for the second product.
Determine the production rate of the two products in the three laboratories on the basis of maximizing profit.
If x_1 and x_2 are the production rates (in units / min) of products 1 and 2 respectively. The problem is to determine the values of x_1 and x_2 that optimize the linear model.

❑ Objective function

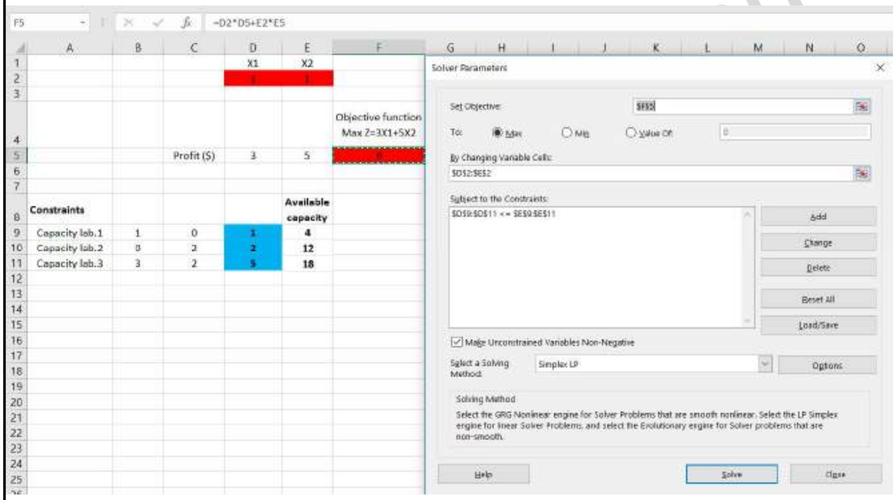
Max $Z = 3^*x_1 + 5^*x_2$

❑ Constraints

$x_1 \leq 4$ (Laboratory 1)
$2^*x_2 \leq 12$ (Laboratory 2)
$3^*x_1 + 2^*x_2 \leq 18$ (Laboratory 3)
$x_1 \geq 0,\ x_2 \geq 0$

Linear Programming

A production planning problem



F5 =D2*D5+E2*E5

	A	B	C	D	E	F
1				X1	X2	
2				1	1	
3						
4						Objective function Max Z=3X1+5X2
5			Profit ($)	3	5	8
6						
7						
8	**Constraints**				**Available capacity**	
9	Capacity lab.1	1	0	1	**4**	
10	Capacity lab.2	0	2	2	**12**	
11	Capacity lab.3	3	2	5	**18**	

Solver Parameters

Set Objective: $F$5

To: ● Max ○ Min ○ Value Of: 0

By Changing Variable Cells: $D$2:$E$2

Subject to the Constraints: $D$9:$D$11 <= $E$9:$E$11

☑ Make Unconstrained Variables Non-Negative

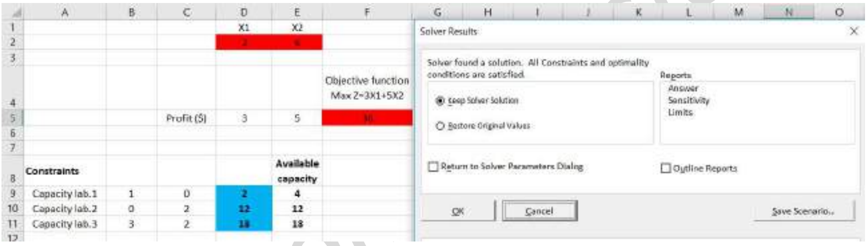
Select a Solving Method: Simplex LP

Solving Method

Select the GRG Nonlinear engine for Solver Problems that are smooth nonlinear. Select the LP Simplex engine for linear Solver Problems, and select the Evolutionary engine for Solver problems that are non-smooth.

Linear Programming

A production planning problem



	A	B	C	D	E	F
1				X1	X2	
2				2	6	
3						
4						Objective function Max Z=3X1+5X2
5			Profit ($)	3	5	36
6						
7						
8	**Constraints**				**Available capacity**	
9	Capacity lab.1	1	0	2	**4**	
10	Capacity lab.2	0	2	12	**12**	
11	Capacity lab.3	3	2	18	**18**	

Solver Results

Solver found a solution. All Constraints and optimality conditions are satisfied.

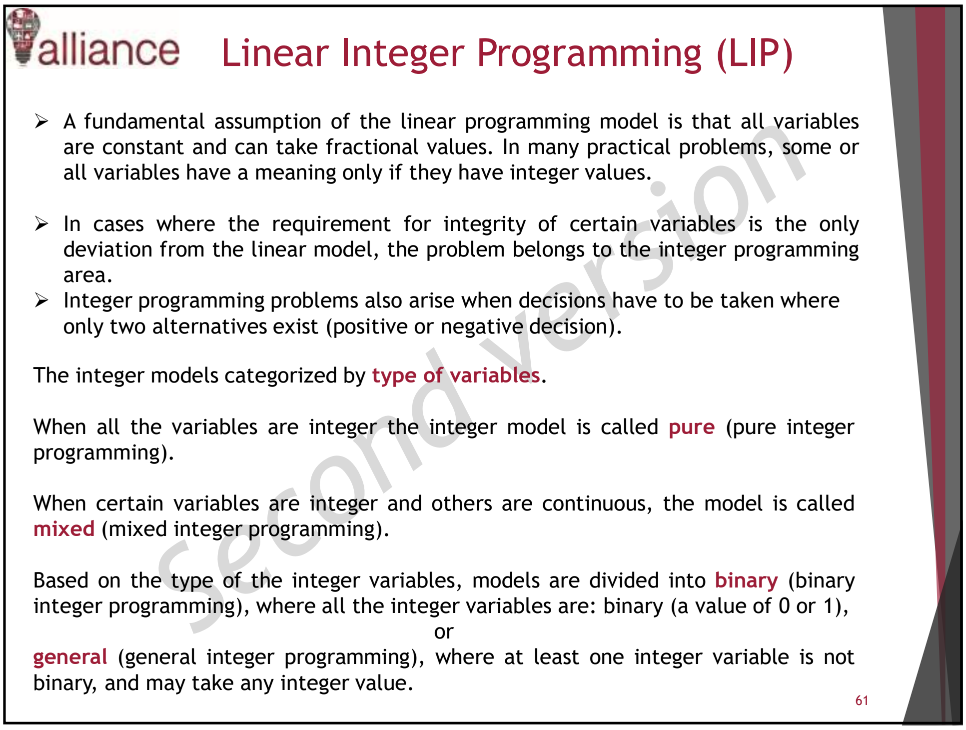
● Keep Solver Solution

○ Restore Original Values

☐ Return to Solver Parameters Dialog

☐ Outline Reports

Best solution: $x_1 = 2$, $x_2 = 6$ which maximizes the objective function maxZ = 36



Linear Integer Programming (LIP)

- A fundamental assumption of the linear programming model is that all variables are constant and can take fractional values. In many practical problems, some or all variables have a meaning only if they have integer values.

- In cases where the requirement for integrity of certain variables is the only deviation from the linear model, the problem belongs to the integer programming area.
- Integer programming problems also arise when decisions have to be taken where only two alternatives exist (positive or negative decision).

The integer models categorized by **type of variables**.

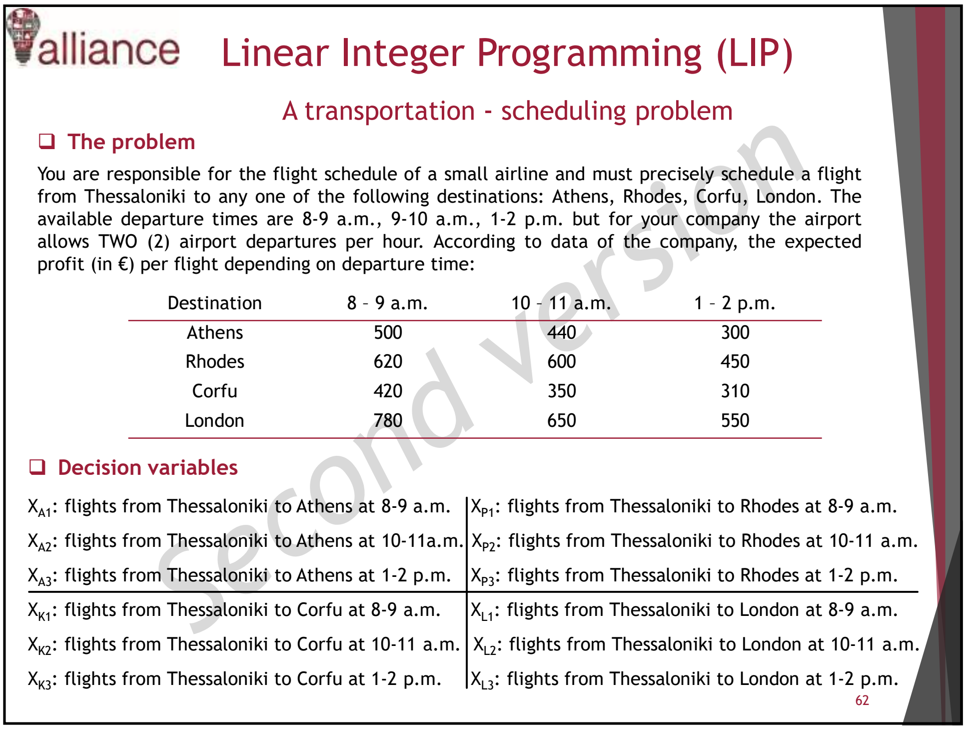
When all the variables are integer the integer model is called **pure** (pure integer programming).

When certain variables are integer and others are continuous, the model is called **mixed** (mixed integer programming).

Based on the type of the integer variables, models are divided into **binary** (binary integer programming), where all the integer variables are: binary (a value of 0 or 1),

or

general (general integer programming), where at least one integer variable is not binary, and may take any integer value.



Linear Integer Programming (LIP)

A transportation - scheduling problem

❑ The problem

You are responsible for the flight schedule of a small airline and must precisely schedule a flight from Thessaloniki to any one of the following destinations: Athens, Rhodes, Corfu, London. The available departure times are 8-9 a.m., 9-10 a.m., 1-2 p.m. but for your company the airport allows TWO (2) airport departures per hour. According to data of the company, the expected profit (in €) per flight depending on departure time:

Destination	8 – 9 a.m.	10 – 11 a.m.	1 – 2 p.m.
Athens	500	440	300
Rhodes	620	600	450
Corfu	420	350	310
London	780	650	550

❑ Decision variables

X_{A1}: flights from Thessaloniki to Athens at 8-9 a.m.
X_{A2}: flights from Thessaloniki to Athens at 10-11a.m.
X_{A3}: flights from Thessaloniki to Athens at 1-2 p.m.

X_{P1}: flights from Thessaloniki to Rhodes at 8-9 a.m.
X_{P2}: flights from Thessaloniki to Rhodes at 10-11 a.m.
X_{P3}: flights from Thessaloniki to Rhodes at 1-2 p.m.

X_{K1}: flights from Thessaloniki to Corfu at 8-9 a.m.
X_{K2}: flights from Thessaloniki to Corfu at 10-11 a.m.
X_{K3}: flights from Thessaloniki to Corfu at 1-2 p.m.

X_{L1}: flights from Thessaloniki to London at 8-9 a.m.
X_{L2}: flights from Thessaloniki to London at 10-11 a.m.
X_{L3}: flights from Thessaloniki to London at 1-2 p.m.

Linear Integer Programming (LIP)

A transportation - scheduling problem

Destination	8 – 9 a.m.	10 – 11 a.m.	1 – 2 p.m.
Athens	500	440	300
Rhodes	620	600	450
Corfu	420	350	310
London	780	650	550

- ❑ **Objective Function:**

MAX: $500*X_{A1} + 440*X_{A2} + 300*X_{A3} + 620*X_{P1} + 600*X_{P2} + 450*X_{P3} + 420*X_{K1} + 350*X_{K2} + 310*X_{K3} + 780*X_{L1} + 650*X_{L2} + 550*X_{L3}$

- ❑ **Constraints**

$X_{A1} + X_{A2} + X_{A3} = 1$

$X_{P1} + X_{P2} + X_{P3} = 1$

$X_{K1} + X_{K2} + X_{K3} = 1$

$X_{L1} + X_{L2} + X_{L3} = 1$

$X_{A1} + X_{P1} + X_{K1} + X_{L1} \leq 2$

$X_{A2} + X_{P2} + X_{K2} + X_{L2} \leq 2$

$X_{A3} + X_{P3} + X_{K3} + X_{L3} \leq 2$

X: binary

Linear Integer Programming (LIP)

A scheduling problem

- ❑ The problem

Twice a week a large freight-storage center is handling flammable materials. For a timely response to a fire at the freight center, a small fire truck has to be placed at some of the chosen locations A, B, C and D of the area (or at all), so that on the one hand there is sufficient coverage and on the other hand to minimize cost.
The overall installation and maintenance costs of a vehicle at the D location is 10% higher than at the positions A, B and C.
Adequate coverage means that the vehicle can reach in five minutes the fire for the first interference.
The area, which has to be covered, is described as a number of points. We assume that the freight center is illustrated with 6 points (possible fire outbreaks) and that the following table shows (indicating "YES") in which one of the points 1,2, ... 6, the vehicle can reach the corresponding position in 5 minutes.

	Location A	Location B	Location C	Location D
Point 1			YES	YES
Point 2	YES	YES		
Point 3	YES			YES
Point 4	YES	YES	YES	
Point 5		YES	YES	YES
Point 6		YES		YES

Determine and solve a pure binary integer linear model which solution can specify the locations of the fire trucks, minimizing costs and offering adequate coverage of the freight center.

Linear Integer Programming (LIP)

A transportation - scheduling problem

❑ Decision variables

X_A, X_B, X_C, X_D binary variables, that take value 1 if the vehicle is placed at the respective location A,B,C,D. Otherwise they get 0 value.

❑ Objective function

MIN: $X_A + X_B + X_C + 1{,}1{*}X_D$

❑ Constraints

$X_C + X_D \geq 1$

$X_A + X_B \geq 1$

$X_A + X_D \geq 1$

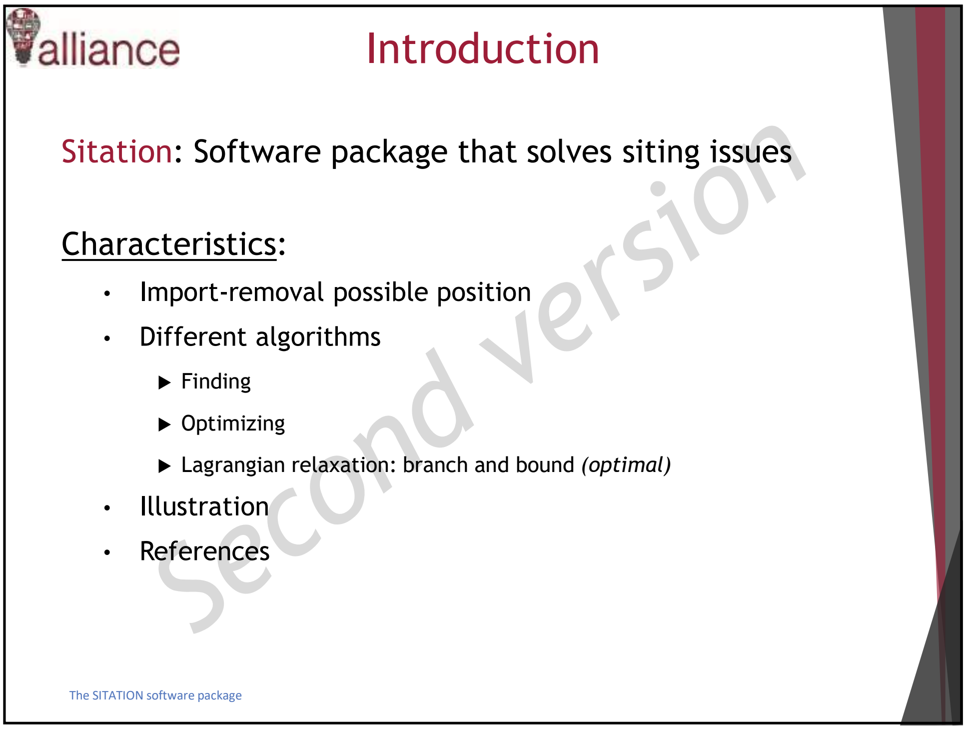
$X_A + X_B + X_C \geq 1$

$X_B + X_C + X_D \geq 1$

$X_B + X_D \geq 1$

Software and applications - The SITATION software

Source: Daskin, 2010

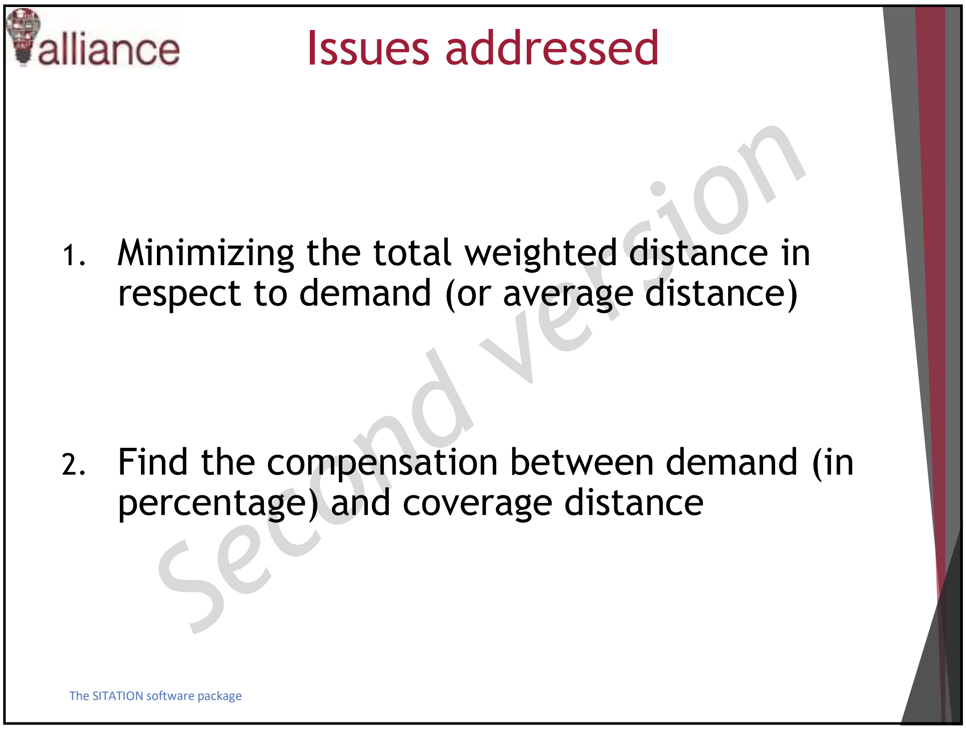


Introduction

Sitation: Software package that solves siting issues

<u>Characteristics</u>:

- Import-removal possible position
- Different algorithms
  - Finding
  - Optimizing
  - Lagrangian relaxation: branch and bound *(optimal)*
- Illustration
- References



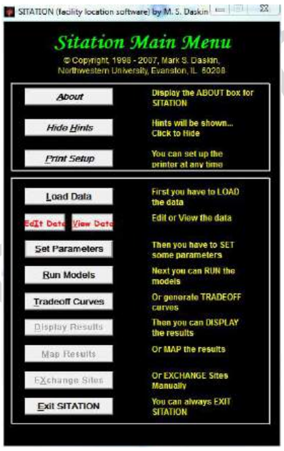
Issues addressed

1. Minimizing the total weighted distance in respect to demand (or average distance)

2. Find the compensation between demand (in percentage) and coverage distance

First step

By clicking on SITATION.EXE, the software loads and the main menu appears.



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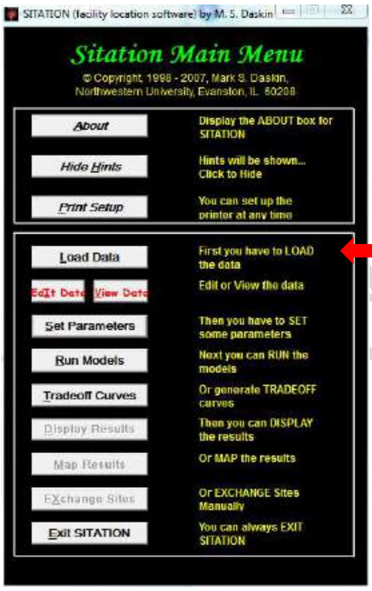
Display the ABOUT box for SITATION
Hints will be shown... Click to Hide
You can set up the printer at any time
First you have to LOAD the data
Edit or View the data
Then you have to SET some parameters
Next you can RUN the models
Or generate TRADEOFF curves
Then you can DISPLAY the results
Or MAP the results
Or EXCHANGE Sites Manually
You can always EXIT SITATION

The SITATION software package

Second step



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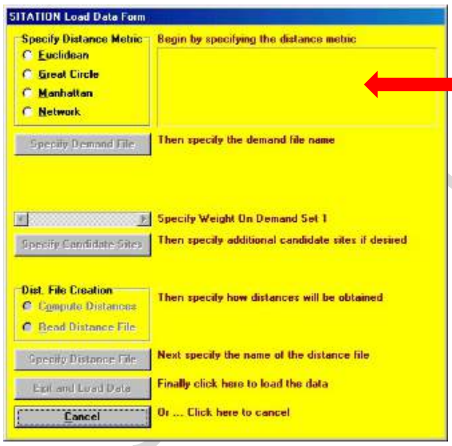
Load Data

The SITATION software package

To select



Begin by specifying the distance metric

Then specify the demand file name

Specify Weight On Demand Set 1

Then specify additional candidate sites if desired

Then specify how distances will be obtained

Next specify the name of the distance file

Finally click here to load the data

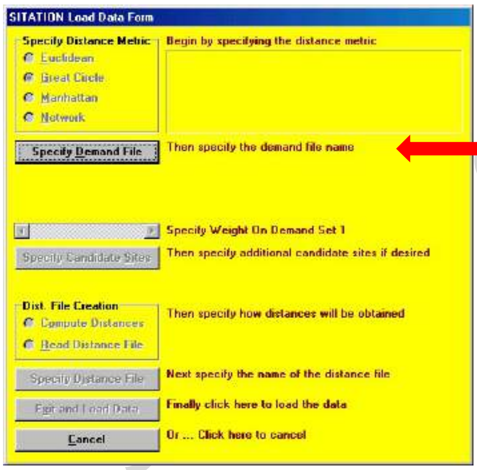
Or ... Click here to cancel

Firstly, the type of distances should be defined:

- Euclidean (straight line)
- Great Circle (shortest distance on a sphere)
- Manhattan (right angle)
- Network

The SITATION software package

Next



Begin by specifying the distance metric

Then specify the demand file name

Specify Weight On Demand Set 1

Then specify additional candidate sites if desired

Then specify how distances will be obtained

Next specify the name of the distance file

Finally click here to load the data

Or ... Click here to cancel

Select the data file

The SITATION software package

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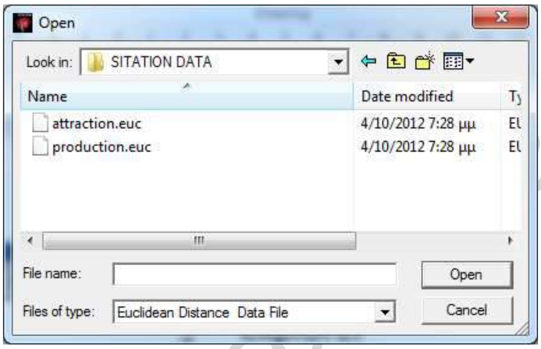
File selection



Open

Look in: SITATION DATA

Name	Date modified	Ty
attraction.euc	4/10/2012 7:28 μμ	EU
production.euc	4/10/2012 7:28 μμ	EU

File name:

Files of type: Euclidean Distance Data File

From explorer

alliance

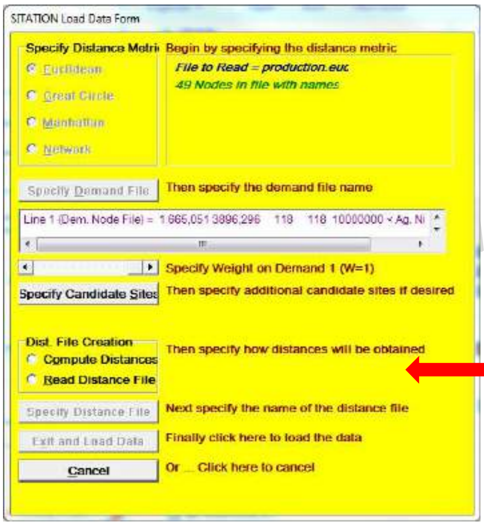
Data form

1	665,051	3896,296	118	118	10000000	< Agios Nikolaos>
point	longitude	latitude	demand 1	demand 2	fixed cost	point name

point, longitude, latitude, demand 1, demand 2, fixed cost, point name

alliance

Set distances



Begin by specifying the distance metric

File to Read = production.euc

49 Nodes in file with names

Then specify the demand file name

Line 1 (Dem. Node File) = 1 665,051 3896,296 118 118 10000000 < Ag. Ni

Specify Weight on Demand 1 (W=1)

Then specify additional candidate sites if desired

Then specify how distances will be obtained

Next specify the name of the distance file

Finally click here to load the data

Or ... Click here to cancel

- can calculate distances based on coordinates

or

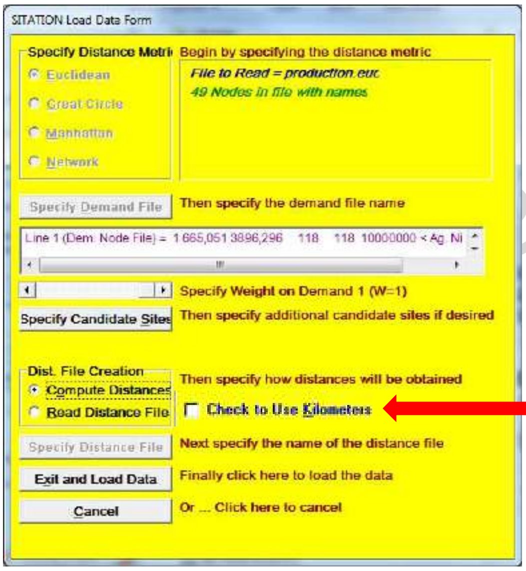
- read from file

The SITATION software package

---

alliance

Units of length



Begin by specifying the distance metric

File to Read = production.euc

49 Nodes in file with names

Then specify the demand file name

Line 1 (Dem. Node File) = 1 665,051 3896,296 118 118 10000000 < Ag. Ni

Specify Weight on Demand 1 (W=1)

Then specify additional candidate sites if desired

Then specify how distances will be obtained

Next specify the name of the distance file

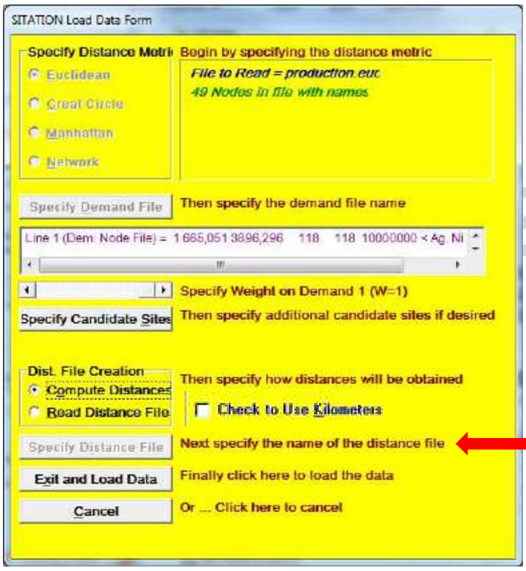
Finally click here to load the data

Or ... Click here to cancel

Select kilometers instead of miles (initial selection)

The SITATION software package

Confirmation



Begin by specifying the distance metric

File to Read = production.euc

49 Nodes in file with names

Then specify the demand file name

Line 1 (Dem. Node File) = 1 665,051 3896,296 118 118 10000000 < Ag. Ni

Specify Weight on Demand 1 (W=1)

Then specify additional candidate sites if desired

Then specify how distances will be obtained

Next specify the name of the distance file

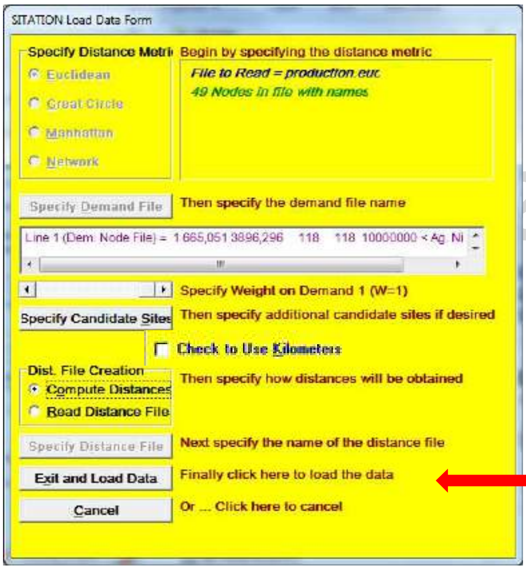
Finally click here to load the data

Or ... Click here to cancel

File name and number of positions

The SITATION software package

Loading



Begin by specifying the distance metric

File to Read = production.euc

49 Nodes in file with names

Then specify the demand file name

Line 1 (Dem. Node File) = 1 665,051 3896,296 118 118 10000000 < Ag. Ni

Specify Weight on Demand 1 (W=1)

Then specify additional candidate sites if desired

Then specify how distances will be obtained

Next specify the name of the distance file

Finally click here to load the data

Or ... Click here to cancel

Exit and Load data

The SITATION software package

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Confirm

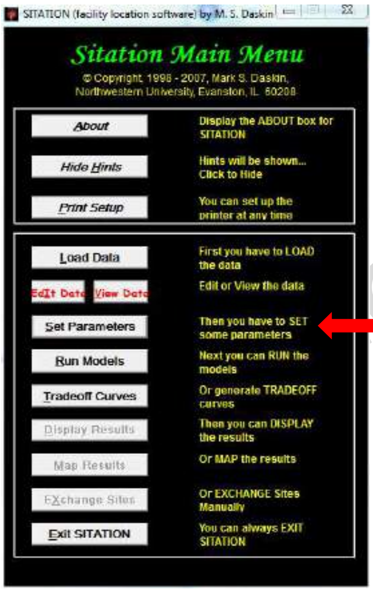
Do you want to save distances?

The SITATION software package

---

alliance

Third step


SITATION (facility location software) by M. S. Daskin

Sitation Main Menu

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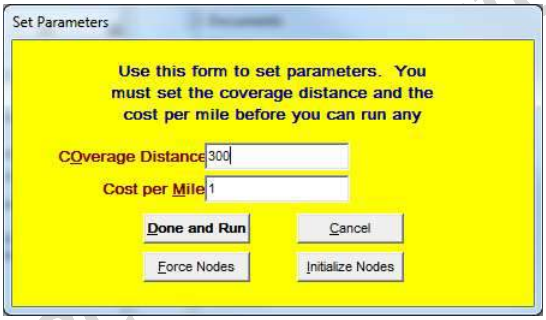
Northwestern University, Evanston, IL 60208

About	Display the ABOUT box for SITATION
Hide Hints	Hints will be shown... Click to Hide
Print Setup	You can set up the printer at any time
Load Data	First you have to LOAD the data
Edit Data View Data	Edit or View the data
Set Parameters	Then you have to SET some parameters
Run Models	Next you can RUN the models
Tradeoff Curves	Or generate TRADEOFF curves
Display Results	Then you can DISPLAY the results
Map Results	Or MAP the results
EXchange Sites	Or EXCHANGE Sites Manually
Exit SITATION	You can always EXIT SITATION

Set parameters

Set parameters



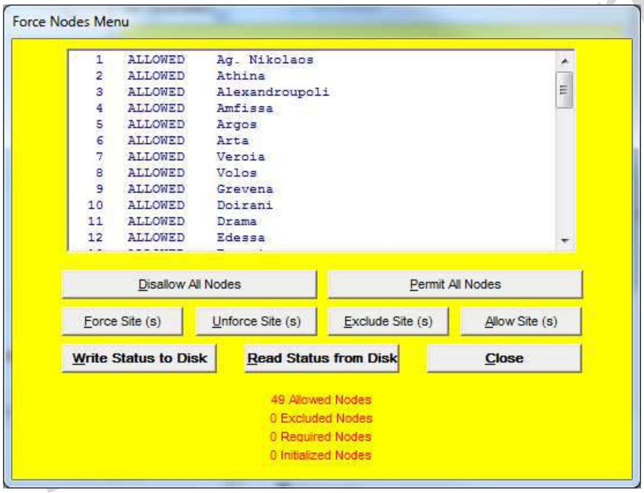
Set Parameters

Use this form to set parameters. You must set the coverage distance and the cost per mile before you can run any

COverage Distance 300

Cost per Mile 1

Nodes preselection



Force Nodes Menu

```
 1   ALLOWED    Ag. Nikolaos
 2   ALLOWED    Athina
 3   ALLOWED    Alexandroupoli
 4   ALLOWED    Amfissa
 5   ALLOWED    Argos
 6   ALLOWED    Arta
 7   ALLOWED    Veroia
 8   ALLOWED    Volos
 9   ALLOWED    Grevena
10   ALLOWED    Doirani
11   ALLOWED    Drama
12   ALLOWED    Edessa
```

49 Allowed Nodes
0 Excluded Nodes
0 Required Nodes
0 Initialized Nodes

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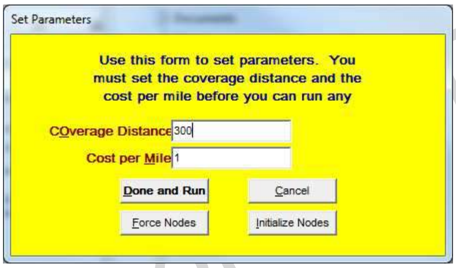
Run


Set Parameters

Use this form to set parameters. You must set the coverage distance and the cost per mile before you can run any

COverage Distance 300

Cost per Mile 1

Select Done and Run

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Information


Information

Cover List is 1445 Items Long

Size of data base

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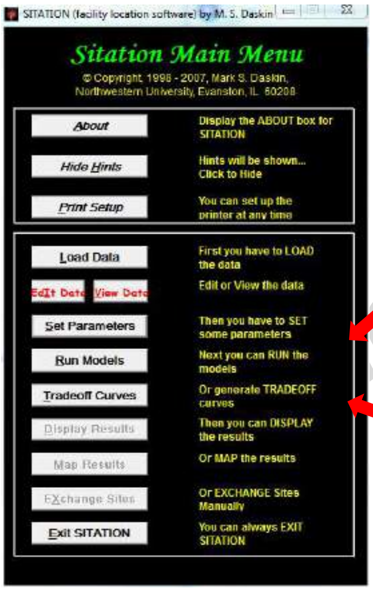
Fourth step



SITATION (facility location software) by M. S. Daskin

Sitation Main Menu

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Display the ABOUT box for SITATION

Hints will be shown... Click to Hide

You can set up the printer at any time

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Then you can DISPLAY the results

Or MAP the results

Or EXCHANGE Sites Manually

You can always EXIT SITATION

Choose between:

- simple optimization (Run Models)

or

- multiple (Tradeoff Curve)

The SITATION software package

---

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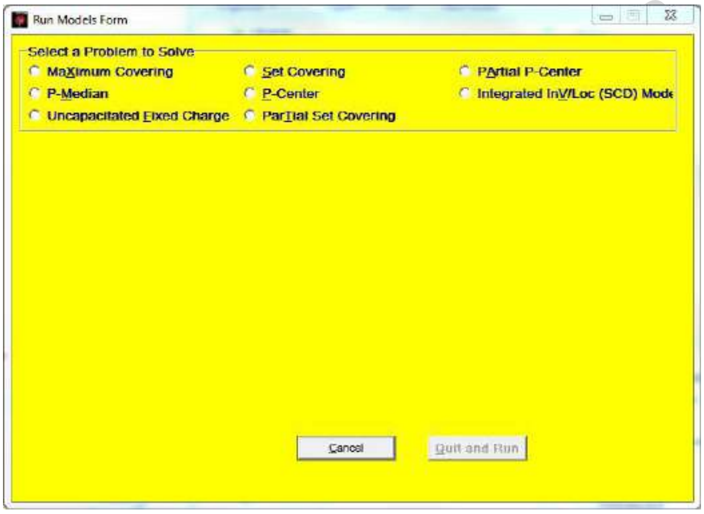
Simple optimization

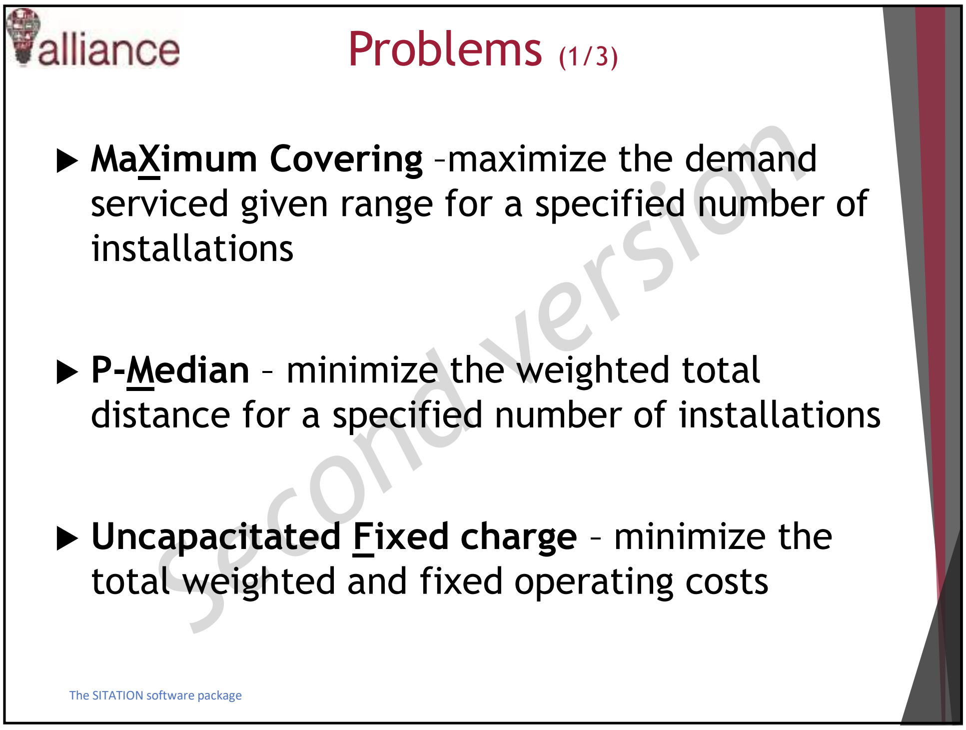


Run Models Form

Select a Problem to Solve

○ MaXimum Covering
○ P-Median
○ Uncapacitated Fixed Charge
○ Set Covering
○ P-Center
○ ParTial Set Covering
○ PArtial P-Center
○ Integrated InV/Loc (SCD) Mode

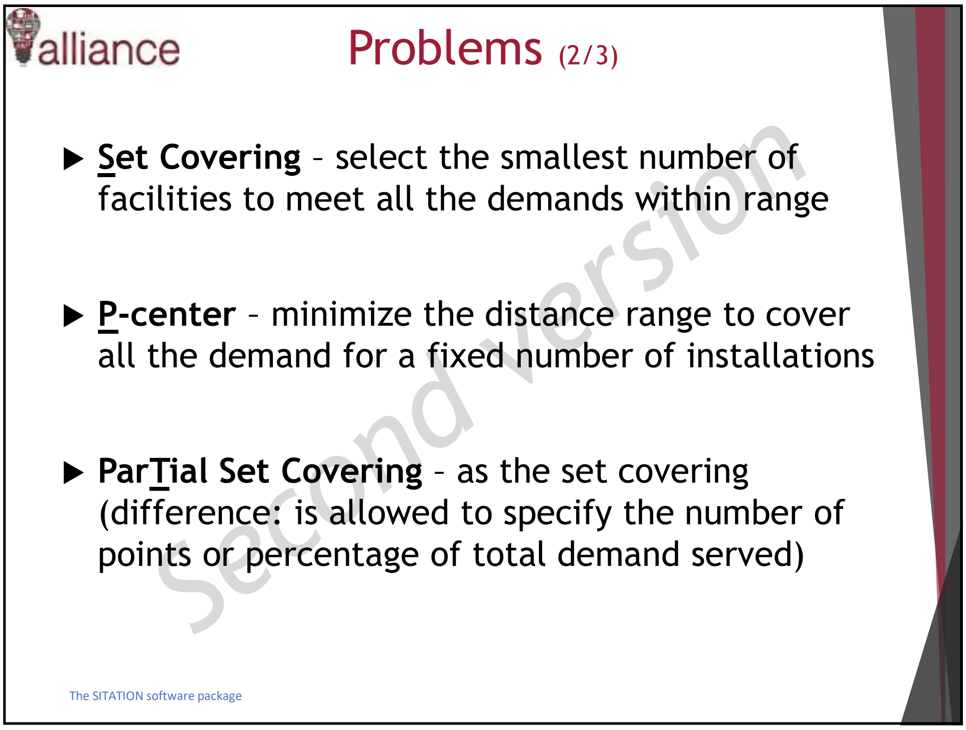
The SITATION software package



Problems (1/3)

- **MaXimum Covering** –maximize the demand serviced given range for a specified number of installations
- **P-Median** – minimize the weighted total distance for a specified number of installations
- **Uncapacitated Fixed charge** – minimize the total weighted and fixed operating costs

The SITATION software package



Problems (2/3)

- **Set Covering** – select the smallest number of facilities to meet all the demands within range
- **P-center** – minimize the distance range to cover all the demand for a fixed number of installations
- **ParTial Set Covering** – as the set covering (difference: is allowed to specify the number of points or percentage of total demand served)

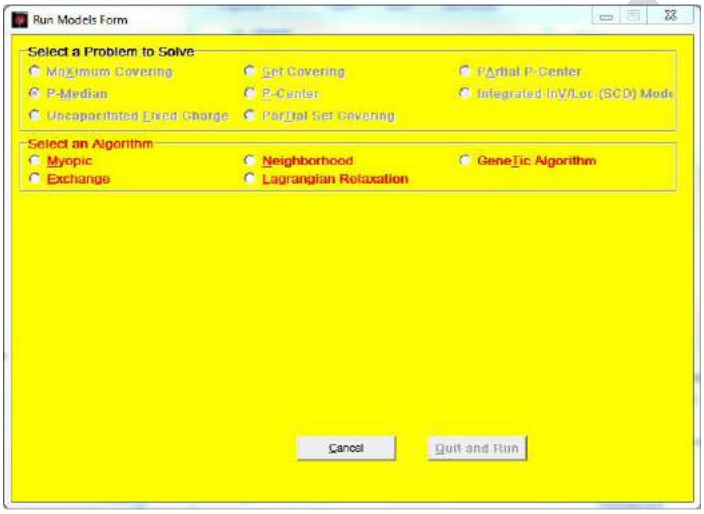
The SITATION software package

Problems (3/3)

- **PArtial P-Center** – as the P-center (difference: it allows to specify the number of points or the demand rate outside the range distance
- **Integrated InV/Loc (SCD) Model** – finding distribution points positions (DC), setting market assignments at these points to reduce fixed costs, storage costs, transport costs to the market and transport costs from the premises

The SITATION software package

Algorithm selection



Run Models Form

Select a Problem to Solve

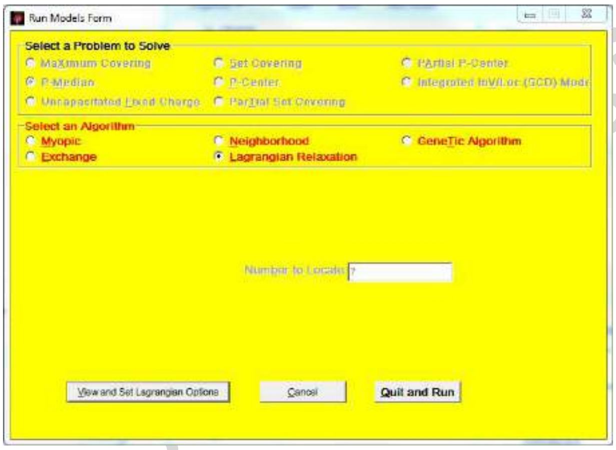
○ MaXimum Covering ○ Set Covering ○ PArtial P-Center
● P-Median ○ P-Center ○ Integrated InV/Loc (SCD) Mode
○ Uncapacitated Fixed Charge ○ ParTial Set Covering

Select an Algorithm

○ Myopic ○ Neighborhood ○ GeneTic Algorithm
○ Exchange ○ Lagrangian Relaxation

The SITATION software package

Select locations’ number



Run Models Form

Select a Problem to Solve

- ○ MaXimum Covering
- ● P-Median
- ○ Uncapacitated Fixed Charge
- ○ Set Covering
- ○ P-Center
- ○ ParTial Set Covering
- ○ PArtial P-Center
- ○ Integrated InVLoc (GCD) Mode

Select an Algorithm

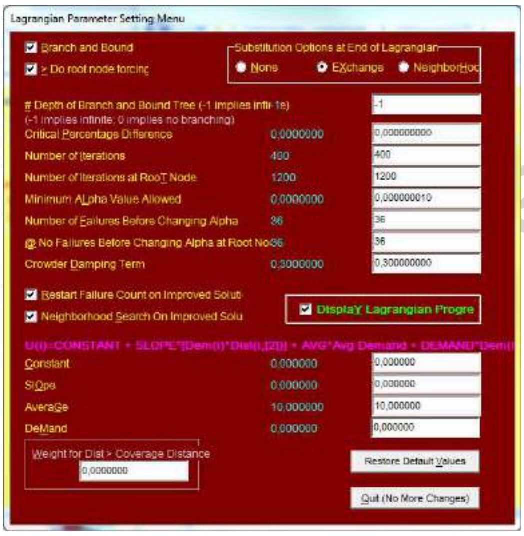
- ○ Myopic
- ○ Exchange
- ○ Neighborhood
- ● Lagrangian Relaxation
- ○ GeneTic Algorithm

Number to Locate: 7

Allows SITATION to choose the optimum

The SITATION software package

Selecting Lagrangian parameters



Lagrangian Parameter Setting Menu

- ☑ Branch and Bound
- ☑ > Do root node forcing

Substitution Options at End of Lagrangian: ○ None ● EXchange ○ NeighborHoo

# Depth of Branch and Bound Tree (-1 implies infinite) (-1 implies infinite; 0 implies no branching)		-1
Critical Percentage Difference	0,0000000	0,000000000
Number of Iterations	400	400
Number of Iterations at RooT Node	1200	1200
Minimum ALpha Value Allowed	0,0000000	0,000000010
Number of Failures Before Changing Alpha	36	36
@ No Failures Before Changing Alpha at Root No	36	36
Crowder Damping Term	0,3000000	0,300000000

- ☑ Restart Failure Count on Improved Soluti
- ☑ Neighborhood Search On Improved Solu
- ☑ DisplaY Lagrangian Progre

U(i)=CONSTANT + SLOPE*[Dem(i)*Dist(i,j2)] + AVG*Avg Demand + DEMAND*Dem(i

Constant	0,000000	0,000000
SlOpe	0,000000	0,000000
AveraGe	10,000000	10,000000
DeMand	0,000000	0,000000

Weight for Dist > Coverage Distance: 0,0000000

Keep the initial values if you do not have any specific knowledge!

The SITATION software package

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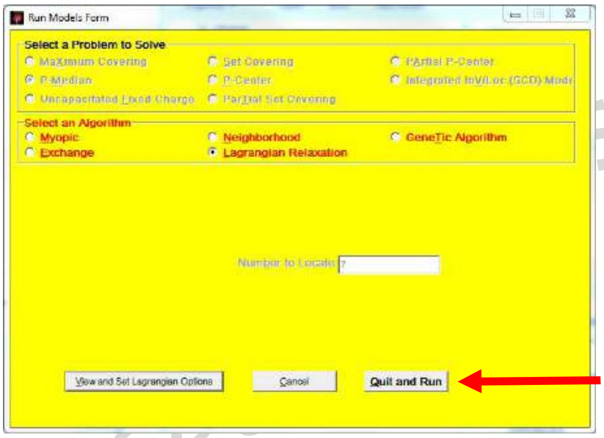
Problem solving



Run Models Form

Select a Problem to Solve

○ MaXimum Covering
● P-Median
○ Uncapacitated Fixed Charge
○ Set Covering
○ P-Center
○ ParTial Set Covering
○ PArtial P-Center
○ Integrated InVLoc (GCD) Mode

Select an Algorithm

○ Myopic
○ Exchange
○ Neighborhood
● Lagrangian Relaxation
○ GeneTic Algorithm

Number to Locate: 7

Select Quit and Run

---

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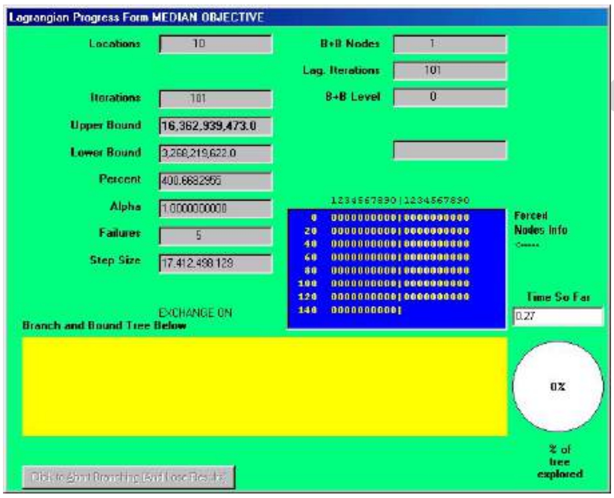
Lagrange Process



Lagrangian Progress Form MEDIAN OBJECTIVE

Locations: 10
Iterations: 101
Upper Bound: 16,362,939,473.0
Lower Bound: 3,268,219,622.0
Percent: 400.6682955
Alpha: 1.0000000000
Failures: 5
Step Size: 17,412,498.129
B+B Nodes: 1
Lag. Iterations: 101
B+B Level: 0
EXCHANGE ON
Time So Far: 0.27

```
      1234567890|1234567890
  0   0000000000|0000000000
 20   0000000000|0000000000
 40   0000000000|0000000000
 60   0000000000|0000000000
 80   0000000000|0000000000
100   0000000000|0000000000
120   0000000000|0000000000
140   0000000000|
```

Algorithm’s evolution and solution’s limits

- Number of iterations
- Branch and bound tree
- Locations defined: in (+) out (-) and undecided (0)
- Percentage of tree explored

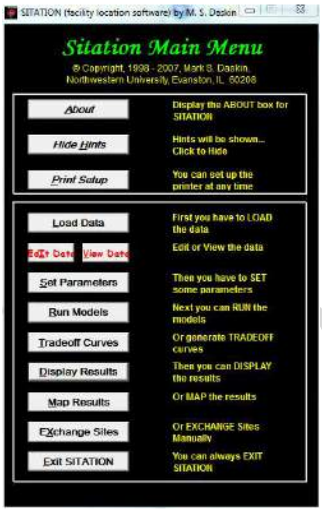
Completion of process


Information

Execution Completed Satisfactorily

The SITATION software package

Next steps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Sitation Main Menu

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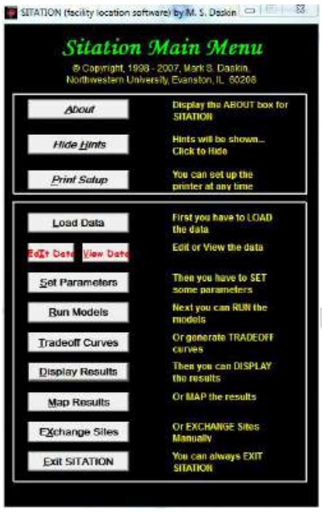
You can always EXIT SITATION

Tabulated
Maps
Exchange

The SITATION software package

Tables



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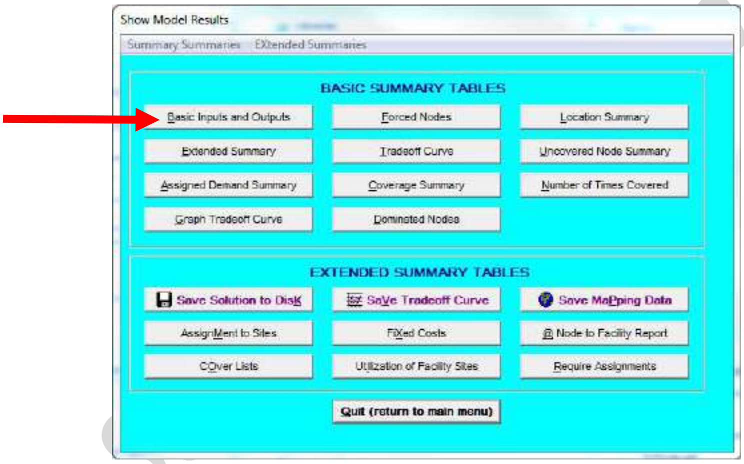
← Tabulated results

Tabulated results

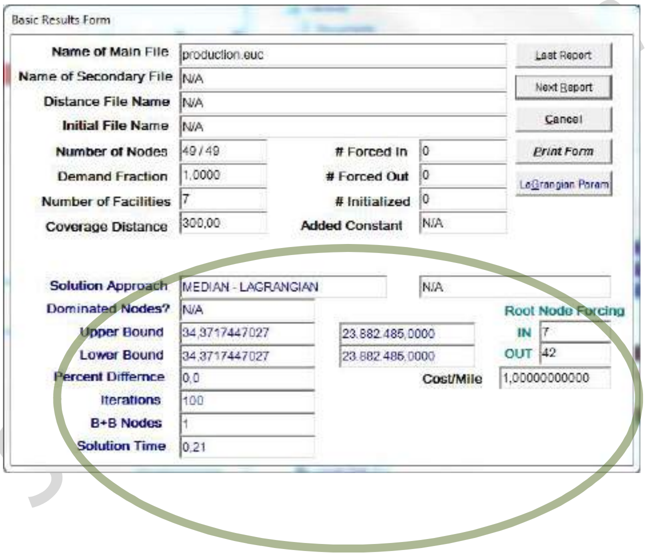


Entry data

Name of Main File: production.euc
Name of Secondary File: N/A
Distance File Name: N/A
Initial File Name: N/A
Number of Nodes: 49 / 49
Forced In: 0
Demand Fraction: 1,0000
Forced Out: 0
Number of Facilities: 7
Initialized: 0
Coverage Distance: 300,00
Added Constant: N/A
Solution Approach: MEDIAN - LAGRANGIAN
N/A
Dominated Nodes?: N/A
Root Node Forcing
Upper Bound: 34,3717447027
23.882.485,0000
IN: 7
Lower Bound: 34,3717447027
23.882.485,0000
OUT: 42
Percent Differnce: 0,0
Cost/Mile: 1,00000000000
Iterations: 100
B+B Nodes: 1
Solution Time: 0,21

The SITATION software package

Results



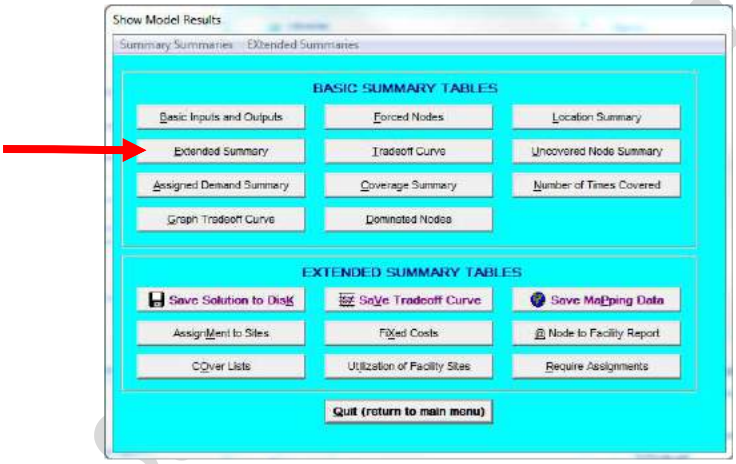
Name of Main File: production.euc
Name of Secondary File: N/A
Distance File Name: N/A
Initial File Name: N/A
Number of Nodes: 49 / 49
Forced In: 0
Demand Fraction: 1,0000
Forced Out: 0
Number of Facilities: 7
Initialized: 0
Coverage Distance: 300,00
Added Constant: N/A
Solution Approach: MEDIAN - LAGRANGIAN
N/A
Dominated Nodes?: N/A
Root Node Forcing
Upper Bound: 34,3717447027
23.882.485,0000
IN: 7
Lower Bound: 34,3717447027
23.882.485,0000
OUT: 42
Percent Differnce: 0,0
Cost/Mile: 1,00000000000
Iterations: 100
B+B Nodes: 1
Solution Time: 0,21

The SITATION software package

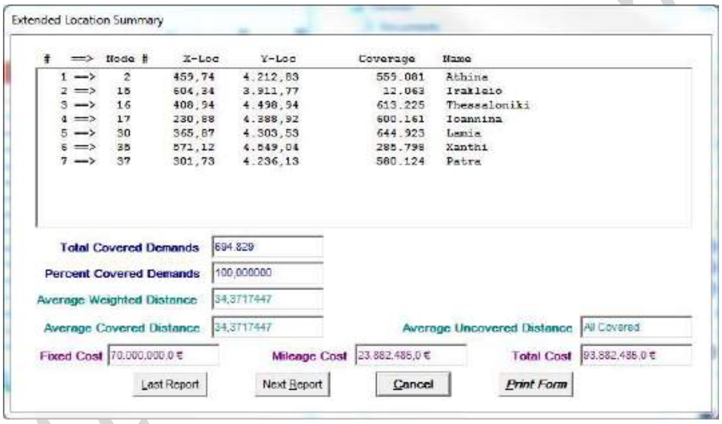
Back to previous menu

Name of Main File: production.euc
Name of Secondary File: N/A
Distance File Name: N/A
Initial File Name: N/A
Number of Nodes: 49 / 49
Demand Fraction: 1,0000
Number of Facilities: 7
Coverage Distance: 300,00
Forced In: 0
Forced Out: 0
Initialized: 0
Added Constant: N/A
Solution Approach: MEDIAN - LAGRANGIAN
N/A
Dominated Nodes?: N/A
Upper Bound: 34,3717447027 23.882.485,0000
Lower Bound: 34,3717447027 23.882.485,0000
Percent Differnce: 0,0
Iterations: 100
B+B Nodes: 1
Solution Time: 0,21
Root Node Forcing
IN: 7
OUT: 42
Cost/Mile: 1,0000000000

Tabulated results



Selecting location



Extended Location Summary

```
 #   ==>  Node #     X-Loc      Y-Loc          Coverage   Name
   1 ==>     2      459,74    4.212,83          555.081   Athina
   2 ==>    15      604,34    3.911,77           12.063   Iraklaio
   3 ==>    16      408,94    4.498,94          613.225   Thessaloniki
   4 ==>    17      230,88    4.388,92          600.161   Ioannina
   5 ==>    30      365,87    4.303,53          644.923   Lamia
   6 ==>    35      571,12    4.549,04          285.798   Xanthi
   7 ==>    37      301,73    4.236,13          580.124   Patra
```

Total Covered Demands: 694.829

Percent Covered Demands: 100,000000

Average Weighted Distance: 34,3717447

Average Covered Distance: 34,3717447

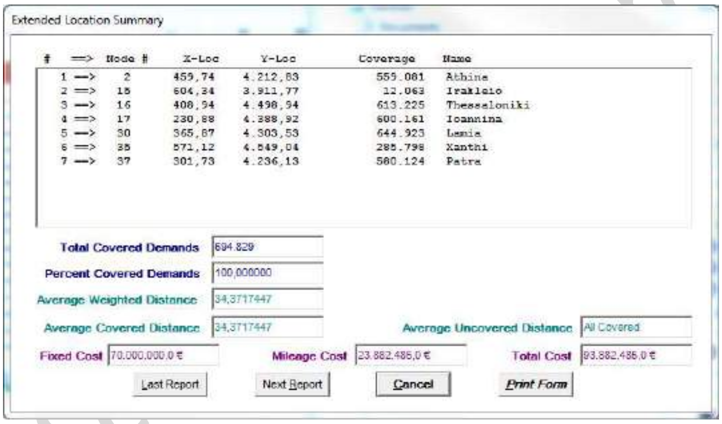
Average Uncovered Distance: All Covered

Fixed Cost: 70.000.000,0 €

Mileage Cost: 23.882.486,0 €

Total Cost: 93.882.486,0 €

Back to previous menu



Extended Location Summary

```
 #   ==>  Node #     X-Loc      Y-Loc          Coverage   Name
   1 ==>     2      459,74    4.212,83          555.081   Athina
   2 ==>    15      604,34    3.911,77           12.063   Iraklaio
   3 ==>    16      408,94    4.498,94          613.225   Thessaloniki
   4 ==>    17      230,88    4.388,92          600.161   Ioannina
   5 ==>    30      365,87    4.303,53          644.923   Lamia
   6 ==>    35      571,12    4.549,04          285.798   Xanthi
   7 ==>    37      301,73    4.236,13          580.124   Patra
```

Total Covered Demands: 694.829

Percent Covered Demands: 100,000000

Average Weighted Distance: 34,3717447

Average Covered Distance: 34,3717447

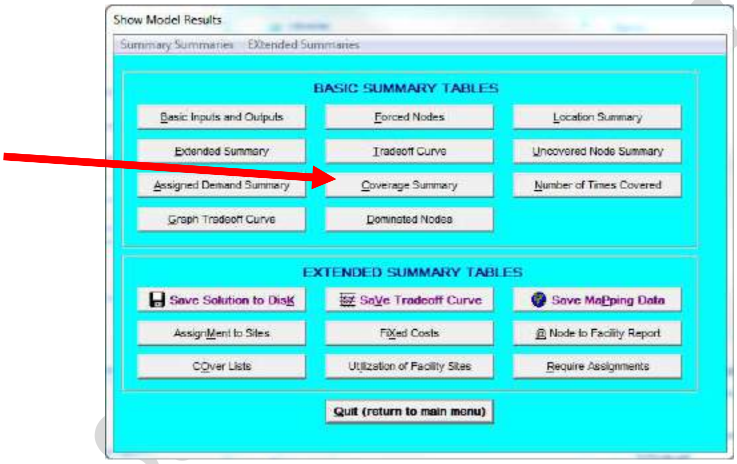
Average Uncovered Distance: All Covered

Fixed Cost: 70.000.000,0 €

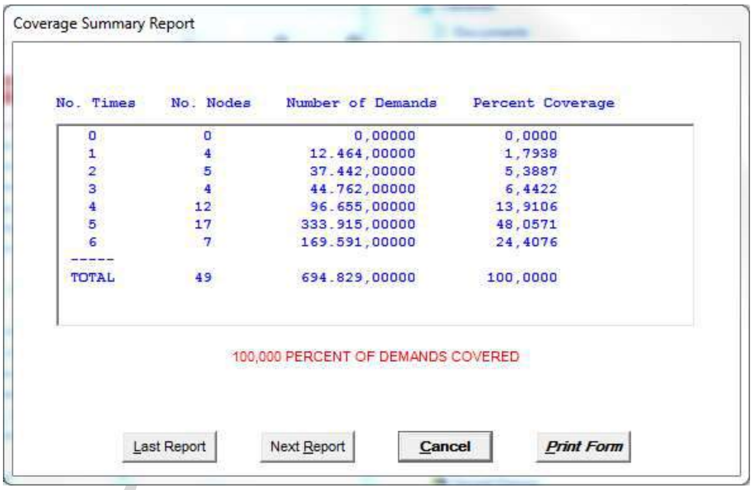
Mileage Cost: 23.882.486,0 €

Total Cost: 93.882.486,0 €

Back to previous menu



Demand Coverage

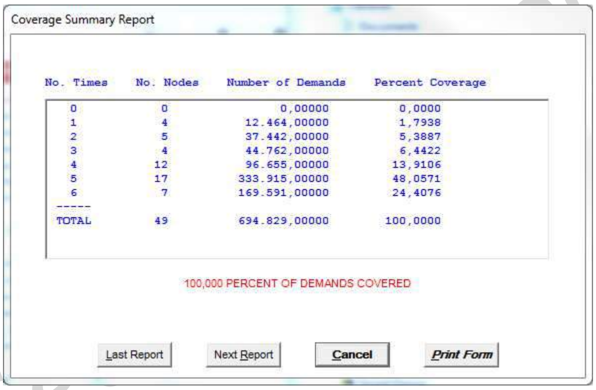


Coverage Summary Report

```
No. Times    No. Nodes    Number of Demands    Percent Coverage

  0              0             0,00000           0,0000
  1              4        12.464,00000           1,7938
  2              5        37.442,00000           5,3887
  3              4        44.762,00000           6,4422
  4             12        96.655,00000          13,9106
  5             17       333.915,00000          48,0571
  6              7       169.591,00000          24,4076
-----
TOTAL           49       694.829,00000         100,0000
```

100,000 PERCENT OF DEMANDS COVERED

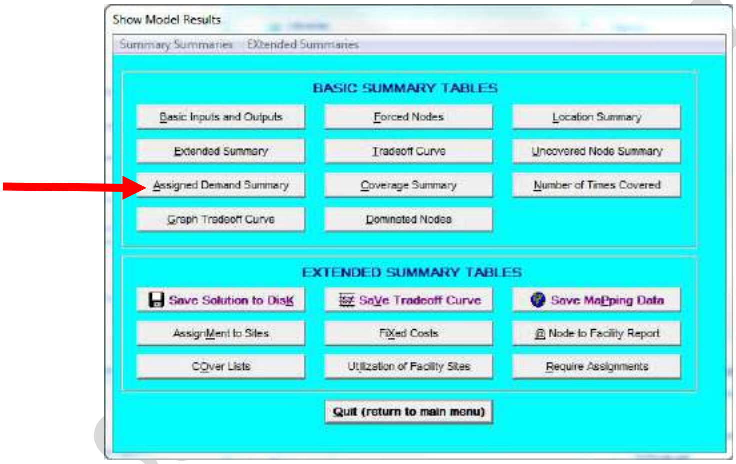
Back to previous menu



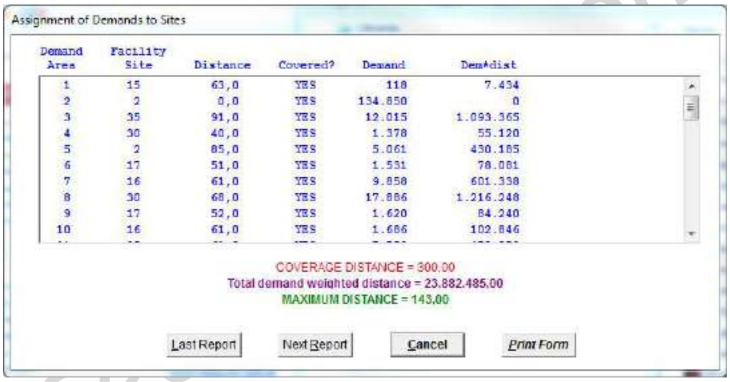
```
No. Times    No. Nodes    Number of Demands    Percent Coverage

    0            0               0,00000           0,0000
    1            4          12.464,00000           1,7938
    2            5          37.442,00000           5,3887
    3            4          44.762,00000           6,4422
    4           12          96.655,00000          13,9106
    5           17         333.915,00000          48,0571
    6            7         169.591,00000          24,4076
  -----
  TOTAL         49         694.829,00000         100,0000
```

100,000 PERCENT OF DEMANDS COVERED

Tabulated results



Assignment to sites



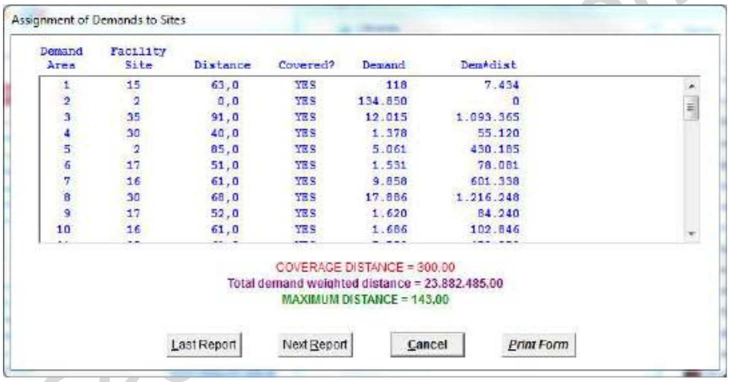
Assignment of Demands to Sites

Demand Area	Facility Site	Distance	Covered?	Demand	Dem*dist
1	15	63,0	YES	118	7.434
2	2	0,0	YES	134.850	0
3	35	91,0	YES	12.015	1.093.365
4	30	40,0	YES	1.378	55.120
5	2	85,0	YES	5.061	430.185
6	17	51,0	YES	1.531	78.081
7	16	61,0	YES	9.858	601.338
8	30	68,0	YES	17.886	1.216.248
9	17	52,0	YES	1.620	84.240
10	16	61,0	YES	1.686	102.846

COVERAGE DISTANCE = 300,00
Total demand weighted distance = 23.882.485,00
MAXIMUM DISTANCE = 143,00

The SITATION software package

Back to previous menu



Assignment of Demands to Sites

Demand Area	Facility Site	Distance	Covered?	Demand	Dem*dist
1	15	63,0	YES	118	7.434
2	2	0,0	YES	134.850	0
3	35	91,0	YES	12.015	1.093.365
4	30	40,0	YES	1.378	55.120
5	2	85,0	YES	5.061	430.185
6	17	51,0	YES	1.531	78.081
7	16	61,0	YES	9.858	601.338
8	30	68,0	YES	17.886	1.216.248
9	17	52,0	YES	1.620	84.240
10	16	61,0	YES	1.686	102.846

COVERAGE DISTANCE = 300,00
Total demand weighted distance = 23.882.485,00
MAXIMUM DISTANCE = 143,00

The SITATION software package

Tabulated results

The SITATION software package

Facility and demand

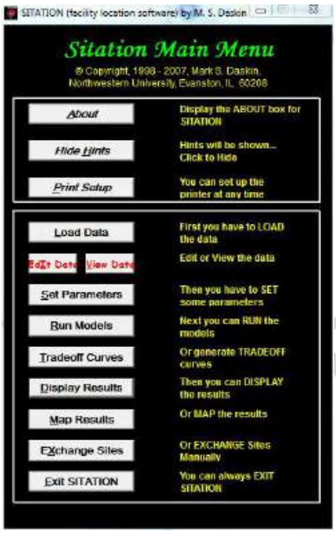
```
Demand Area                  (   Population   ) --> Facility

  1        Ag. Nikolaos      (           118 ) -->  15          Irakleio
  2              Athina      (       134.850 ) -->   2            Athina
  3       Alexandroupoli     (        12.015 ) -->  35            Xanthi
  4             Amfissa      (         1.378 ) -->  30             Lamia
  5               Argos      (         5.061 ) -->   2            Athina
  6                Arta      (         1.531 ) -->  17          Ioannina
  7              Veroia      (         9.858 ) -->  16      Thessaloniki
  8               Volos      (        17.886 ) -->  30             Lamia
  9             Grevena      (         1.620 ) -->  17          Ioannina
 10             Doirani      (         1.686 ) -->  16      Thessaloniki
 11               Drama      (         7.752 ) -->  35            Xanthi
 12              Edessa      (        10.864 ) -->  16      Thessaloniki
 13              Evzoni      (         7.860 ) -->  16      Thessaloniki
```

The SITATION software package

Back to main menu

The SITATION software package

Maps



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Northwestern University, Evanston, IL 60208

Display the ABOUT box for SITATION

Hints will be shown... Click to Hide

You can set up the printer at any time

First you have to LOAD the data

Edit or View the data

Then you have to SET some parameters

Next you can RUN the models

Or generate TRADEOFF curves

Then you can DISPLAY the results

Or MAP the results

Or EXCHANGE Sites Manually

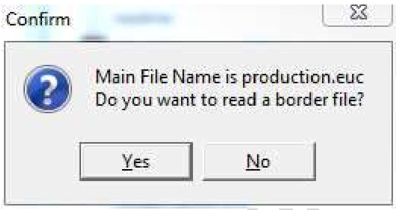
You can always EXIT SITATION

← Maps

The SITATION software package

alliance

Border file



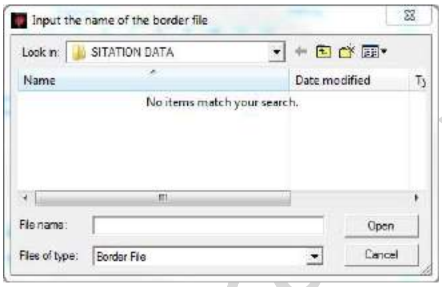
Main File Name is production.euc
Do you want to read a border file?

- If there is a file: Yes
- Otherwise: No

---

alliance

File selection



Look in: SITATION DATA

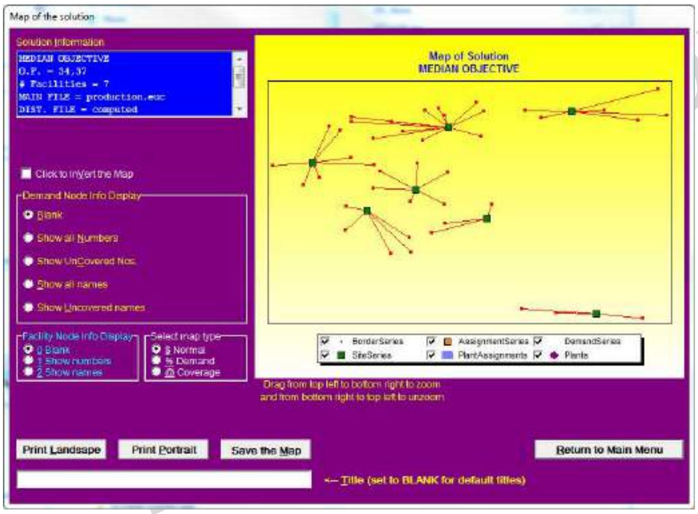
No items match your search.

File name:

Files of type: Border File

- Double click on the file (.brd) with the borders

Map of solution



Map of the solution

Solution Information

```
MEDIAN OBJECTIVE
O.F. = 34,37
# Facilities = 7
MAIN FILE = production.euc
DIST. FILE = computed
```

☐ Click to InVert the Map

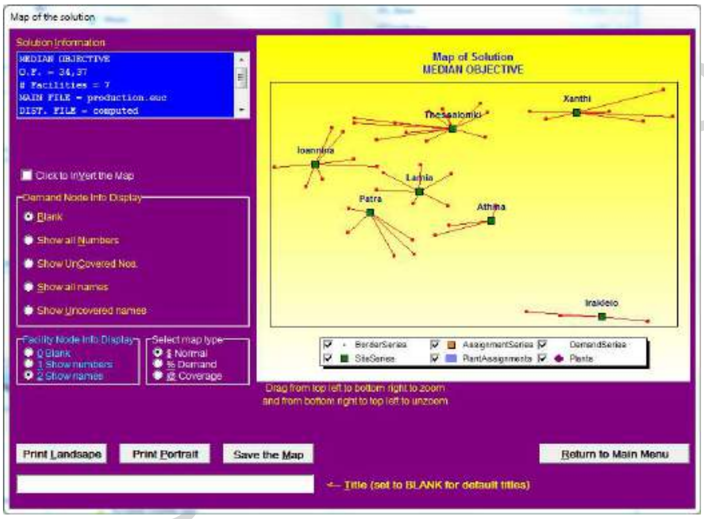
Demand Node Info Display: ● Blank

Facility Node Info Display: ● 0 Blank

Select map type: ● $ Normal

Facilities and demand nodes

The SITATION software package



Map of the solution

Solution Information

```
MEDIAN OBJECTIVE
O.F. = 34,37
# Facilities = 7
MAIN FILE = production.euc
DIST. FILE = computed
```

☐ Click to InVert the Map

Demand Node Info Display: ● Blank

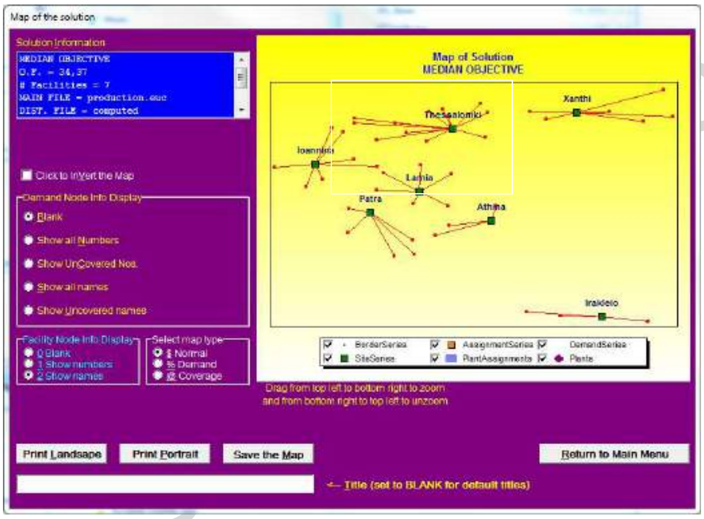
Facility Node Info Display: ● 2 Show names

Select map type: ● $ Normal

The SITATION software package

alliance

Zoom in



```
MEDIAN OBJECTIVE
O.F. = 34,37
# Facilities = 7
MAIN FILE = production.euc
DIST. FILE = computed
```

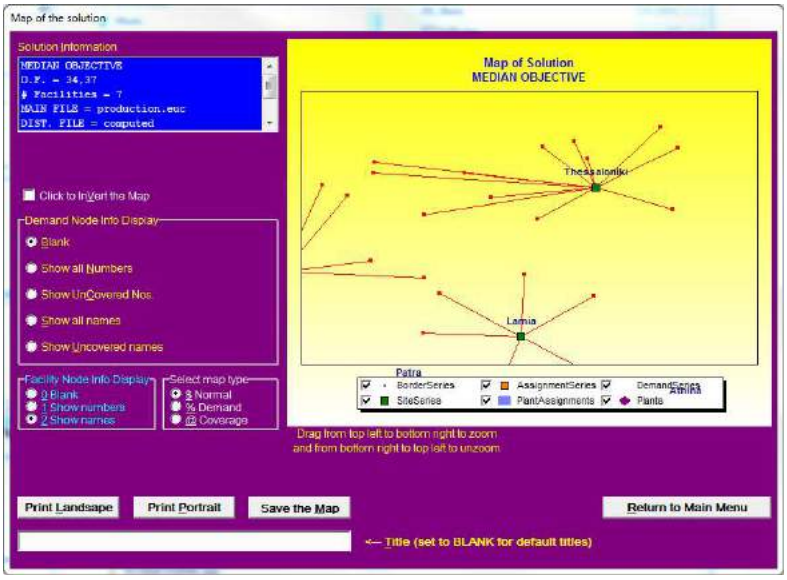
Click and drag the mouse from top left to bottom right

The SITATION software package

---

alliance

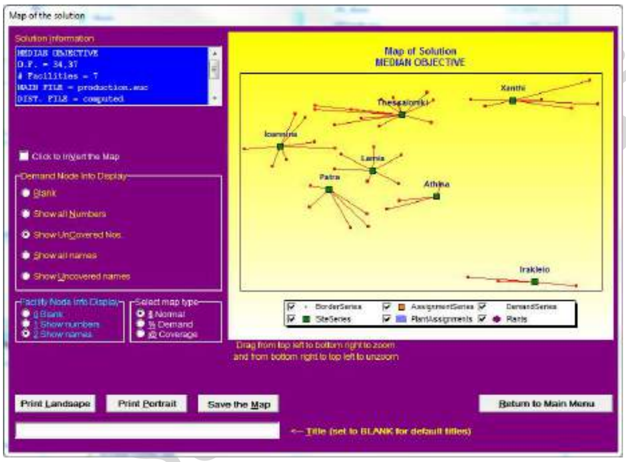
Zoom in



```
MEDIAN OBJECTIVE
O.F. = 34,37
# Facilities = 7
MAIN FILE = production.euc
DIST. FILE = computed
```

The SITATION software package

Names



Map of the solution

Solution Information

```
MEDIAN OBJECTIVE
O.F. = 34.37
# Facilities = 7
MAIN FILE = production.mac
DIST. FILE = computed
```

☐ Click to Invert the Map

Demand Node Info Display
- ○ Blank
- ○ Show all Numbers
- ● Show UnCovered Nos
- ○ Show all names
- ○ Show Uncovered names

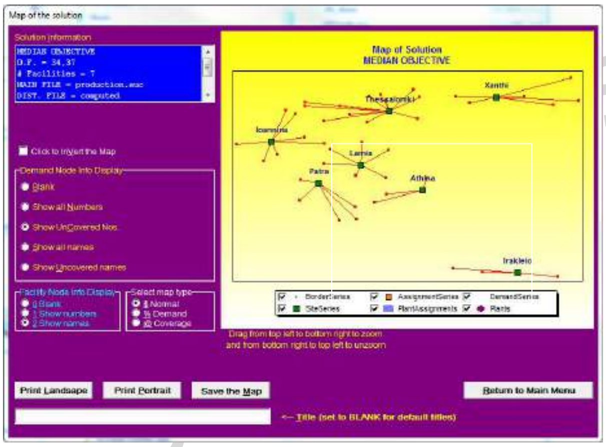
Facility Node Info Display
- ○ 0 Blank
- ○ 1 Show numbers
- ● 2 Show names

Select map type
- ● 0 Normal
- ○ % Demand
- ○ % Coverage

Drag from top left to bottom right to zoom
and from bottom right to top left to unzoom

- Demand within range distance → red connection
- Demand out of range distance → blue line

Zoom out



Map of the solution

Solution Information

```
MEDIAN OBJECTIVE
O.F. = 34.37
# Facilities = 7
MAIN FILE = production.mac
DIST. FILE = computed
```

☐ Click to Invert the Map

Demand Node Info Display
- ○ Blank
- ○ Show all Numbers
- ● Show UnCovered Nos
- ○ Show all names
- ○ Show Uncovered names

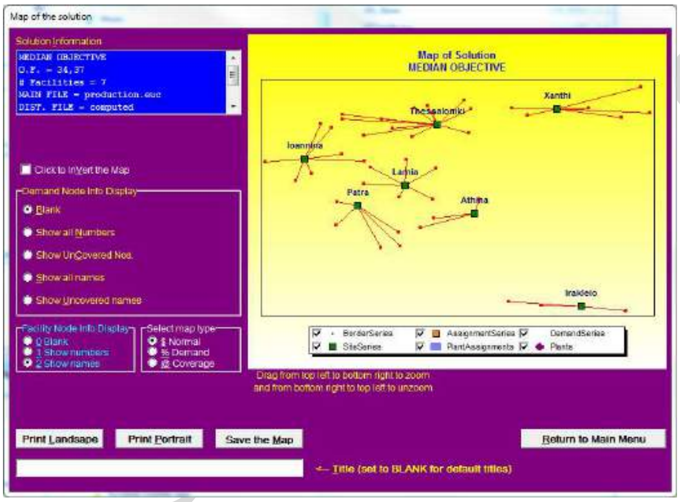
Facility Node Info Display
- ○ 0 Blank
- ○ 1 Show numbers
- ● 2 Show names

Select map type
- ● 0 Normal
- ○ % Demand
- ○ % Coverage

Drag from top left to bottom right to zoom
and from bottom right to top left to unzoom

Opposite from zooming in.

Settings



Solution Information

```
MEDIAN OBJECTIVE
O.F. = 34,37
# Facilities = 7
MAIN FILE = production.euc
DIST. FILE = computed
```

☐ Click to Invert the Map

Demand Node Info Display
- ● Blank
- ○ Show all Numbers
- ○ Show UnCovered Nos.
- ○ Show all names
- ○ Show Uncovered names

Facility Node Info Display
- ○ 0 Blank
- ○ 1 Show numbers
- ● 2 Show names

Select map type
- ● $ Normal
- ○ % Demand
- ○ @ Coverage

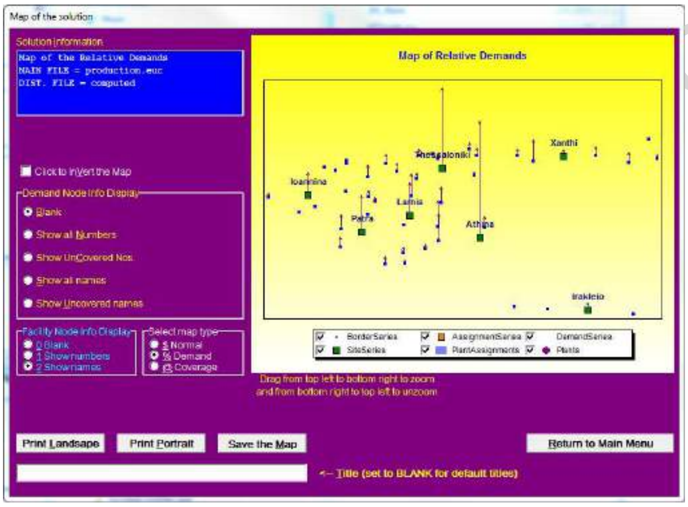
Drag from top left to bottom right to zoom
and from bottom right to top left to unzoom

<-- Title (set to BLANK for default titles)

Select «Blank»
to erase the
names

The SITATION software package

Relative demand



Solution Information

```
Map of the Relative Demands
MAIN FILE = production.euc
DIST. FILE = computed
```

☐ Click to Invert the Map

Demand Node Info Display
- ● Blank
- ○ Show all Numbers
- ○ Show UnCovered Nos.
- ○ Show all names
- ○ Show Uncovered names

Facility Node Info Display
- ○ 0 Blank
- ○ 1 Show numbers
- ● 2 Show names

Select map type
- ○ $ Normal
- ● % Demand
- ○ @ Coverage

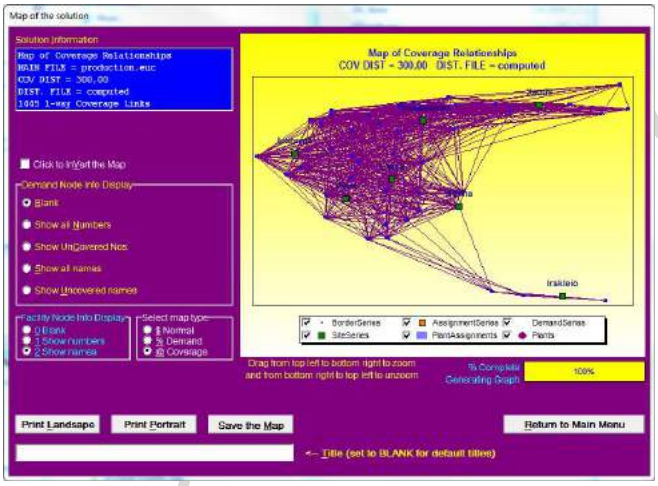
Drag from top left to bottom right to zoom
and from bottom right to top left to unzoom

<-- Title (set to BLANK for default titles)

Select «%»
Demand

The SITATION software package

Map of coverage



Map of the solution

Solution Information

```
Map of Coverage Relationships
MAIN FILE = production.euc
COV DIST = 300.00
DIST. FILE = computed
1005 1-way Coverage Links
```

Map of Coverage Relationships
COV DIST = 300.00 DIST. FILE = computed

☐ Click to InVert the Map

Demand Node Info Display
- ● Blank
- ○ Show all Numbers
- ○ Show UnCovered Nos
- ○ Show all names
- ○ Show Uncovered names

Facility Node Info Display
- ○ 0 Blank
- ○ 1 Show numbers
- ● 2 Show names

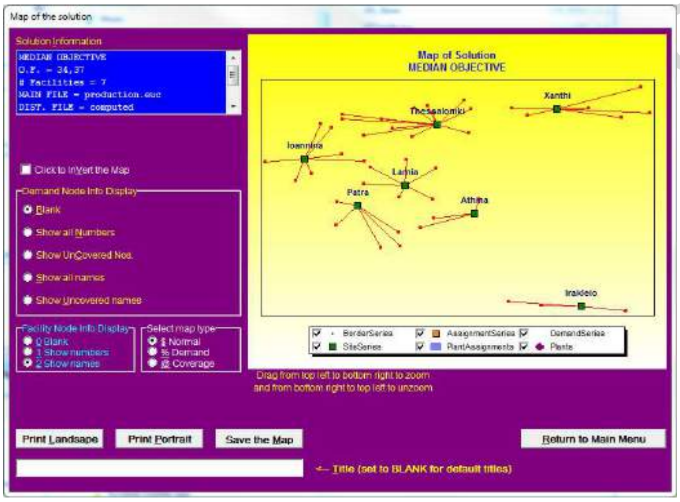
Select map type
- ○ $ Normal
- ○ % Demand
- ● @ Coverage

% Complete: 100%
Generating Graph

Select «@» Coverage

The SITATION software package

Return to initial settings



Map of the solution

Solution Information

```
MEDIAN OBJECTIVE
O.F. = 34,37
# Facilities = 7
MAIN FILE = production.euc
DIST. FILE = computed
```

Map of Solution
MEDIAN OBJECTIVE

☐ Click to InVert the Map

Demand Node Info Display
- ● Blank
- ○ Show all Numbers
- ○ Show UnCovered Nos.
- ○ Show all names
- ○ Show Uncovered names

Facility Node Info Display
- ○ 0 Blank
- ○ 1 Show numbers
- ● 2 Show names

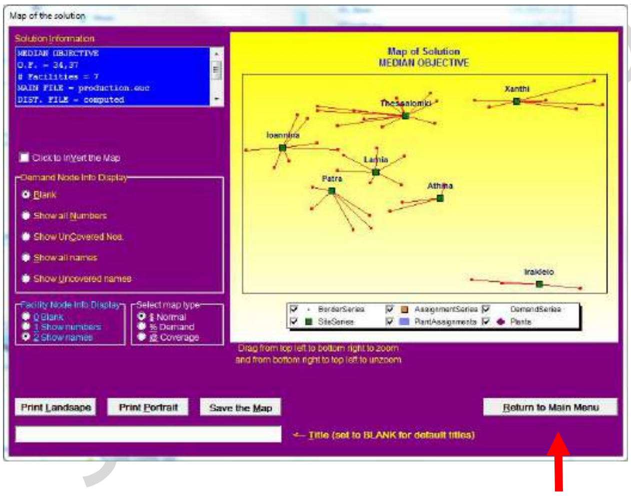
Select map type
- ● $ Normal
- ○ % Demand
- ○ @ Coverage

Select «$» Normal

The SITATION software package

alliance

Return to initial menu



```
MEDIAN OBJECTIVE
O.F. = 34,37
# Facilities = 7
MAIN FILE = production.euc
DIST. FILE = computed
```

Drag from top left to bottom right to zoom
and from bottom right to top left to unzoom

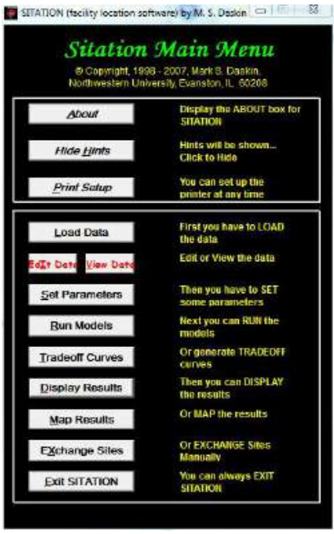
← Title (set to BLANK for default titles)

The SITATION software package

---

alliance

Site exchange



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Northwestern University, Evanston, IL 60208

Display the ABOUT box for SITATION

Hints will be shown... Click to Hide

You can set up the printer at any time

First you have to LOAD the data

Edit or View the data

Then you have to SET some parameters

Next you can RUN the models

Or generate TRADEOFF curves

Then you can DISPLAY the results

Or MAP the results

Or EXCHANGE Sites Manually

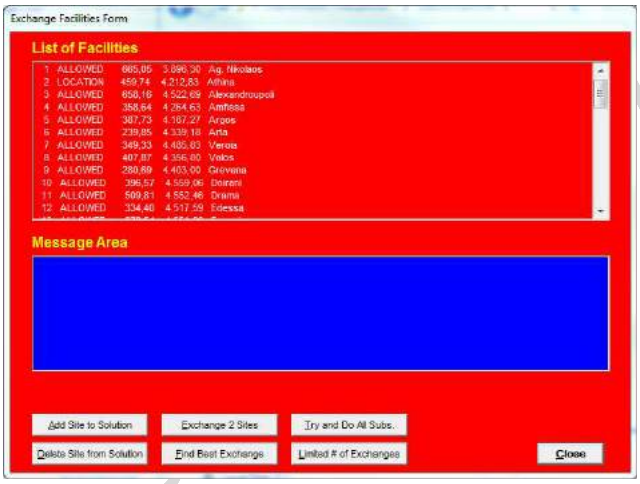
You can always EXIT SITATION

← Manual site exchange

The SITATION software package

alliance

Example



```
1  ALLOWED    665,05   3.896,30  Ag. Nikolaos
2  LOCATION   459,74   4.212,83  Athina
3  ALLOWED    658,16   4.522,69  Alexandroupoli
4  ALLOWED    358,64   4.264,63  Amfissa
5  ALLOWED    387,73   4.167,27  Argos
6  ALLOWED    239,85   4.339,18  Arta
7  ALLOWED    349,33   4.485,83  Veroia
8  ALLOWED    407,87   4.356,80  Volos
9  ALLOWED    280,69   4.403,00  Grevena
10  ALLOWED    396,57   4.559,06  Doirani
11  ALLOWED    509,81   4.552,46  Drama
12  ALLOWED    334,40   4.517,59  Edessa
```

Replace
- ▶ New York

with
- ▶ Philadelphia

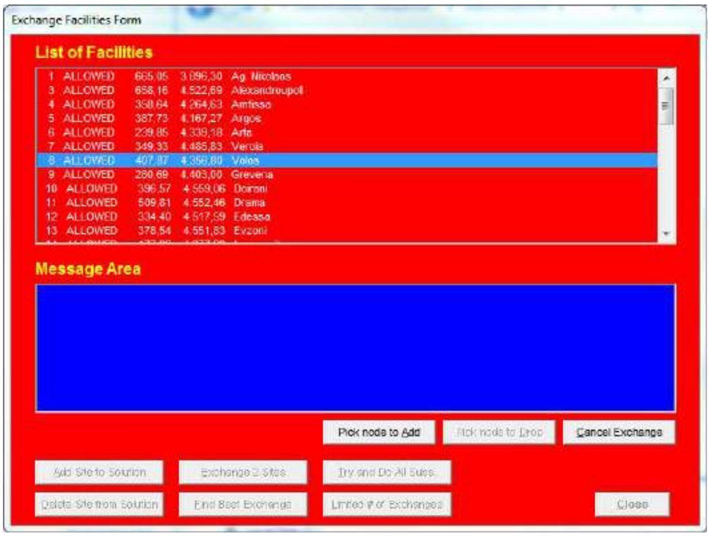
Select Exchange 2 Sites

The SITATION software package

---

alliance

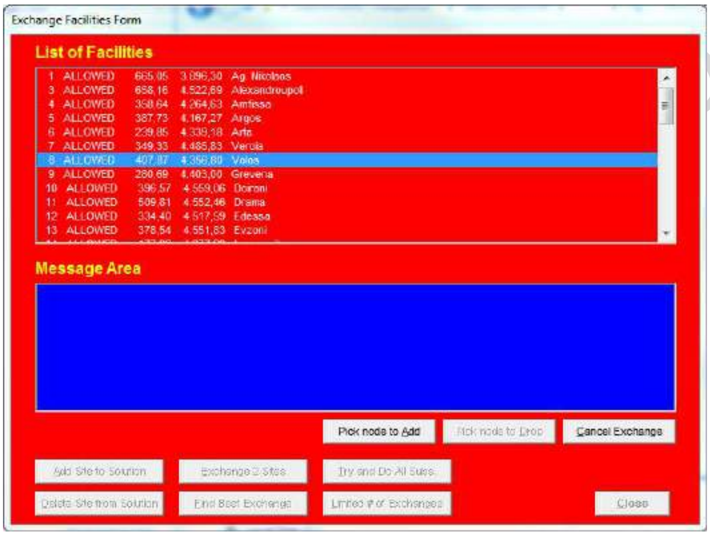
Add Volos



```
1  ALLOWED    665,05   3.896,30  Ag. Nicolaos
3  ALLOWED    658,16   4.522,69  Alexandroupoli
4  ALLOWED    358,64   4.264,63  Amfissa
5  ALLOWED    387,73   4.167,27  Argos
6  ALLOWED    239,85   4.339,18  Arta
7  ALLOWED    349,33   4.485,83  Veroia
8  ALLOWED    407,87   4.356,80  Volos
9  ALLOWED    280,69   4.403,00  Grevena
10  ALLOWED    396,57   4.559,06  Doironi
11  ALLOWED    509,81   4.552,46  Drama
12  ALLOWED    334,40   4.517,59  Edessa
13  ALLOWED    378,54   4.551,83  Evzoni
```

The SITATION software package

Add node


Exchange Facilities Form

List of Facilities

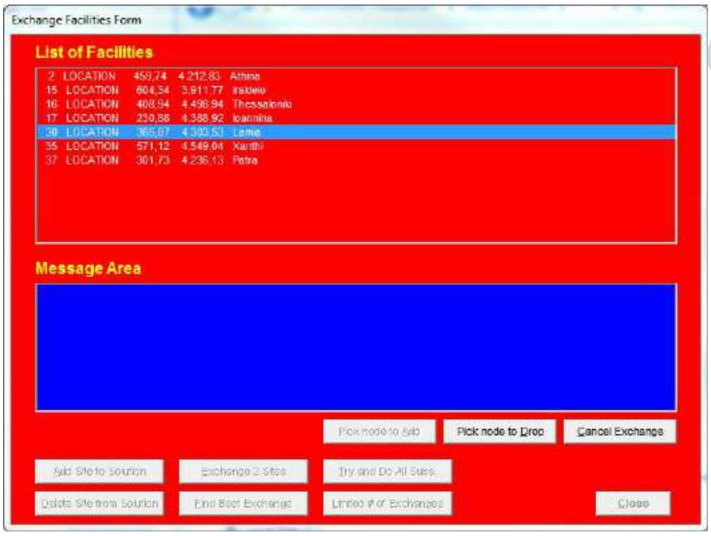
```
 1  ALLOWED   665,05  3.896,30  Ag. Nikolaos
 3  ALLOWED   658,16  4.522,69  Alexandroupoli
 4  ALLOWED   358,64  4.264,63  Amfissa
 5  ALLOWED   387,73  4.167,27  Argos
 6  ALLOWED   239,85  4.339,18  Arta
 7  ALLOWED   349,33  4.485,83  Veroia
 8  ALLOWED   407,87  4.356,80  Volos
 9  ALLOWED   280,69  4.403,00  Grevena
10  ALLOWED   396,57  4.559,06  Doirani
11  ALLOWED   509,81  4.552,46  Drama
12  ALLOWED   334,40  4.517,59  Edessa
13  ALLOWED   378,54  4.551,83  Evzoni
```

Message Area

Select Pick node to Add

The SITATION software package

Drop Lamia


Exchange Facilities Form

List of Facilities

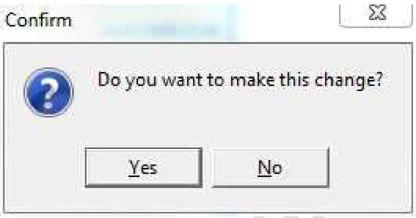
```
 2  LOCATION  459,74  4.212,83  Athina
15  LOCATION  604,34  3.911,77  Iraklelo
16  LOCATION  408,94  4.498,94  Thessaloniki
17  LOCATION  230,88  4.388,92  Ioannina
30  LOCATION  365,87  4.303,53  Lamia
35  LOCATION  571,12  4.549,04  Xanthi
37  LOCATION  301,73  4.236,13  Patra
```

Message Area

Select node to Drop

The SITATION software package

Exchange results



Do you want to make this change?

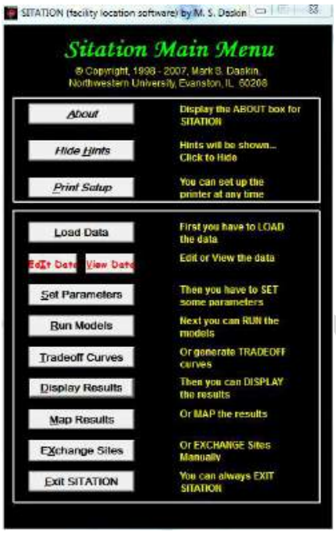
- ✓ Notify change of the distance
- ✓ Select acceptance or not

Exchange

```
 1  ALLOWED    665,05  3.896,30  Ag. Nicolaos
 2  LOCATION   459,74  4.212,83  Athina
 3  ALLOWED    658,16  4.522,69  Alexandroupoli
 4  ALLOWED    358,64  4.264,83  Amfissa
 5  ALLOWED    387,73  4.167,27  Argos
 6  ALLOWED    239,85  4.339,18  Arta
 7  ALLOWED    349,33  4.485,83  Veroia
 8  LOCATION   407,87  4.356,80  Volos
 9  ALLOWED    280,69  4.403,00  Grevena
10  ALLOWED    396,57  4.559,06  Doirani
11  ALLOWED    509,81  4.552,46  Drama
12  ALLOWED    334,40  4.517,59  Edessa
```

- Facility in Philadelphia
- New York not existed
- Return to main menu by selecting «Close»

Multiple Optimization



SITATION (facility location software) by M. S. Daskin

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Display the ABOUT box for SITATION

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Or generate TRADEOFF curves

Then you can DISPLAY the results

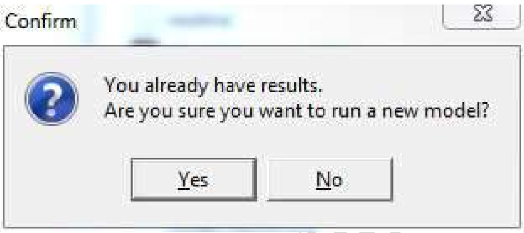
Or MAP the results

Or EXCHANGE Sites Manually

You can always EXIT SITATION

Select Tradeoff Curves

Warning



Confirm

You already have results.
Are you sure you want to run a new model?

SITATION saves only one version:

- ✓ The last one

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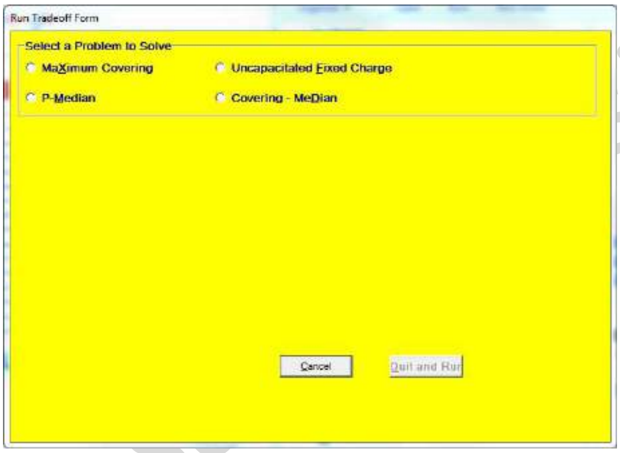
Problem to solve



Run Tradeoff Form

Select a Problem to Solve

○ MaXimum Covering
○ Uncapacitated Fixed Charge
○ P-Median
○ Covering - MeDian

- Covering – MeDian is the only real choice of multiple optimization
- The other options indicate the compensation between the target and the number of facilities

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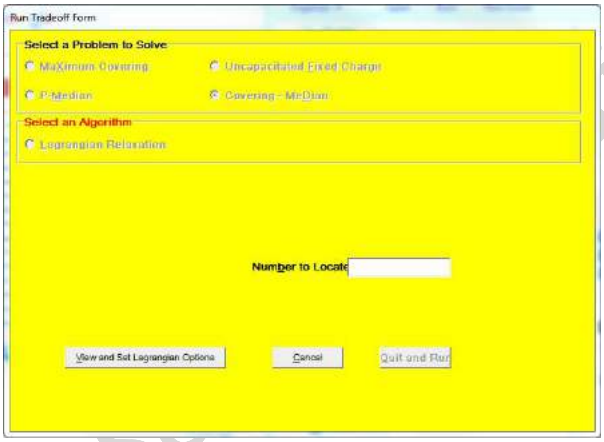
Select an algorithm



Run Tradeoff Form

Select a Problem to Solve

○ MaXimum Covering
○ Uncapacitated Fixed Charge
○ P-Median
● Covering - MeDian

Select an Algorithm

○ Lagrangian Relaxation

Number to Locate

- Only Lagrangian option is available
- Set number of facilities

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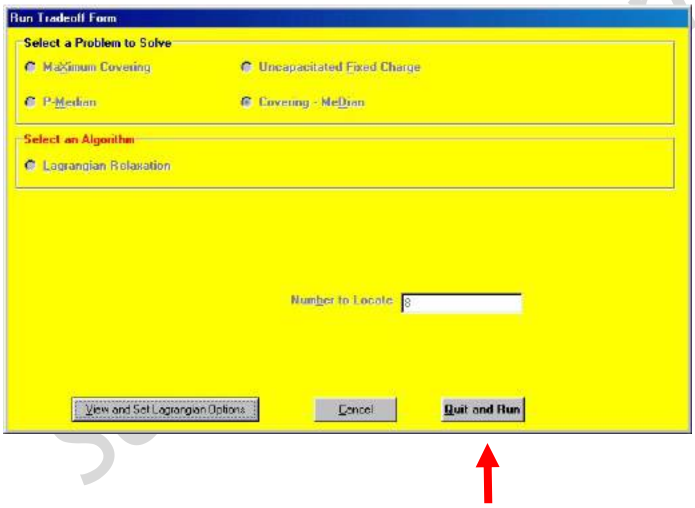
Run model



Select a Problem to Solve

○ Maximum Covering
○ Uncapacitated Fixed Charge
○ P-Median
● Covering - Median

Select an Algorithm

● Lagrangian Relaxation

Number to Locate: 8

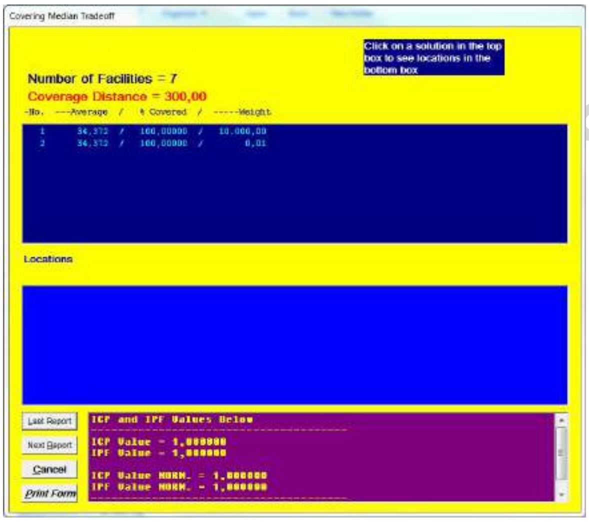
The SITATION software package

Summary

Select Tradeoff Curve

The SITATION software package

Solutions



Covering Median Tradeoff

Click on a solution in the top box to see locations in the bottom box

Number of Facilities = 7

Coverage Distance = 300,00

```
-No.  ---Average  /   % Covered  /  -----Weight
  1      34,372  /   100,00000  /   10.000,00
  2      34,372  /   100,00000  /        0,01
```

Locations

```
ICP and IPF Values Below
----------------------------------------
ICP Value = 1,000000
IPF Value = 1,000000

ICP Value NORM. = 1,000000
IPF Value NORM. = 1,000000
----------------------------------------
```

6 solutions at an average distance of 153-181 miles and coverage of demand

from 83% to 91%.

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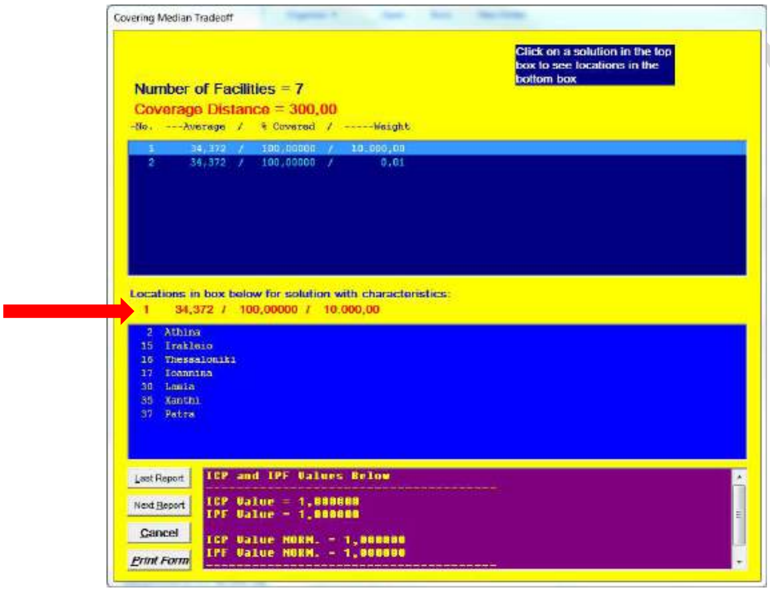
In detail



Covering Median Tradeoff

Click on a solution in the top box to see locations in the bottom box

Number of Facilities = 7

Coverage Distance = 300,00

```
-No.  ---Average  /   % Covered  /  -----Weight
  1      34,372  /   100,00000  /   10.000,00
  2      34,372  /   100,00000  /        0,01
```

Locations in box below for solution with characteristics:

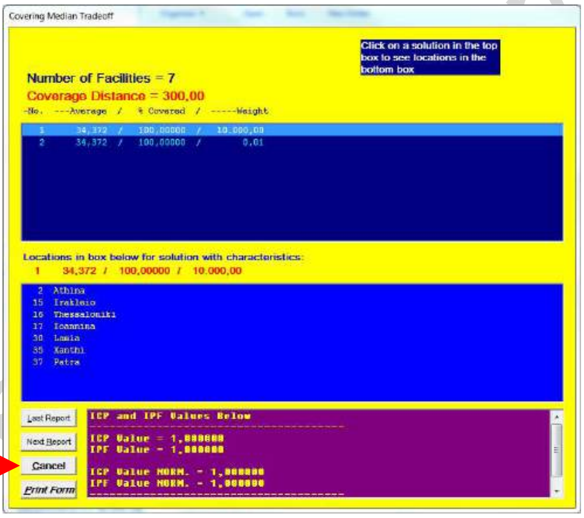
```
1    34,372 /  100,00000 /  10.000,00
```

```
 2  Athina
15  Irakleio
16  Thessaloniki
17  Ioannina
30  Lamia
35  Xanthi
37  Patra
```

```
ICP and IPF Values Below
----------------------------------------
ICP Value = 1,000000
IPF Value = 1,000000

ICP Value NORM. = 1,000000
IPF Value NORM. = 1,000000
----------------------------------------
```

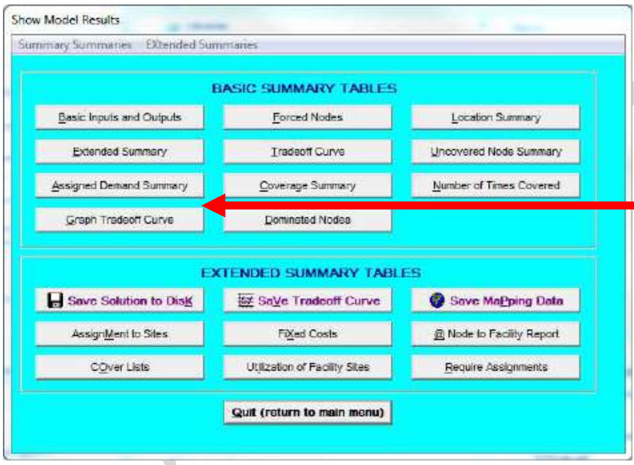
The SITATION software package

Return to previous menu



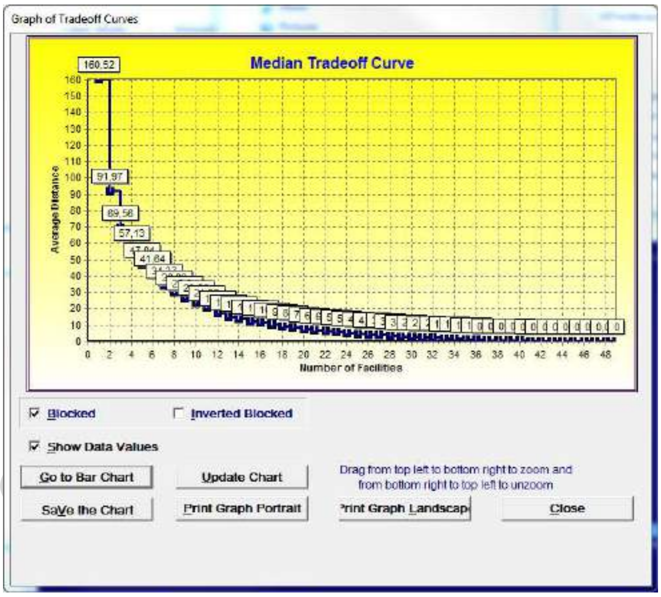
```
Click on a solution in the top
box to see locations in the
bottom box

Number of Facilities = 7
Coverage Distance = 300,00
-No.  ---Average  /  % Covered  /  -----Weight
  1     34,372  /  100,00000  /  10.000,00
  2     34,372  /  100,00000  /       0,01

Locations in box below for solution with characteristics:
  1   34,372  /  100,00000  /  10.000,00
  2  Athina
 15  Irakleio
 16  Thessaloniki
 17  Ioannina
 30  Lamia
 35  Xanthi
 37  Patra

ICP and IPF Values Below
-------------------------------------
ICP Value = 1,000000
IPF Value - 1,000000

ICP Value NORM. - 1,000000
IPF Value NORM. - 1,000000
-------------------------------------
```

Graph



Select Graph Tradeoff Curve

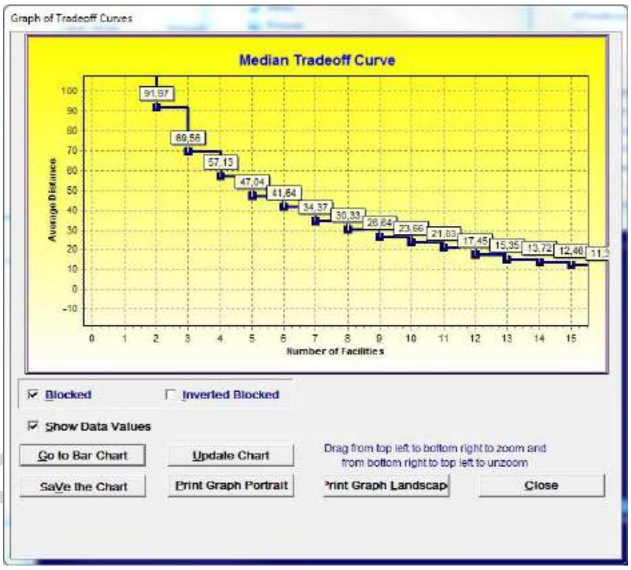
Diagram



Drag from top left to bottom right to zoom and from bottom right to top left to unzoom

The SITATION software package

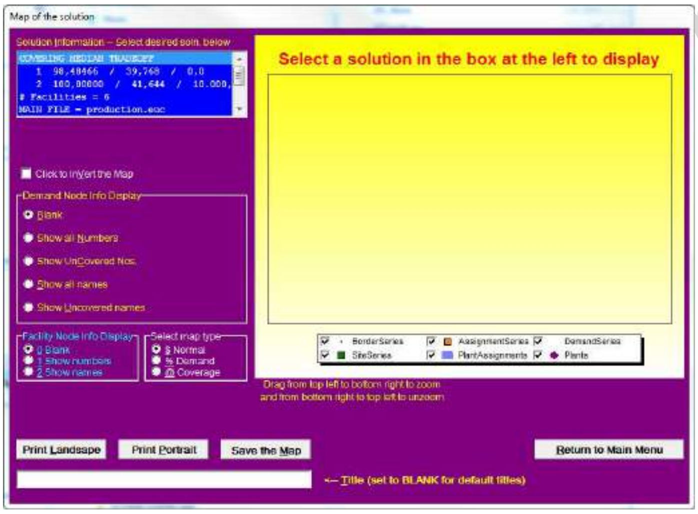
Zoom in



Drag from top left to bottom right to zoom and from bottom right to top left to unzoom

The SITATION software package

You get a blank map!!



Map of the solution

Solution Information -- Select desired soln. below

```
COVERING MEDIAN TRADEOFF
   1  98,48466  /  39,768  /  0,0
   2  100,00000  /  41,644  /  10.000,
# Facilities = 6
MAIN FILE = production.euc
```

Select a solution in the box at the left to display

☐ Click to InVert the Map

Demand Node Info Display: ● Blank ○ Show all Numbers ○ Show UnCovered Nos. ○ Show all names ○ Show Uncovered names

Facility Node Info Display: ● 0 Blank ○ 1 Show numbers ○ 2 Show names

Select map type: ● $ Normal ○ % Demand ○ @ Coverage

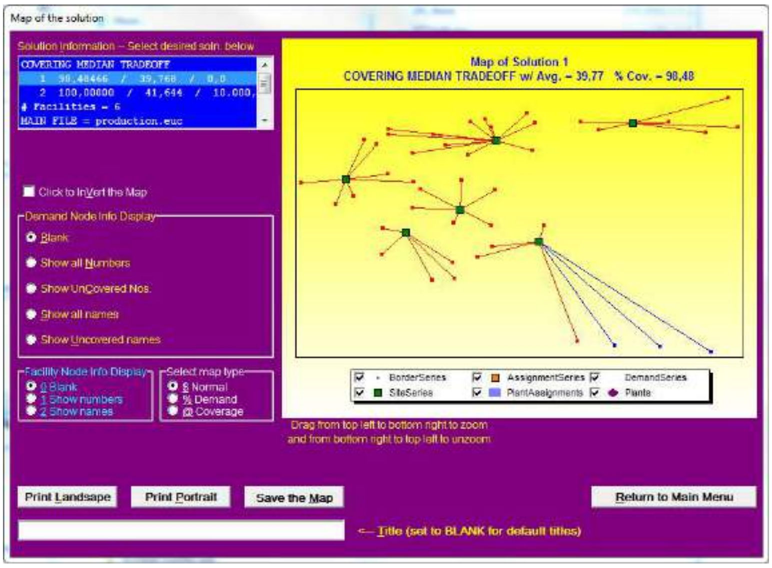
Drag from top left to bottom right to zoom and from bottom right to top left to unzoom

<-- Title (set to BLANK for default titles)

Selecting solution

The SITATION software package

Map of new solution



Map of the solution

Solution Information -- Select desired soln. below

```
COVERING MEDIAN TRADEOFF
   1  98,48466  /  39,768  /  0,0
   2  100,00000  /  41,644  /  10.000,
# Facilities = 6
MAIN FILE = production.euc
```

Map of Solution 1
COVERING MEDIAN TRADEOFF w/ Avg. = 39,77 % Cov. = 98,48

☐ Click to InVert the Map

Demand Node Info Display: ● Blank ○ Show all Numbers ○ Show UnCovered Nos. ○ Show all names ○ Show Uncovered names

Facility Node Info Display: ● 0 Blank ○ 1 Show numbers ○ 2 Show names

Select map type: ● $ Normal ○ % Demand ○ @ Coverage

Drag from top left to bottom right to zoom and from bottom right to top left to unzoom

<-- Title (set to BLANK for default titles)

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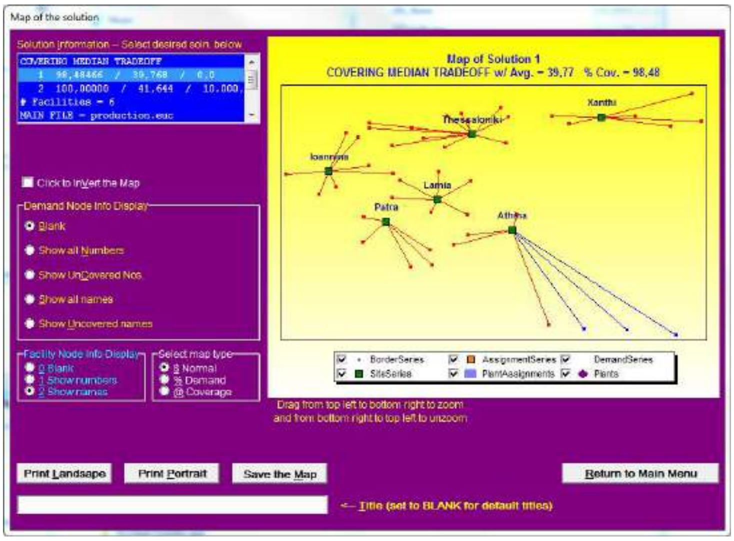
With names..



Map of the solution

Solution information -- Select desired soln. below

```
COVERING MEDIAN TRADEOFF
   1  98,48466  /  39,768  /  0,0
   2  100,00000  /  41,644  /  10,000
# Facilities = 6
MAIN FILE = production.euc
```

☐ Click to inVert the Map

Demand Node Info Display
● Blank
○ Show all Numbers
○ Show UnCovered Nos
○ Show all names
○ Show Uncovered names

Facility Node Info Display
○ 0 Blank
○ 1 Show numbers
● 2 Show names

Select map type
● $ Normal
○ % Demand
○ @ Coverage

Map of Solution 1
COVERING MEDIAN TRADEOFF w/ Avg. = 39,77 % Cov. = 98,48

Drag from top left to bottom right to zoom
and from bottom right to top left to unzoom

<-- Title (set to BLANK for default titles)

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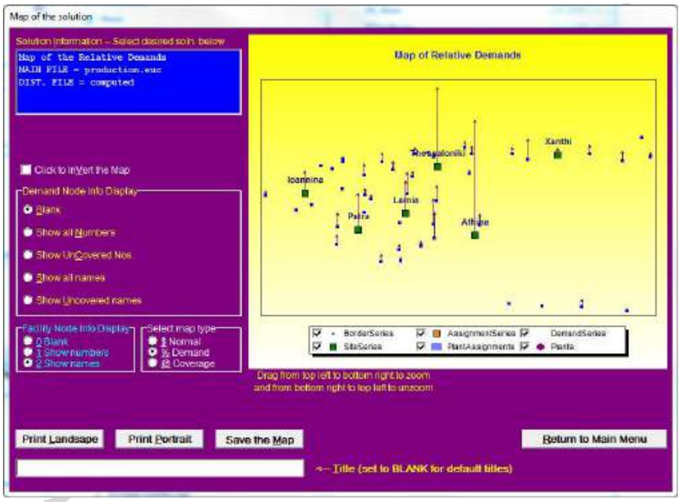
Demand



Map of the solution

Solution information -- Select desired soln. below

```
Map of the Relative Demands
MAIN FILE = production.euc
DIST. FILE = computed
```

☐ Click to inVert the Map

Demand Node Info Display
● Blank
○ Show all Numbers
○ Show UnCovered Nos
○ Show all names
○ Show Uncovered names

Facility Node Info Display
○ 0 Blank
○ 1 Show numbers
● 2 Show names

Select map type
○ $ Normal
● % Demand
○ @ Coverage

Map of Relative Demands

Drag from top left to bottom right to zoom
and from bottom right to top left to unzoom

<-- Title (set to BLANK for default titles)

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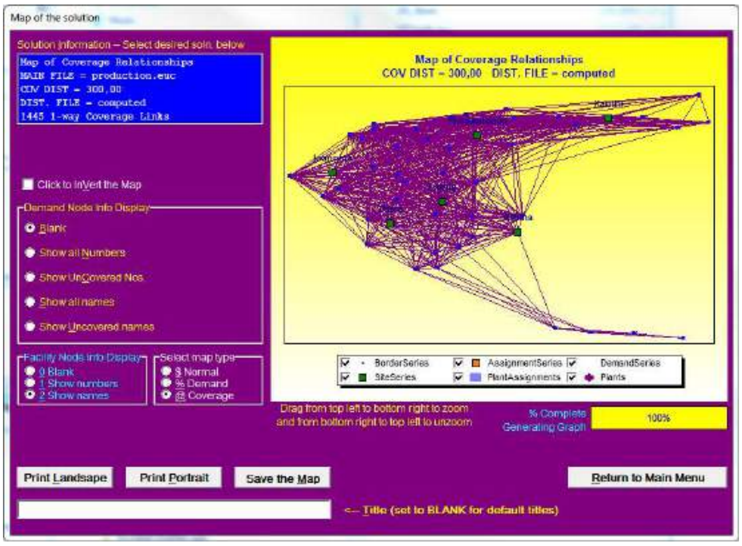
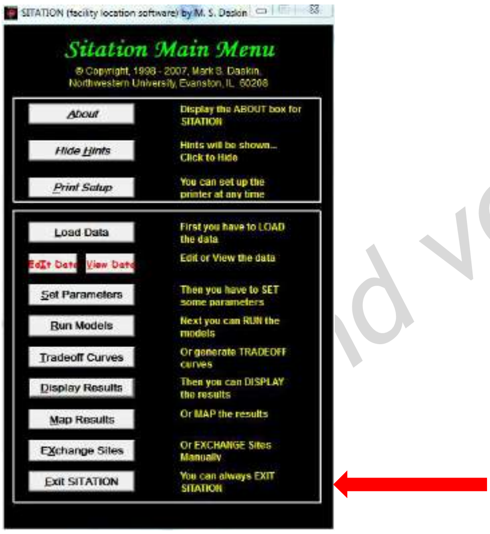
Coverage



```
Map of Coverage Relationships
MAIN FILE = production.euc
COV DIST = 300,00
DIST. FILE = computed
1445 1-way Coverage Links
```

The SITATION software package

Exit



Display the ABOUT box for SITATION

Hints will be shown... Click to Hide

You can set up the printer at any time

First you have to LOAD the data

Edit or View the data

Then you have to SET some parameters

Next you can RUN the models

Or generate TRADEOFF curves

Then you can DISPLAY the results

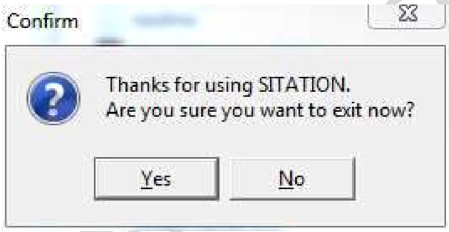
Or MAP the results

Or EXCHANGE Sites Manually

You can always EXIT SITATION

The SITATION software package

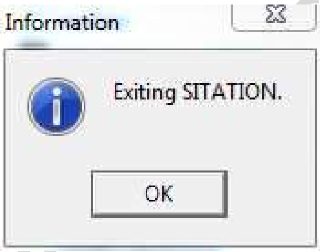
Confirmation



Confirm

Thanks for using SITATION.
Are you sure you want to exit now?

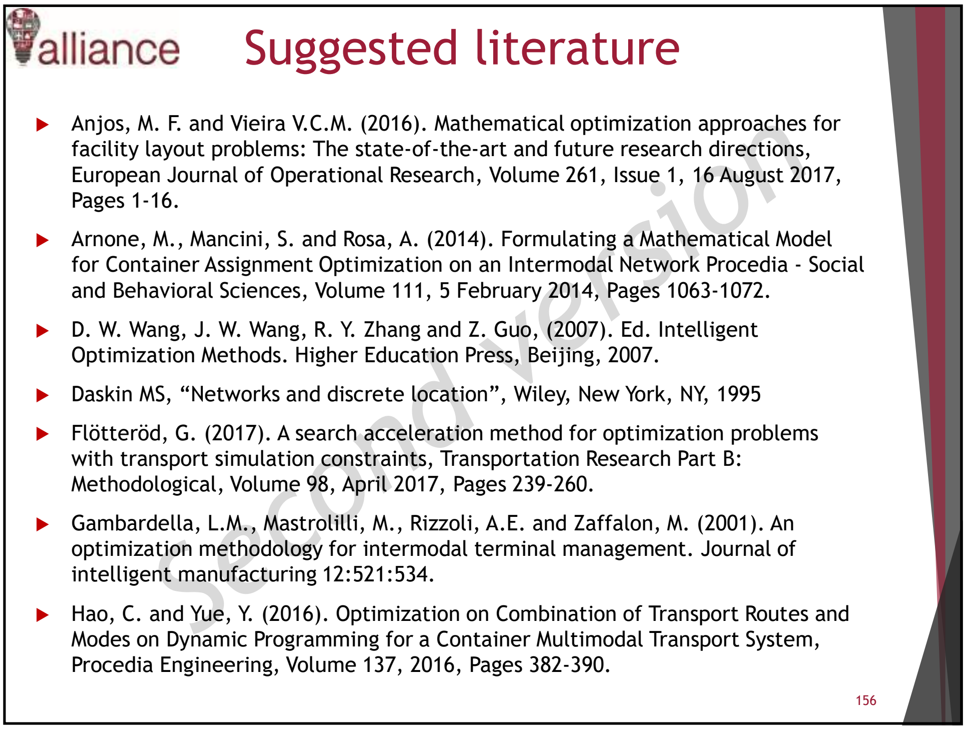
Exiting



Information

Exiting SITATION.

Guidance to further knowledge acquisition



Suggested literature

- Anjos, M. F. and Vieira V.C.M. (2016). Mathematical optimization approaches for facility layout problems: The state-of-the-art and future research directions, European Journal of Operational Research, Volume 261, Issue 1, 16 August 2017, Pages 1-16.
- Arnone, M., Mancini, S. and Rosa, A. (2014). Formulating a Mathematical Model for Container Assignment Optimization on an Intermodal Network Procedia - Social and Behavioral Sciences, Volume 111, 5 February 2014, Pages 1063-1072.
- D. W. Wang, J. W. Wang, R. Y. Zhang and Z. Guo, (2007). Ed. Intelligent Optimization Methods. Higher Education Press, Beijing, 2007.
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- Hao, C. and Yue, Y. (2016). Optimization on Combination of Transport Routes and Modes on Dynamic Programming for a Container Multimodal Transport System, Procedia Engineering, Volume 137, 2016, Pages 382-390.

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Suggested literature

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- Sörensen, K. and Vanovermeire, C. (2013). Bi-objective optimization of the intermodal terminal location problem as a policy-support tool Computers in Industry, Volume 64, Issue 2, February 2013, Pages 128-135.
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- Taha Hamdy (2011). Operations Research: An introduction. Prendice Hall.
- Yang, K., Yang, L., Gao, Z. (2016). Planning and optimization of intermodal hub-and-spoke network under mixed uncertainty, Transportation Research Part E: Logistics and Transportation Review, Volume 95, November 2016, Pages 248–266.
- Wang, Q. B. and Z. X. Han (2010). “The optimal routes and modes selection in container multimodal transportation networks,” Int. Conf. Optoelectron. Image Process., vol. 2, pp. 573-576, 2010.

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- Daskin, S. M. (2010). A Brief Introduction to the SITATION Software.Department of IOE, Univ. of Michigan. Ann Arbor, MI 48109. Summer, 2010. Summer, 2010. 2.
- Hillier, F.S., & Lieberman, G.J. (2000) Introduction to Operation Research, McGraw Hill, 7th Edition.
- Ragsdale, C.T. (1998) Spreadsheets Modeling and Decision Analysis: A practical Introduction to Management Science, South-Western College Publishing, 2nd edition.
- Taha, A. H. (1997) Operations Research: An introduction (6th edition). New Jersey: Prentice Hall
- https://support.office.com/en-us/article/Load-the-Solver-Add-in-612926fc-d53b-46b4-872c-e24772f078ca

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Thank you
for your attention!

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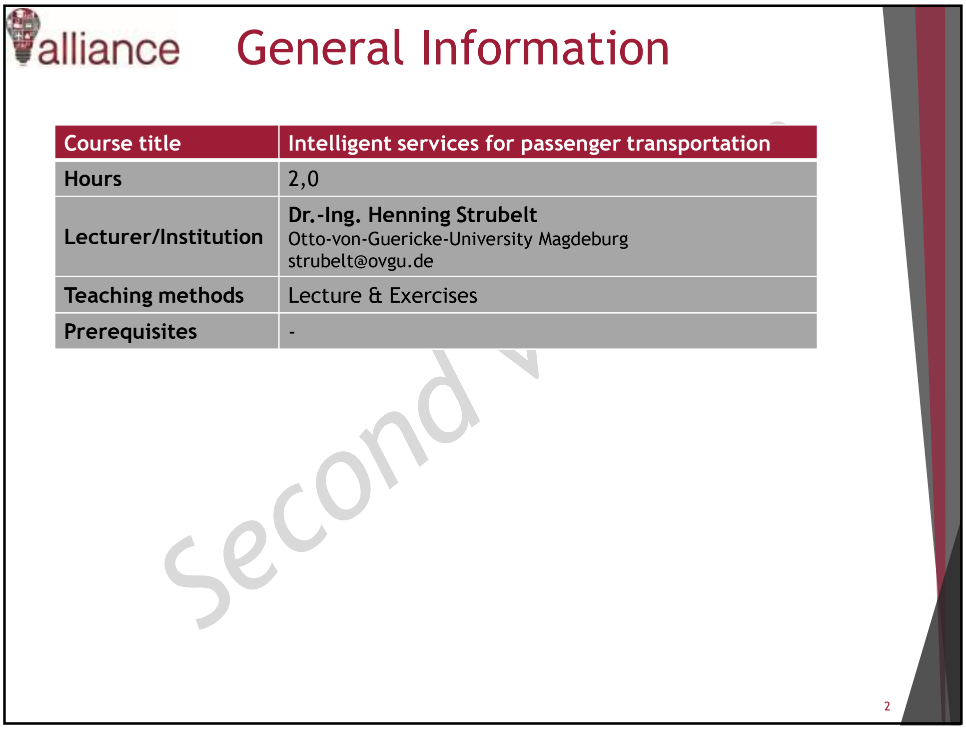
Intelligent services for passenger transportation

Dr.-Ing. Henning Strubelt
Otto von Guericke University Magdeburg, Germany

Magdeburg, 12/21/2017

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



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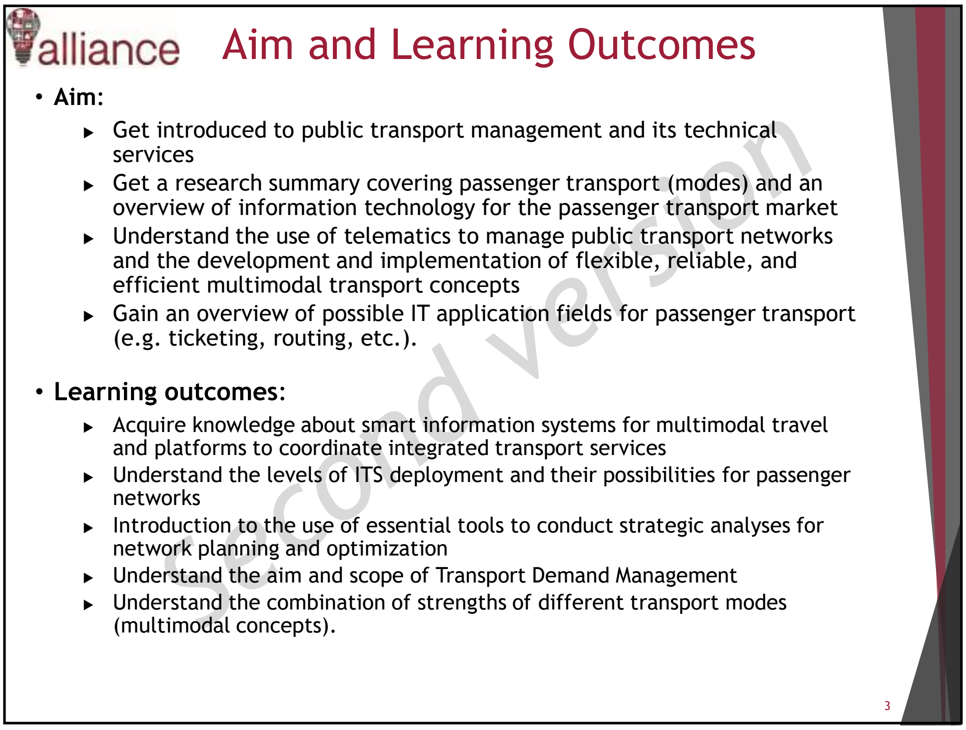
General Information

Course title	Intelligent services for passenger transportation
Hours	2,0
Lecturer/Institution	**Dr.-Ing. Henning Strubelt** Otto-von-Guericke-University Magdeburg strubelt@ovgu.de
Teaching methods	Lecture & Exercises
Prerequisites	-



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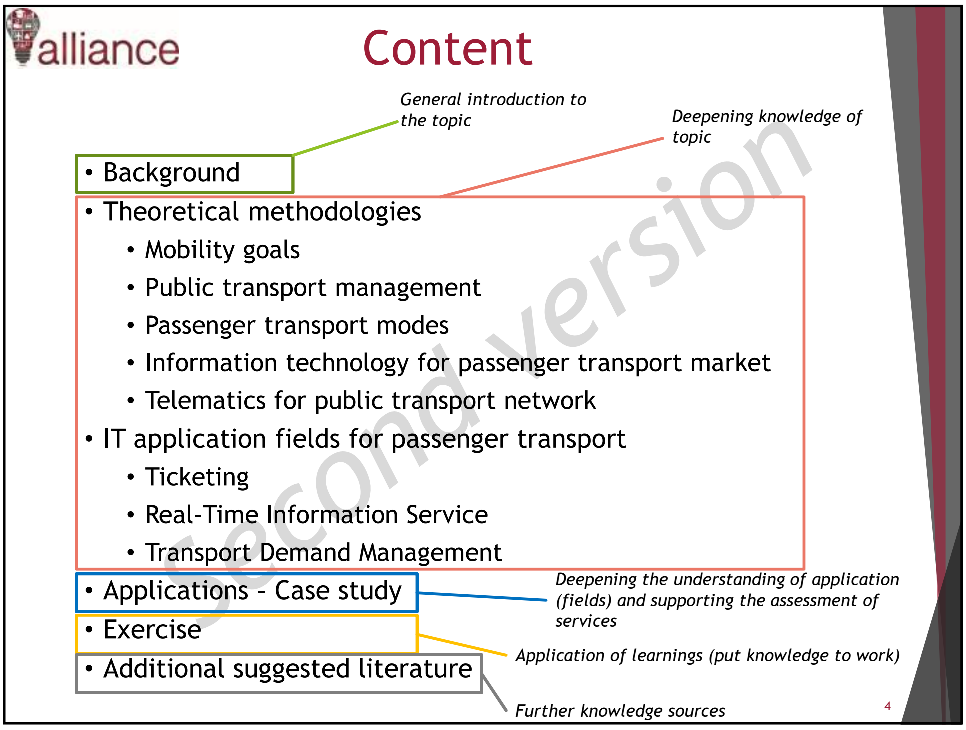
Aim and Learning Outcomes

- **Aim:**
  - Get introduced to public transport management and its technical services
  - Get a research summary covering passenger transport (modes) and an overview of information technology for the passenger transport market
  - Understand the use of telematics to manage public transport networks and the development and implementation of flexible, reliable, and efficient multimodal transport concepts
  - Gain an overview of possible IT application fields for passenger transport (e.g. ticketing, routing, etc.).
- **Learning outcomes:**
  - Acquire knowledge about smart information systems for multimodal travel and platforms to coordinate integrated transport services
  - Understand the levels of ITS deployment and their possibilities for passenger networks
  - Introduction to the use of essential tools to conduct strategic analyses for network planning and optimization
  - Understand the aim and scope of Transport Demand Management
  - Understand the combination of strengths of different transport modes (multimodal concepts).



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Content

- Background
- Theoretical methodologies
  - Mobility goals
  - Public transport management
  - Passenger transport modes
  - Information technology for passenger transport market
  - Telematics for public transport network
- IT application fields for passenger transport
  - Ticketing
  - Real-Time Information Service
  - Transport Demand Management
- Applications - Case study
- Exercise
- Additional suggested literature

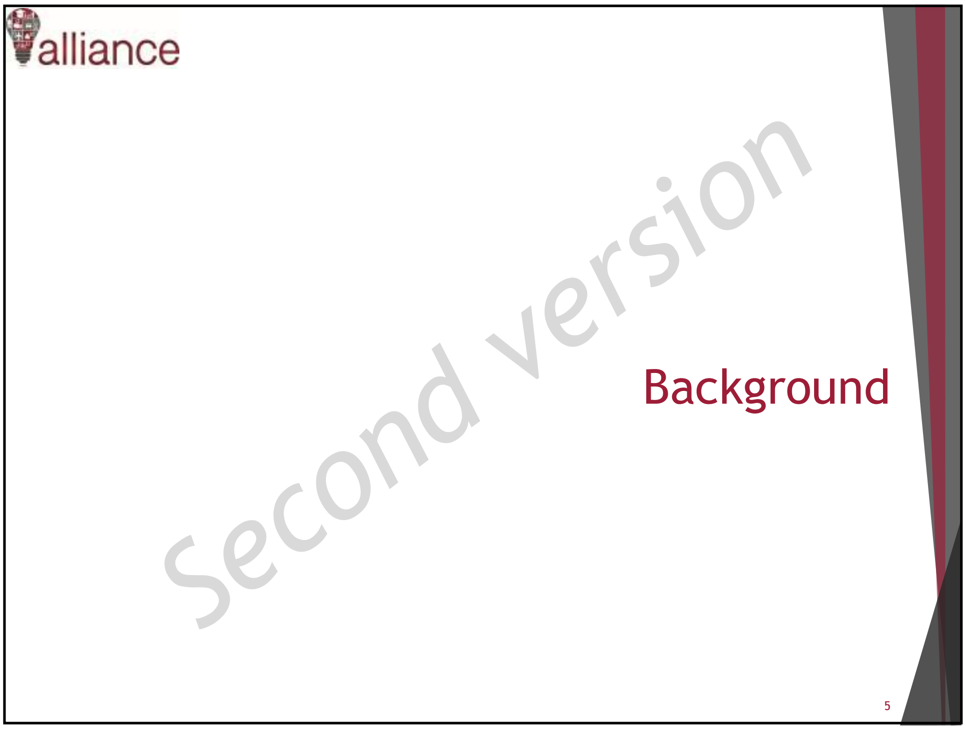
General introduction to the topic

Deepening knowledge of topic

Deepening the understanding of application (fields) and supporting the assessment of services

Application of learnings (put knowledge to work)

Further knowledge sources



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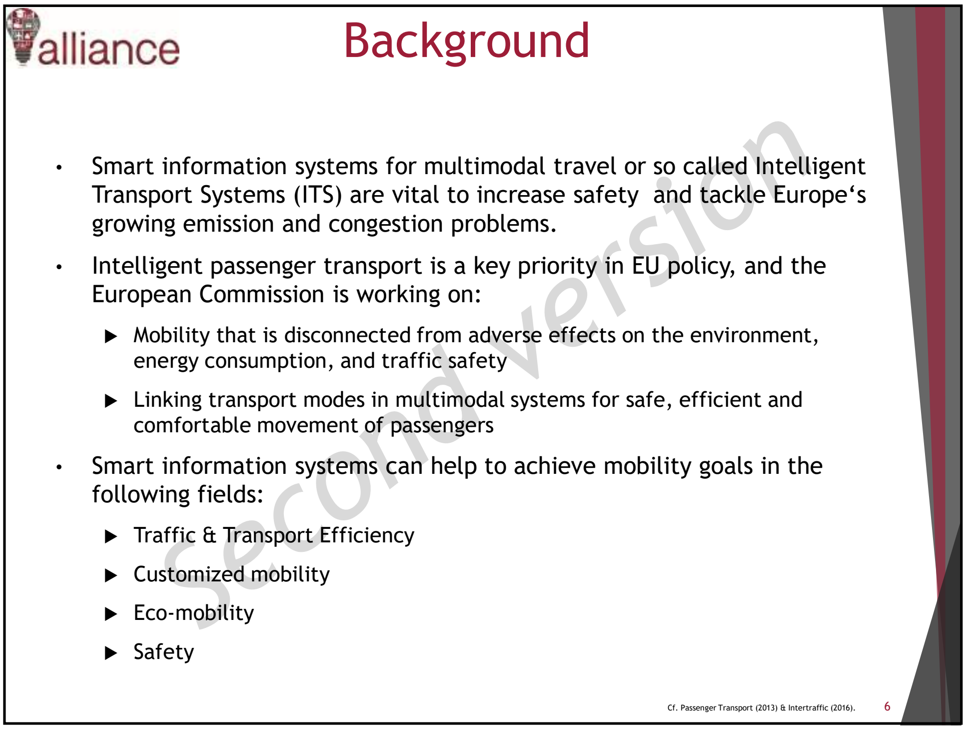
Background



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Background

- Smart information systems for multimodal travel or so called Intelligent Transport Systems (ITS) are vital to increase safety and tackle Europe‘s growing emission and congestion problems.
- Intelligent passenger transport is a key priority in EU policy, and the European Commission is working on:
  - Mobility that is disconnected from adverse effects on the environment, energy consumption, and traffic safety
  - Linking transport modes in multimodal systems for safe, efficient and comfortable movement of passengers
- Smart information systems can help to achieve mobility goals in the following fields:
  - Traffic & Transport Efficiency
  - Customized mobility
  - Eco-mobility
  - Safety

Cf. Passenger Transport (2013) & Intertraffic (2016).

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Theoretical methodologies

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Mobility Goals

Traffic & Transport Efficiency	Traffic and incident management via in-car solutions using existing infrastructure. Smarter and easier travel with the help of efficient routing and traffic information will ensure that a journey proceeds smoothly for both passengers and carriers. Examples: Dynamic Traffic Management, Real time traffic information, multimodal Transport, Park & Ride, In-car information systems, Autonomous & Cooperative Driving, Talking Traffic, Intelligent parking systems,
Customized mobility	Travelers have access to the internet, apps, and navigation and communication systems via their smartphones or tablets. Based on real time information and personal preferences of travelers, solution vendors are able to customize mobility services. Examples: Social media and mobility, Personal mobility services, Smart solutions for public transport, Multimodal travel services, Integrated ticketing & smart payment systems, Smart Travelling/Smart Working, Car sharing and ride sharing
Eco-mobility	Eco-mobility refers to all systems and solutions targeting sustainable mobility. The use of mobility solutions such as electric vehicles, public transport, walking or (electric) bicycles should be encouraged/enforced in order to reduce traditional polluting transport and to increase the quality of life.
Safety	Safety comprises all systems and solutions that focus on safety and the reduction of traffic accidents and injuries. Changing driver behavior and mapping it by means of comprehensive studies is crucial in order to improve traffic safety. New in-vehicle technologies influence the way we will use our cars. Examples: Autonomous & cooperative driving, Driver assistance systems, Solutions for vulnerable road users such as pedestrians and cyclists, Lighting, Sensors, Safe routing

Cf. Intertraffic (2016).

Public transport management

Public transport:

- Plays an essential role in the EU because approximately 60 billion public transport passenger journeys per year are carried out with local and regional buses, suburban rail transport, metros, trams, and waterborne transport services.
- The economic value of public transport services in Europe is estimated to range around 150–200 billion € per year, with growing relevance.

ITS management for public transport:

- ITS for public transport includes systems installed in public transport vehicles as well as at terminals, stops, and depots.
- Back office IT systems ensure that public transport services can be planned, scheduled, and managed. They are necessary to achieve efficient operations.
- Providing travelers with updated information about routes, departure times, possible disturbances, and connecting services.

Cf. Berg Insight (2013).

Passenger transport modes (1/5)

Multimodal Passenger Transport:

- Public transport needs to make more effective use of integrated transport modes in order to offer passenger modal choices
- Transportation stations have to be linked and transformed into multimodal platforms for passengers usage
- Using two or more modes of transportation (i.e. plans, railways, metros, bicycle and bus) in a journey

Pic 1: End-to-end-travel circle

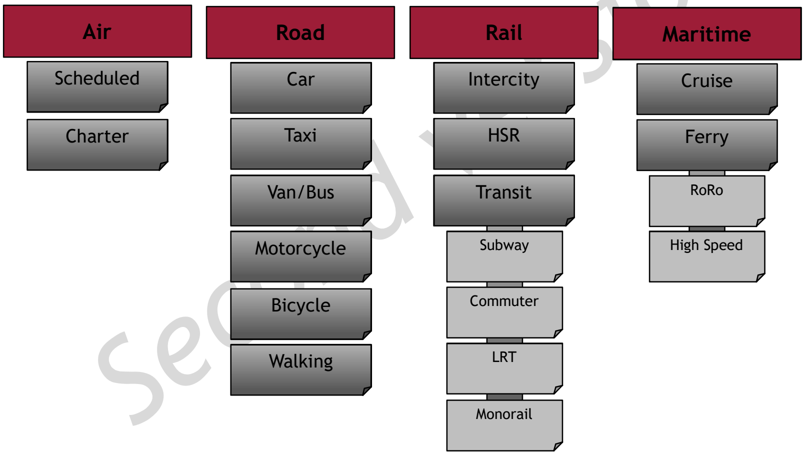
Multimodal integrated mobility platform:

- End-to-end-travelling by using public network
- Encourages modal shift and increases the usage of multimodal transportation within a single journey

Cf. Siemens (2013).

Passenger transport modes (2/5)

Diversity and characterization of transportation modes



- **Air**
  - Scheduled
  - Charter
- **Road**
  - Car
  - Taxi
  - Van/Bus
  - Motorcycle
  - Bicycle
  - Walking
- **Rail**
  - Intercity
  - HSR
  - Transit
    - Subway
    - Commuter
    - LRT
    - Monorail
- **Maritime**
  - Cruise
  - Ferry
    - RoRo
    - High Speed

Cf. Rodrigue, J.-P., et al. (2013).

Passenger transport modes (3/5)

Diversity and characterization of transportation modes

Air

- Routes are practically unlimited
- Long distance mobility
- Used for transport of passenger and high value freight

Road

- Infrastructures are large consumers of space with the lowest level of physical constraints of all transportation modes
- Historically developed to support non-motorized forms of transportation modes
- Average operational flexibility (vehicles can serve several purposes but are rarely able to move outside roads)
- High maintenance costs for road transport systems (vehicles and infrastructure)

Cf. Rodrigue, J.-P., et al. (2013).

Passenger transport modes (4/5)

Diversity and characterization of transportation modes

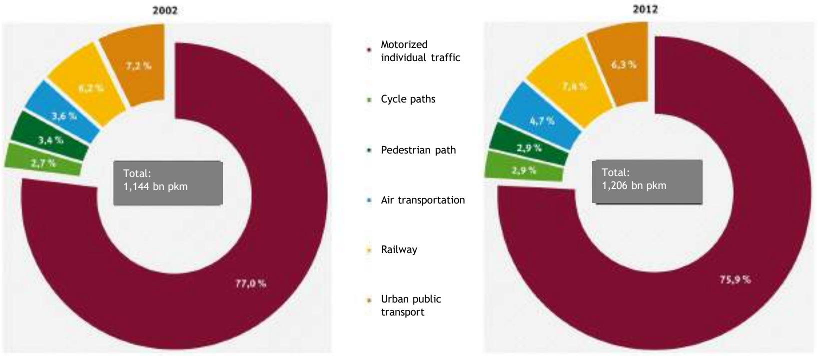
Rail
- Composed of a traced path on which wheeled vehicles are bound
- Rail transportation includes monorails and maglev
- Particularly used for freight and passenger transport
- High loading capacity
- Containerization has improved the flexibility of rail transportation by linking it with road and maritime modes

Maritime
- Most effective mode to move large quantities of cargo over long distances
- Main maritime routes are composed of oceans, coasts, seas, lakes, rivers and channels
- High terminal and inventory costs, port infrastructures are among the most expensive to build, maintain and improve

Cf. Rodrigue, J.-P., et al. (2013).

Passenger transport modes (5/5)

Modal Split for passenger traffic (incl. not motorized traffic)
(Example Germany)



* passenger kilometer in billions

Cf. BMVI (2014/2015).

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Information technology for passenger transport (1/4)

- ITS Solutions for Fleet Management allows:
  - ▶ Real-time tracking, location, monitoring and visualization of PT vehicles
  - ▶ Collect data for analysis of performance and for planning purposes
  - ▶ High-quality real-time passenger information services both on-board and off-board
  - ▶ Dynamic control and advisory systems through on-board communication
  - ▶ Improved punctuality of bus/tram services through coordinating lines and transfers
  - ▶ Transit Signal Priority (TSP) at traffic lights and equipment diagnostics and maintenance planning and scheduling

↳ Improving the efficiency, reliability and the environmental impact of public transportation (PT) systems

Cf. Nökel, K., Gentile, G. (2016).

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Information technology for passenger transport (2/4)

- The best way to monitor Public Transportation systems with ITS technologies is through a centralized control center using a two-way communication protocol (practice in some European cities)
  - ▶ Provides real-time information to the control centre with automatic vehicle location (AVL) systems
  - ▶ Produces guidance instructions to each vehicle, through the driver display or by information panels along the line
  - ▶ Different electronic data interchange (EDI) protocols support this continuous communication between control centre and vehicles

Pic 2: ITS communication protocol for PT

- This communication helps to:
  - ▶ Overcome road-obstacles
  - ▶ Solving any emergency or accident rapidly
  - ▶ Deliver real time information to the travelers at the stops or stations
  - ▶ Shows waiting time for the next services and reports on incidents

First Version of 11/10/2016

Cf. Nökel, K., Gentile, G. (2016).

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Information technology for passenger transport (3/4)

Pic 3: Ticket machine

Pic 4: Security camera system

Pic 5: Train/Tram/Bus station monitoring

- **Info mobility Tools for Sustainable Fleet Management**
  - Providing a reliable, predictable, comfortable and safe service
  - Reduce traffic levels and levels of pollution an fuel consumption by encourage people to use public transport instead of private car
  - System uses GPS in order to increase efficiency of public transport and to optimize energy consumption
- **Monitoring and Planning of Public Transport Systems**
  - Security camera system on-board of the vehicle and at stops and terminals combined with a communication system between vehicle and control centre
  - Control centre can get real-time views of all cameras and are able to forwarded the views to police
  - Combined with GPS it is possible to locate the incident automatically and send proper service if needed
  - Improved security and the physical integrity of the drivers, travelers and material equipment (reduces vandalism problems)

Cf. Nökel, K., Gentile, G. (2016).

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Information technology for passenger transport (4/4)

Pic 6: Bus lane

Pic 7: Bus light signal

- **Integrated Management of Traffic and Public Transport Prioritization**
  - Coordination of ITS for controlling bus services and traffic
  - Requires a platform where traffic and public transport control centers are linked and coordinated
  - Gives priority to buses in traffic lights and intersections and green waves for bus lanes and corridors
  - Anticipating information on congestion or incidents in the bus line to allow changing itineraries or rescheduling
  - Active traffic signal priority (TSP) is one of the most efficient and cost-effective measures to improve the efficiency of PT operations
  - TSP is based AVL as detection systems to allow active priority, in which the system verifies if the approaching vehicle meets the criteria for granting the priority

Example: In Toulouse (France), the average bus waiting time at traffic lights was reduced by 52 % with this kind of systems, at comparatively low costs

↳ **This coordination is to facilitate the reliability in bus services**

Cf. Nökel, K., Gentile, G. (2016).

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Telematics for public transport network (1/2)

Automated Data Collection Systems

- Automatic Vehicle Location Systems (AVL)
  - Location based on GPS
  - Tracking based on track circuit occupancy
  - Real-time availability of data
- Automatic Passenger Counting Systems (APC)
  - Systems based on sensors in doors with channelized passenger movements
  - passenger boarding counts for stops/stations with fare barriers
  - Weighing systems to estimate number of passengers on board
  - Traditionally not available in real-time
- Automatic Fare Collection Systems (AFC)
  - Based on contactless smart cards with unique ID
  - Provides entry (exit) information at the individual level
  - Not available in real-time

Cf. Wilson, N. (2009).

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Telematics for public transport network (2/2)

Transit agency/operation function

- **Service and Operations Planning (SOP)**
  - Network and route design
  - Frequency setting and timetable development
  - Vehicle and crew scheduling
  - Off-line, non real-time function
- **Service and Operations Control and Management (SOCM)**
  - Dealing with deviations from SOP, both minor and major
  - Dealing with unexpected changes in demand
  - Real-time function
- **Customer Information (CI)**
  - Information on routes, trip times, vehicle arrival times
  - Both static (based on SOP) and dynamic (based on SOP and SOCM)
  - Both pre-trip and en-route
- **Performance Measurement and Monitoring (PMM)**
  - Measures of operator performance against SOP
  - Measures of service from customer viewpoint
  - Traditionally an off-line function

Cf. Wilson, N. (2009).

IT application fields

Ticketing (1/2)

Negative factors by using different public transportation systems is the need to buy different tickets and use different kind of payments!

Integrated Ticketing

- Key issue for the use of public transport and acceptance of intermodality
- Near field communication (NFC) protocols provide contactless payment systems for all transport modes in the city
- Electronic payment by using intelligent smart cards
  - ▶ Contactless and different payment options
  - ▶ Convenient for designing different price schemes (special groups, different times of a day)
  - ▶ Provides useful information for transport managers and planners
  - ▶ Option to avoid survey costs or counting of number of passengers using time-consuming and labor-intensive data collection methods
- Ticketing data for improving transit planning and scheduling services
  - ▶ AVL data, which inform driver and may lead to a next time bus stop point
  - ▶ Measures of effectiveness include average waiting and standing time per passenger average holding time and delay per bus
  - ▶ AVL, APC and AFC are also used to assess transit system performance and reliability
  - ▶ Estimates dwell time and passenger waiting times as related to service reliability

Cf. Nökel, K., Gentile, G. (2016).

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Ticketing (2/2)

Different parts of Ticketing

- **On-Street Ticket Vending Machines**
  - ▶ Roadside ticket vending machines with networked communications links to remote monitoring and revenue management systems
  - ▶ Customers are able to choose between different operators and tariffs when buying a ticket
  - ▶ Solution for roadside bus ticket sales suitable for the deregulated environment applicable
- **Smart Card System**
  - ▶ Ticketing and access control system installed in access channels target transportation network to interact with the magnetic ticket (card)
  - ▶ Doors within the access channels are commanded by the reading and validation of data stored in tickets
  - ▶ Ticket with embedded chip and antenna which works by holding the card over a validator, located at entrances of a station
  - ▶ The card allows the loading of fares exclusive to each associated operator, multimodal fares and combined fares
  - ▶ Provides greater security and revenue protection, faster Ticketing and better knowledge of origin-destination flows

Pic 8: Ticket/Smart card validation machine

Pic 9: On-board smart card system

Pic 10: On-board smart card system

Cf. Nökel, K., Gentile, G. (2016).

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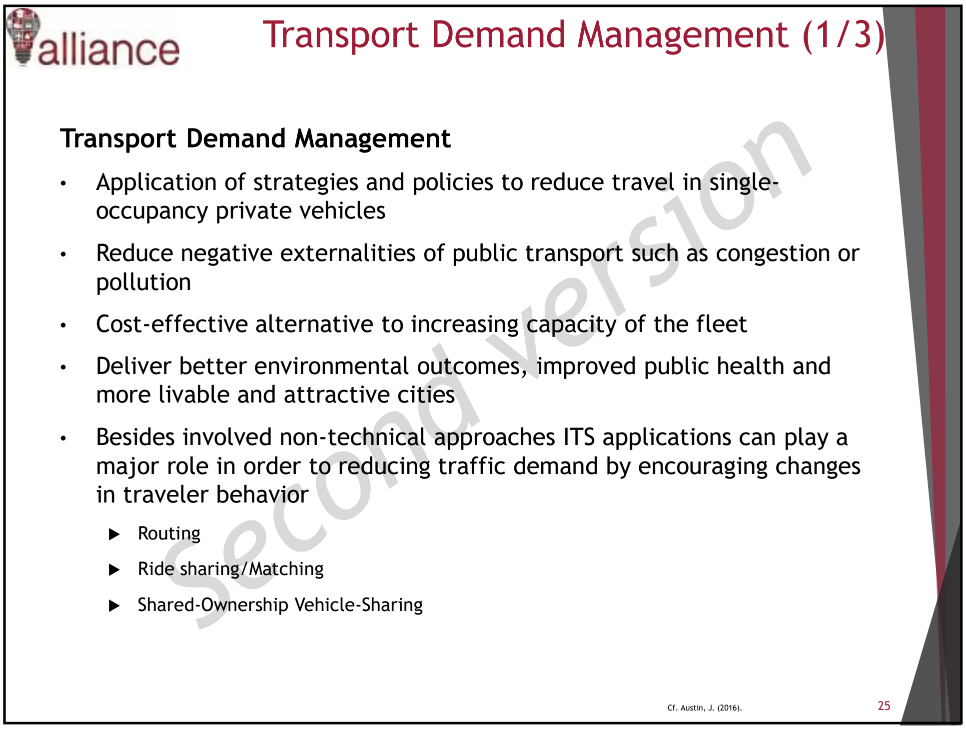
Real-Time Information Service

- ITS real-time data can be also used to improve the information offered to the service stakeholders
  - ▶ Information to travelers throughout the total journey, in the trip planning phase and during the trip especially at the interchange points
  - ▶ Online integrated information given at the interchange points including incident information
  - ▶ Dialogue between information systems of various operators
  - ▶ Integrated information (Emergency and daily incident information) appears on the screens in the vehicles, stops and terminals and mobile equipment
  - ▶ Ticket purchasing systems, especially smartphone-based solutions.

Pic 11: Real-time information panel at a bus stop

Pic 12: Real-time smartphone routing-app

Cf. Nökel, K., Gentile, G. (2016).

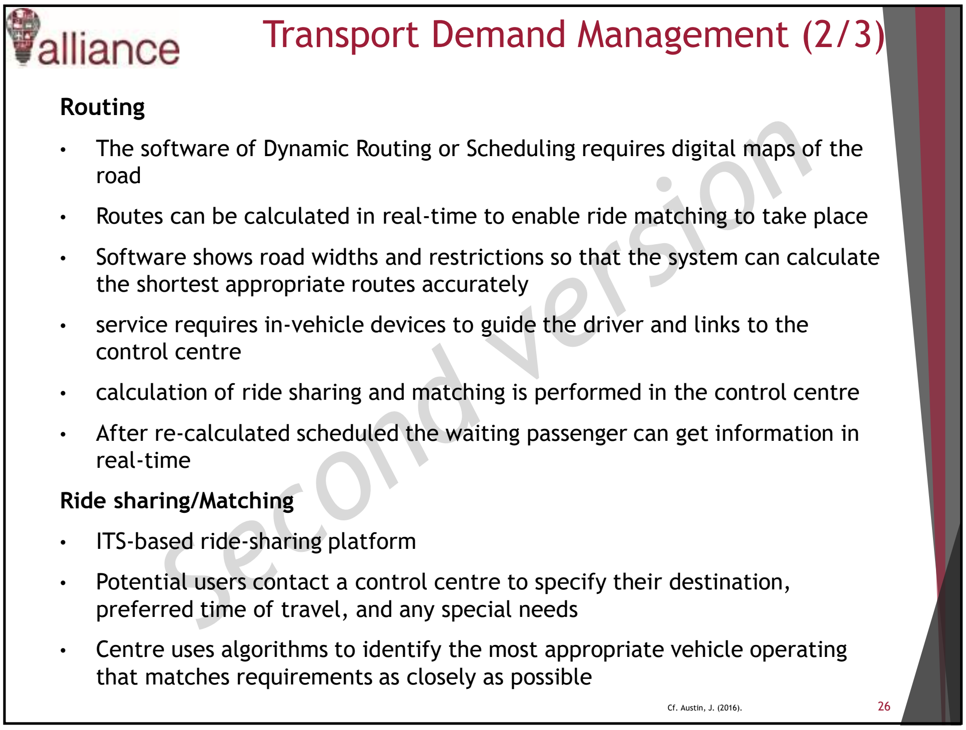


Transport Demand Management (1/3)

Transport Demand Management

- Application of strategies and policies to reduce travel in single-occupancy private vehicles
- Reduce negative externalities of public transport such as congestion or pollution
- Cost-effective alternative to increasing capacity of the fleet
- Deliver better environmental outcomes, improved public health and more livable and attractive cities
- Besides involved non-technical approaches ITS applications can play a major role in order to reducing traffic demand by encouraging changes in traveler behavior
  - ▶ Routing
  - ▶ Ride sharing/Matching
  - ▶ Shared-Ownership Vehicle-Sharing

Cf. Austin, J. (2016).



Transport Demand Management (2/3)

Routing

- The software of Dynamic Routing or Scheduling requires digital maps of the road
- Routes can be calculated in real-time to enable ride matching to take place
- Software shows road widths and restrictions so that the system can calculate the shortest appropriate routes accurately
- service requires in-vehicle devices to guide the driver and links to the control centre
- calculation of ride sharing and matching is performed in the control centre
- After re-calculated scheduled the waiting passenger can get information in real-time

Ride sharing/Matching

- ITS-based ride-sharing platform
- Potential users contact a control centre to specify their destination, preferred time of travel, and any special needs
- Centre uses algorithms to identify the most appropriate vehicle operating that matches requirements as closely as possible

Cf. Austin, J. (2016).

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Transport Demand Management (3/3)

Services for disabled patrons

- Mobility assistants (App) for intermodal route planning and navigation on the basis of real-time data
- Example: EU research project “aim4it” aims to develop the interactive aim4it-app to make public transport journeys for persons with disabilities as barrier-free as possible. The app facilitates journey planning and support during the journey for different disabilities, e.g. wheelchair users, blind or deaf passengers.
  - ▶ Delay or disturbance updates available in real-time in sign language
  - ▶ Requesting assistance from the driver
  - ▶ Barrier-free re-routing in the case of disturbances on the planned route
  - ▶ Connection Protection: the next vehicle gets informed and waits if needed

Cf. Fluidtime (2017).

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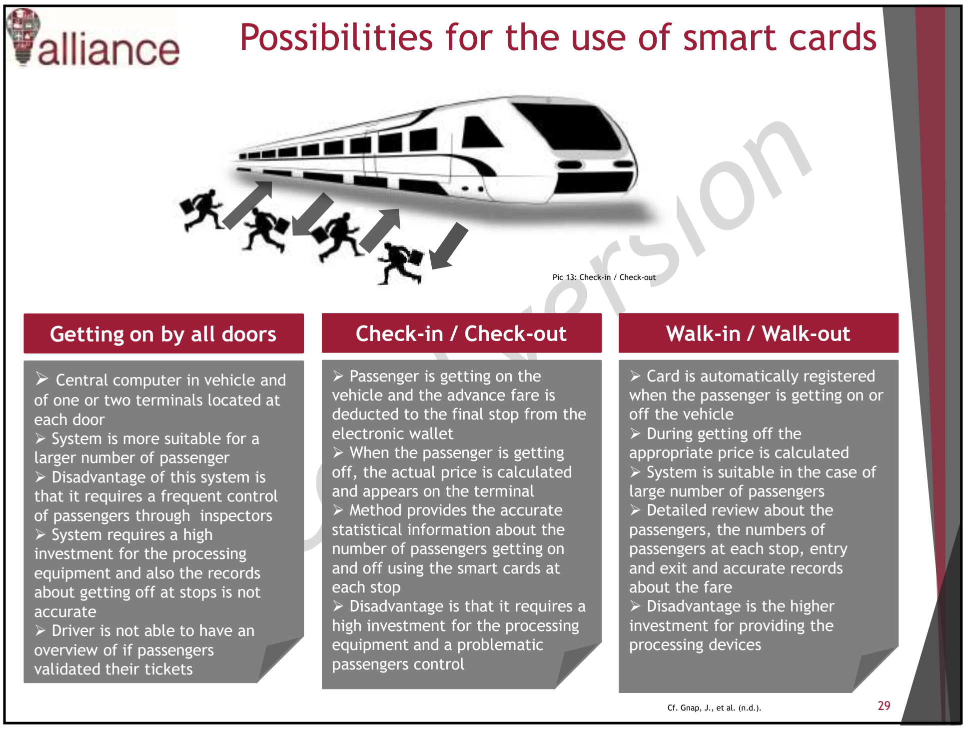
Applications – Case study



Possibilities for the use of smart cards

Pic 13: Check-in / Check-out

Getting on by all doors

- Central computer in vehicle and of one or two terminals located at each door
- System is more suitable for a larger number of passenger
- Disadvantage of this system is that it requires a frequent control of passengers through inspectors
- System requires a high investment for the processing equipment and also the records about getting off at stops is not accurate
- Driver is not able to have an overview of if passengers validated their tickets

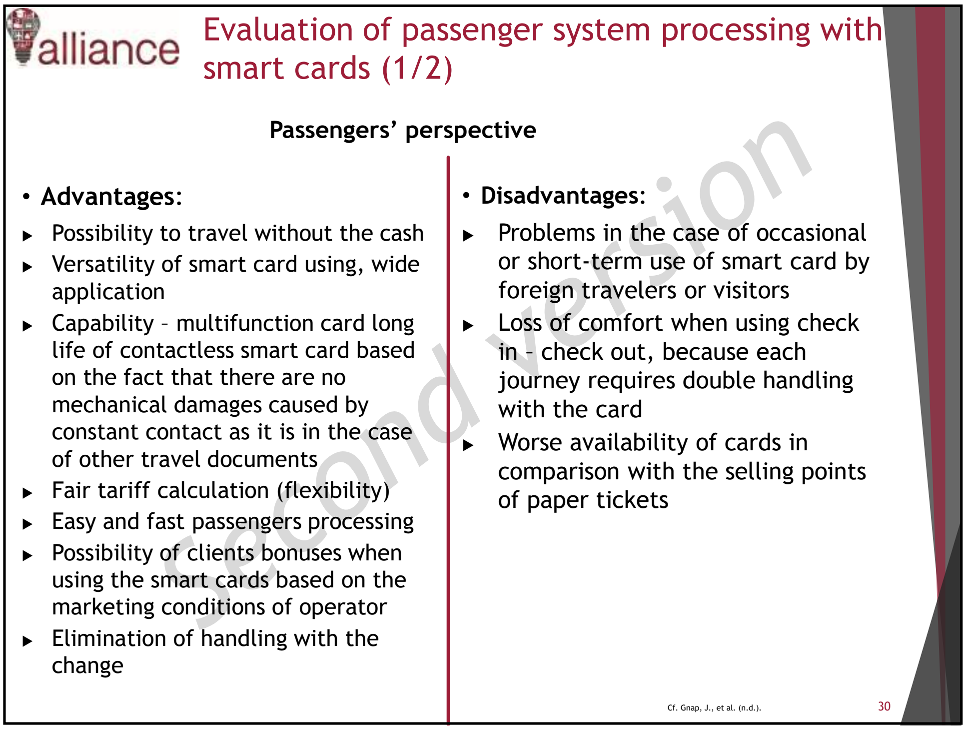
Check-in / Check-out

- Passenger is getting on the vehicle and the advance fare is deducted to the final stop from the electronic wallet
- When the passenger is getting off, the actual price is calculated and appears on the terminal
- Method provides the accurate statistical information about the number of passengers getting on and off using the smart cards at each stop
- Disadvantage is that it requires a high investment for the processing equipment and a problematic passengers control

Walk-in / Walk-out

- Card is automatically registered when the passenger is getting on or off the vehicle
- During getting off the appropriate price is calculated
- System is suitable in the case of large number of passengers
- Detailed review about the passengers, the numbers of passengers at each stop, entry and exit and accurate records about the fare
- Disadvantage is the higher investment for providing the processing devices

Cf. Gnap, J., et al. (n.d.).



Evaluation of passenger system processing with smart cards (1/2)

Passengers' perspective

- **Advantages:**
  - Possibility to travel without the cash
  - Versatility of smart card using, wide application
  - Capability – multifunction card long life of contactless smart card based on the fact that there are no mechanical damages caused by constant contact as it is in the case of other travel documents
  - Fair tariff calculation (flexibility)
  - Easy and fast passengers processing
  - Possibility of clients bonuses when using the smart cards based on the marketing conditions of operator
  - Elimination of handling with the change

- **Disadvantages:**
  - Problems in the case of occasional or short-term use of smart card by foreign travelers or visitors
  - Loss of comfort when using check in – check out, because each journey requires double handling with the card
  - Worse availability of cards in comparison with the selling points of paper tickets

Cf. Gnap, J., et al. (n.d.).

Evaluation of passenger system processing with smart cards (2/2)

Perspective of operator or integrated transport system coordinator

- **Advantages:**
  - When the cards are charging and these sources are accounted as the advance payment by operator
  - Allows watching the real operating costs
  - Complete overview about the passenger's journeys, number of passengers, their getting on and off numbers at each stop, information about the profitability of each connection what allows to achieve a high flexibility of optimization processes, possibilities for better coordination of transport systems
  - Tariff flexibility of processing system

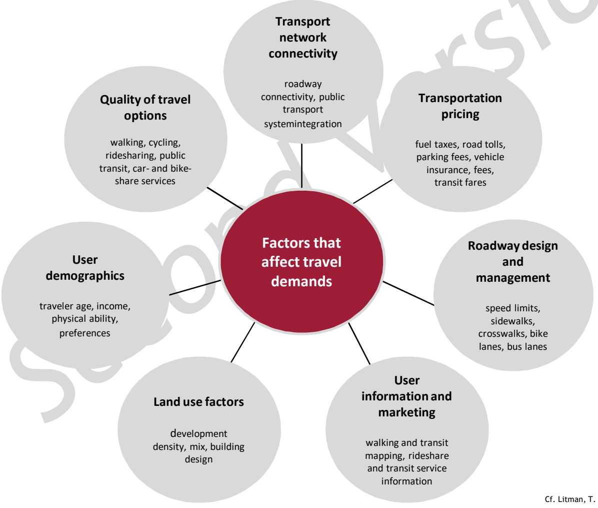
- **Disadvantages:**
  - High price of cards and the problematic solution for the casual passenger
  - High purchasing costs for devices of passengers processing validators, machines, pre-sale equipment) and the implementation of system
  - Complicated control of tickets validity from the technical side.
  - Higher purchasing costs for the technical means of system (hardware, software).

Cf. Gnap, J., et al. (n.d.).

Exercise 1
Travel Demand Management

Travel Demand

- Refers to the amount and type of travel, people would choose under various conditions and circumstances



Factors that affect travel demands

Transport network connectivity
roadway connectivity, public transport systemintegration

Transportation pricing
fuel taxes, road tolls, parking fees, vehicle insurance, fees, transit fares

Roadway design and management
speed limits, sidewalks, crosswalks, bike lanes, bus lanes

User information and marketing
walking and transit mapping, rideshare and transit service information

Land use factors
development density, mix, building design

User demographics
traveler age, income, physical ability, preferences

Quality of travel options
walking, cycling, ridesharing, public transit, car- and bike-share services

Cf. Litman, T. (2016).

TDM Influence

Pic 14: Efficient use of street space

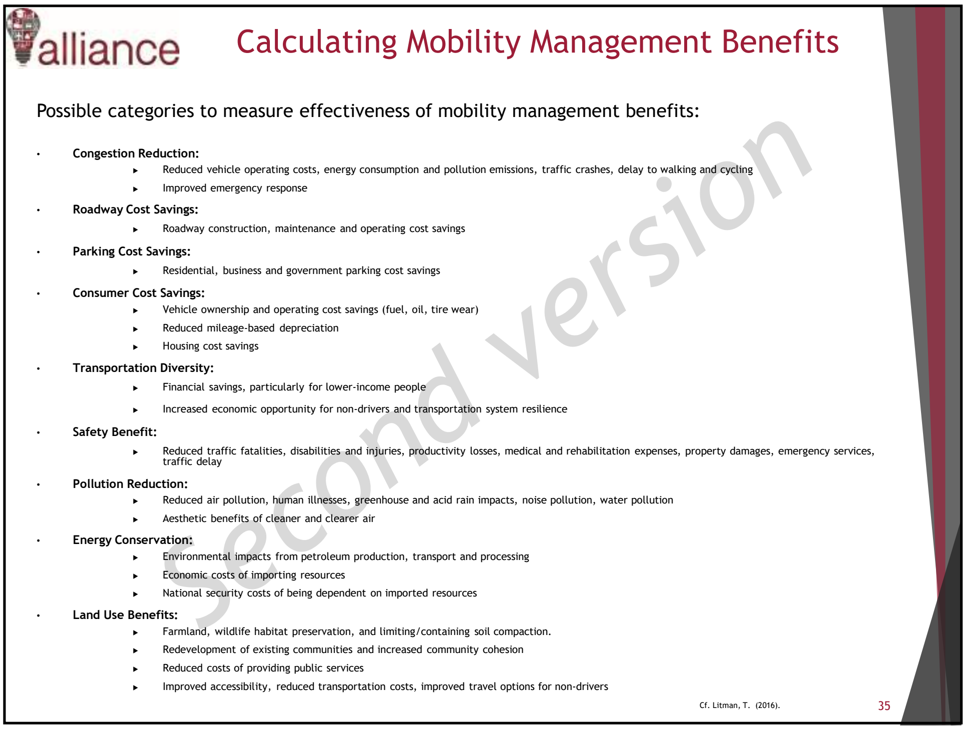
Potential TDM planning benefits

Benefits	Definition
Congestion reduction	Reduced traffic congestion to motorists, bus users, pedestrians and cyclists
Road cost savings	Reduced costs to build, maintain and operate roadway systems
Parking savings	Reduced parking problems and parking facility costs
Consumer savings	Transportation cost savings to consumers
Improved mobility options	Improved mobility options, particularly for non-drivers
Road safety	Reduced per capita traffic crash risk
Energy conservation	Reduced per capita energy consumption
Emission reductions	Reduced per capita pollution emissions
Efficient land use	More accessible community design, reduced per capita land consumption
Public fitness and health	Increased physical activity and associated health benefits

Cf. Transportation Demand Management Training Document (2009).

TDM travel impacts

TDM Measure	Mechanism	Travel changes
Traffic calming	Roadway design	Reduces traffic speeds, improves pedestrian conditions
Flexible work hours	Improved transport choice	Shifts travel time
Road/congestion pricing	Pricing	Shifts travel time, reduces vehicle travel on a particular roadway
Distance-based charges	Pricing	Reduces overall vehicle travel
Transit improvements	Improved transport choice	Shifts mode, increases transit use
Ridesharing	Improved transport choice	Increases vehicle occupancy, reduces vehicle trips
Pedestrian and bicycle improvements	Improved transport choice, roadway design	Shifts mode, increases walking and cycling
Car sharing	Improved transport choice	Reduces vehicle ownership and trips
Compact land use (Smart Growth)	Improved transport choice	Shifts mode, reduces vehicle ownership and trip distances



Calculating Mobility Management Benefits

Possible categories to measure effectiveness of mobility management benefits:

- **Congestion Reduction:**
  - Reduced vehicle operating costs, energy consumption and pollution emissions, traffic crashes, delay to walking and cycling
  - Improved emergency response
- **Roadway Cost Savings:**
  - Roadway construction, maintenance and operating cost savings
- **Parking Cost Savings:**
  - Residential, business and government parking cost savings
- **Consumer Cost Savings:**
  - Vehicle ownership and operating cost savings (fuel, oil, tire wear)
  - Reduced mileage-based depreciation
  - Housing cost savings
- **Transportation Diversity:**
  - Financial savings, particularly for lower-income people
  - Increased economic opportunity for non-drivers and transportation system resilience
- **Safety Benefit:**
  - Reduced traffic fatalities, disabilities and injuries, productivity losses, medical and rehabilitation expenses, property damages, emergency services, traffic delay
- **Pollution Reduction:**
  - Reduced air pollution, human illnesses, greenhouse and acid rain impacts, noise pollution, water pollution
  - Aesthetic benefits of cleaner and clearer air
- **Energy Conservation:**
  - Environmental impacts from petroleum production, transport and processing
  - Economic costs of importing resources
  - National security costs of being dependent on imported resources
- **Land Use Benefits:**
  - Farmland, wildlife habitat preservation, and limiting/containing soil compaction.
  - Redevelopment of existing communities and increased community cohesion
  - Reduced costs of providing public services
  - Improved accessibility, reduced transportation costs, improved travel options for non-drivers

Cf. Litman, T. (2016).

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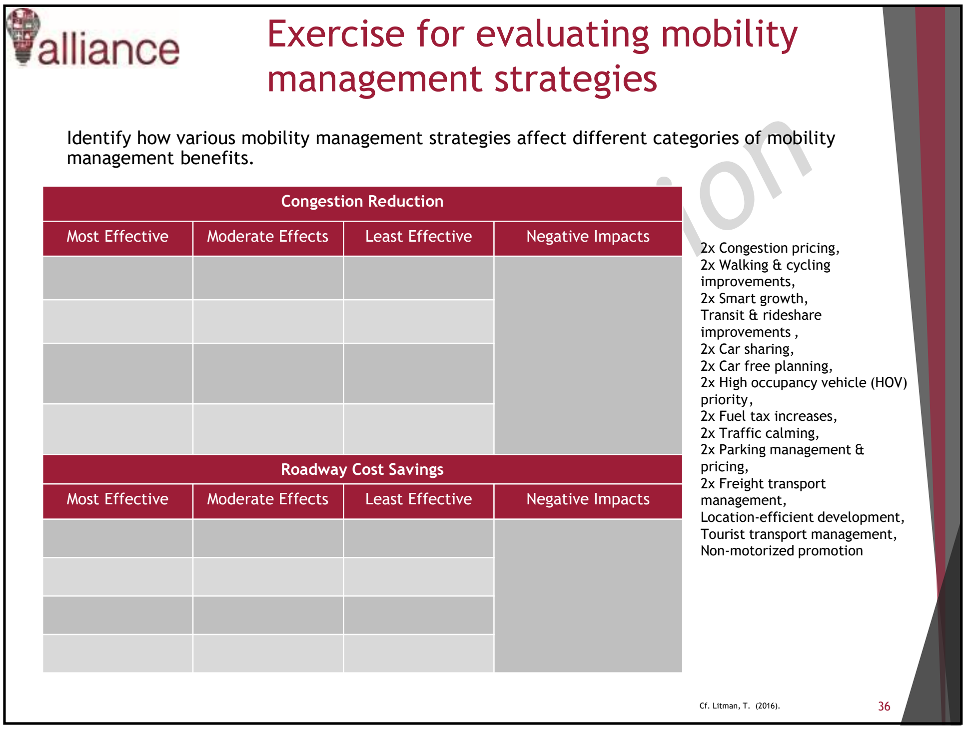

Exercise for evaluating mobility management strategies

Identify how various mobility management strategies affect different categories of mobility management benefits.

Congestion Reduction			
Most Effective	Moderate Effects	Least Effective	Negative Impacts

Roadway Cost Savings			
Most Effective	Moderate Effects	Least Effective	Negative Impacts

2x Congestion pricing,
2x Walking & cycling improvements,
2x Smart growth,
Transit & rideshare improvements ,
2x Car sharing,
2x Car free planning,
2x High occupancy vehicle (HOV) priority,
2x Fuel tax increases,
2x Traffic calming,
2x Parking management & pricing,
2x Freight transport management,
Location-efficient development,
Tourist transport management,
Non-motorized promotion

Cf. Litman, T. (2016).

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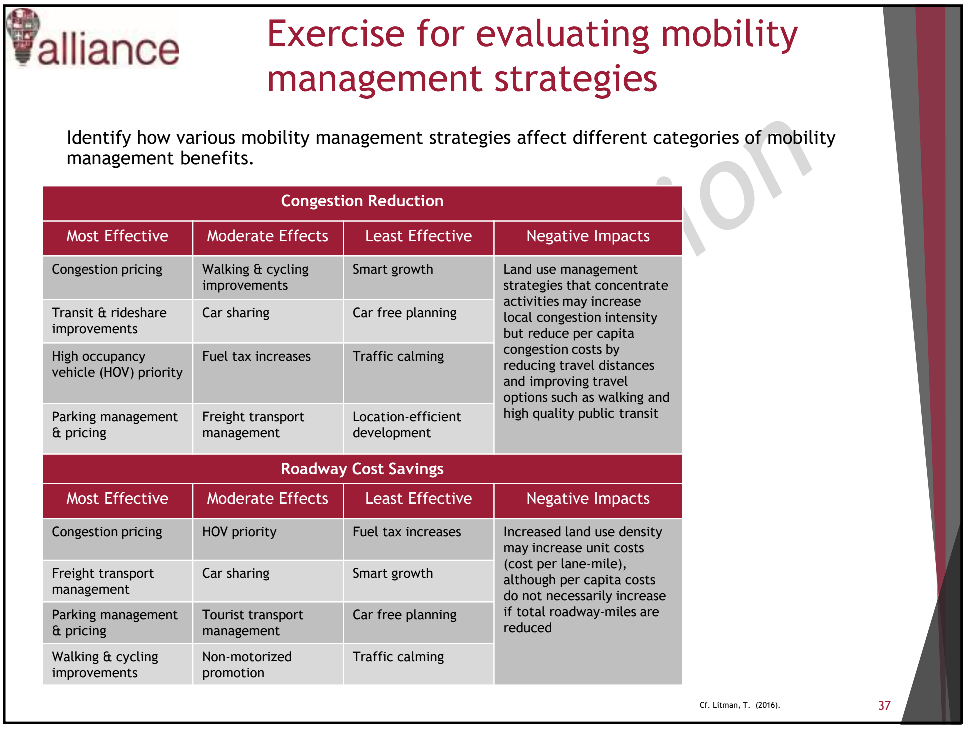


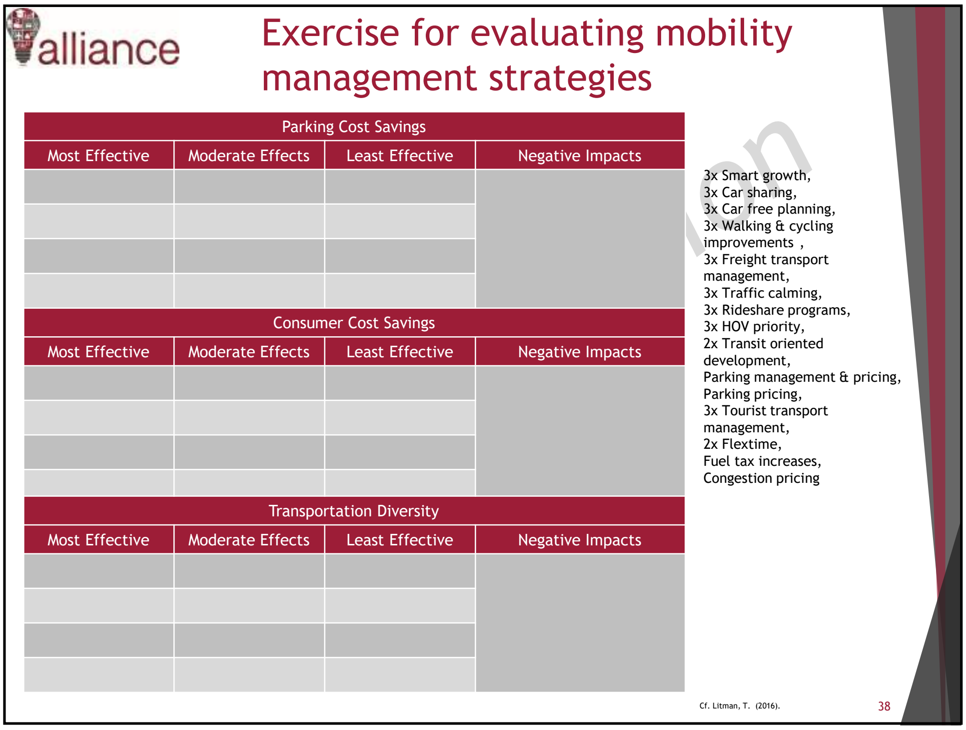
Exercise for evaluating mobility management strategies

Identify how various mobility management strategies affect different categories of mobility management benefits.

Congestion Reduction			
Most Effective	**Moderate Effects**	**Least Effective**	**Negative Impacts**
Congestion pricing	Walking & cycling improvements	Smart growth	Land use management strategies that concentrate activities may increase local congestion intensity but reduce per capita congestion costs by reducing travel distances and improving travel options such as walking and high quality public transit
Transit & rideshare improvements	Car sharing	Car free planning	
High occupancy vehicle (HOV) priority	Fuel tax increases	Traffic calming	
Parking management & pricing	Freight transport management	Location-efficient development	

Roadway Cost Savings			
Most Effective	**Moderate Effects**	**Least Effective**	**Negative Impacts**
Congestion pricing	HOV priority	Fuel tax increases	Increased land use density may increase unit costs (cost per lane-mile), although per capita costs do not necessarily increase if total roadway-miles are reduced
Freight transport management	Car sharing	Smart growth	
Parking management & pricing	Tourist transport management	Car free planning	
Walking & cycling improvements	Non-motorized promotion	Traffic calming	

Cf. Litman, T. (2016).



Exercise for evaluating mobility management strategies

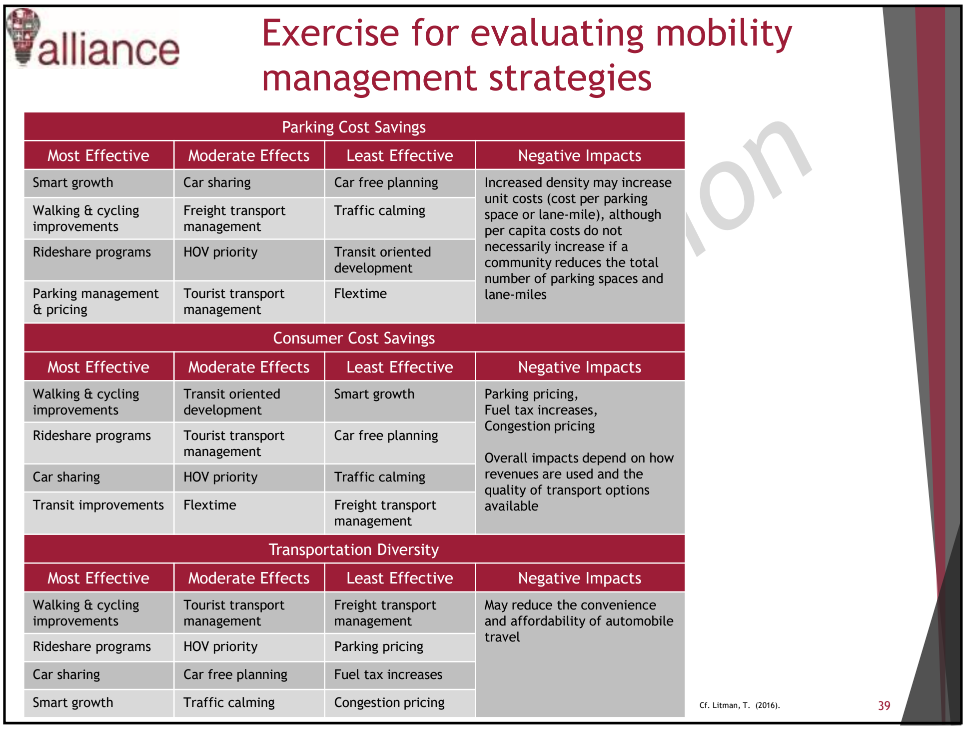
Parking Cost Savings			
Most Effective	Moderate Effects	Least Effective	Negative Impacts

Consumer Cost Savings			
Most Effective	Moderate Effects	Least Effective	Negative Impacts

Transportation Diversity			
Most Effective	Moderate Effects	Least Effective	Negative Impacts

3x Smart growth,
3x Car sharing,
3x Car free planning,
3x Walking & cycling improvements ,
3x Freight transport management,
3x Traffic calming,
3x Rideshare programs,
3x HOV priority,
2x Transit oriented development,
Parking management & pricing,
Parking pricing,
3x Tourist transport management,
2x Flextime,
Fuel tax increases,
Congestion pricing

Cf. Litman, T. (2016).



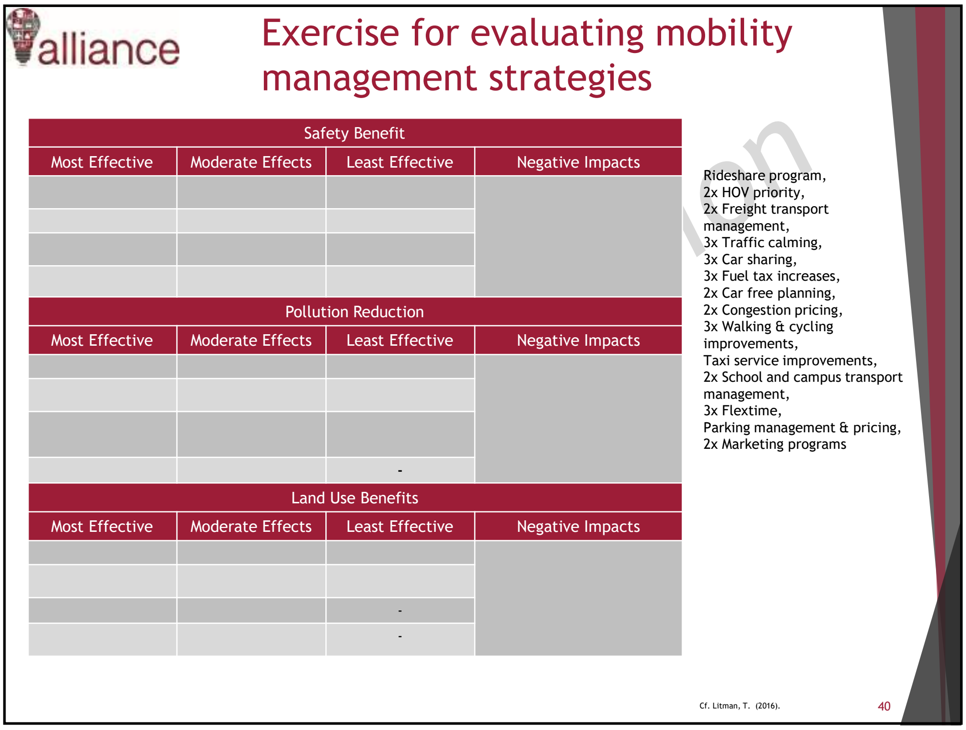
Exercise for evaluating mobility management strategies

Parking Cost Savings			
Most Effective	Moderate Effects	Least Effective	Negative Impacts
Smart growth	Car sharing	Car free planning	Increased density may increase unit costs (cost per parking space or lane-mile), although per capita costs do not necessarily increase if a community reduces the total number of parking spaces and lane-miles
Walking & cycling improvements	Freight transport management	Traffic calming	
Rideshare programs	HOV priority	Transit oriented development	
Parking management & pricing	Tourist transport management	Flextime	

Consumer Cost Savings			
Most Effective	Moderate Effects	Least Effective	Negative Impacts
Walking & cycling improvements	Transit oriented development	Smart growth	Parking pricing, Fuel tax increases, Congestion pricing Overall impacts depend on how revenues are used and the quality of transport options available
Rideshare programs	Tourist transport management	Car free planning	
Car sharing	HOV priority	Traffic calming	
Transit improvements	Flextime	Freight transport management	

Transportation Diversity			
Most Effective	Moderate Effects	Least Effective	Negative Impacts
Walking & cycling improvements	Tourist transport management	Freight transport management	May reduce the convenience and affordability of automobile travel
Rideshare programs	HOV priority	Parking pricing	
Car sharing	Car free planning	Fuel tax increases	
Smart growth	Traffic calming	Congestion pricing	

Cf. Litman, T. (2016).



Exercise for evaluating mobility management strategies

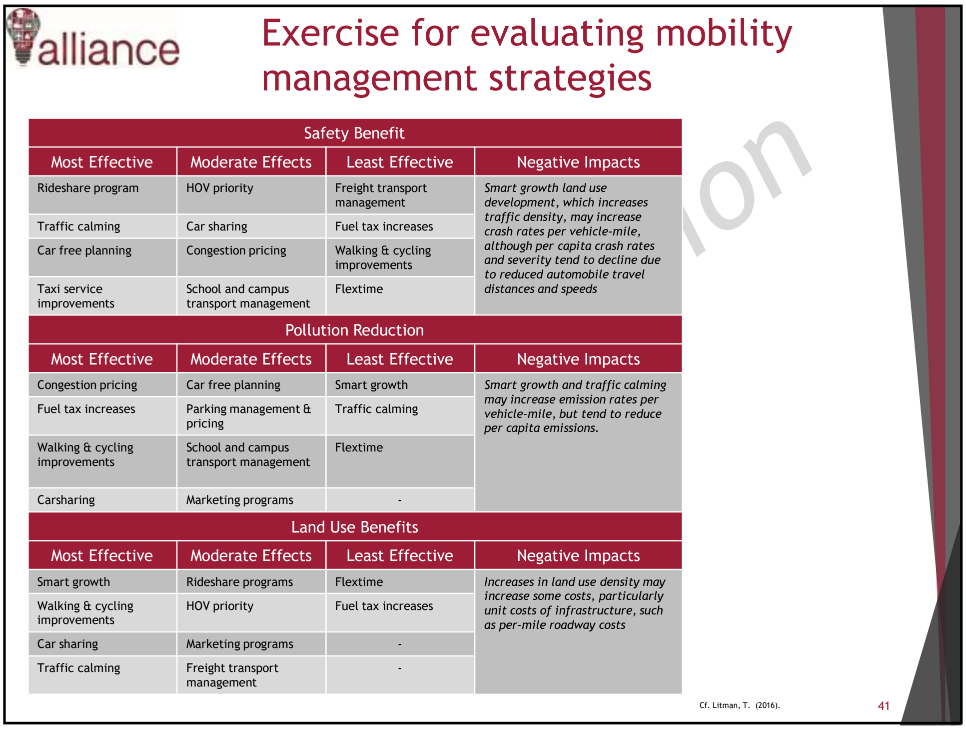
Safety Benefit			
Most Effective	Moderate Effects	Least Effective	Negative Impacts

Pollution Reduction			
Most Effective	Moderate Effects	Least Effective	Negative Impacts
		-	

Land Use Benefits			
Most Effective	Moderate Effects	Least Effective	Negative Impacts
		-	
		-	

Rideshare program,
2x HOV priority,
2x Freight transport management,
3x Traffic calming,
3x Car sharing,
3x Fuel tax increases,
2x Car free planning,
2x Congestion pricing,
3x Walking & cycling improvements,
Taxi service improvements,
2x School and campus transport management,
3x Flextime,
Parking management & pricing,
2x Marketing programs

Cf. Litman, T. (2016).



Exercise for evaluating mobility management strategies

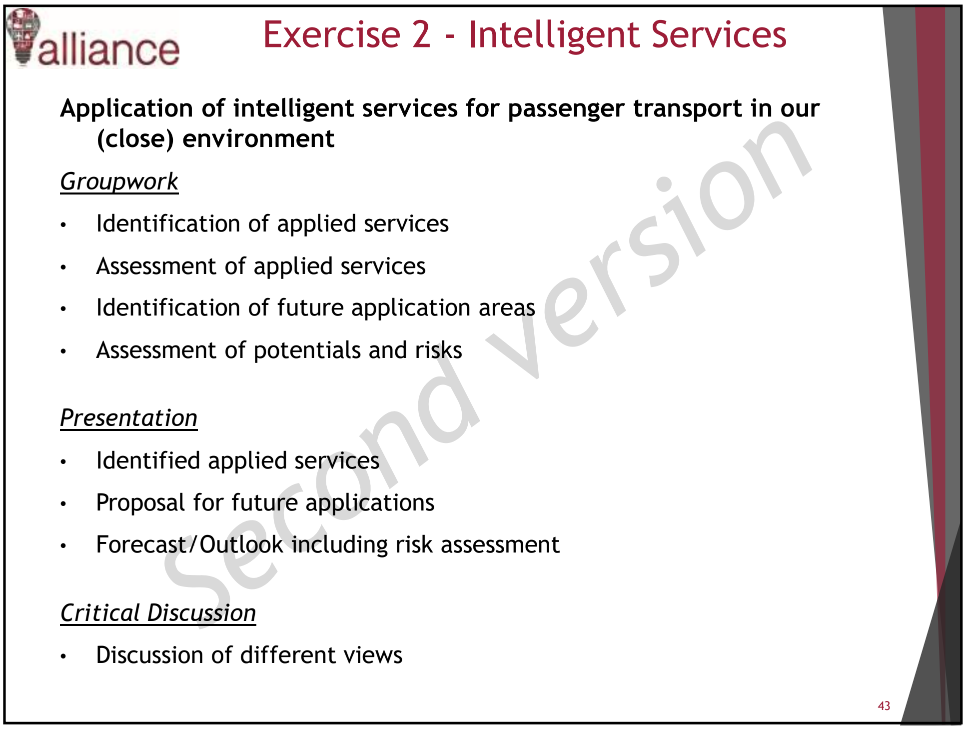
Safety Benefit			
Most Effective	Moderate Effects	Least Effective	Negative Impacts
Rideshare program	HOV priority	Freight transport management	*Smart growth land use development, which increases traffic density, may increase crash rates per vehicle-mile, although per capita crash rates and severity tend to decline due to reduced automobile travel distances and speeds*
Traffic calming	Car sharing	Fuel tax increases	
Car free planning	Congestion pricing	Walking & cycling improvements	
Taxi service improvements	School and campus transport management	Flextime	

Pollution Reduction			
Most Effective	Moderate Effects	Least Effective	Negative Impacts
Congestion pricing	Car free planning	Smart growth	*Smart growth and traffic calming may increase emission rates per vehicle-mile, but tend to reduce per capita emissions.*
Fuel tax increases	Parking management & pricing	Traffic calming	
Walking & cycling improvements	School and campus transport management	Flextime	
Carsharing	Marketing programs	-	

Land Use Benefits			
Most Effective	Moderate Effects	Least Effective	Negative Impacts
Smart growth	Rideshare programs	Flextime	*Increases in land use density may increase some costs, particularly unit costs of infrastructure, such as per-mile roadway costs*
Walking & cycling improvements	HOV priority	Fuel tax increases	
Car sharing	Marketing programs	-	
Traffic calming	Freight transport management	-	

Cf. Litman, T. (2016).

Exercise 2
ITS in our (close) environment



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Exercise 2 - Intelligent Services

Application of intelligent services for passenger transport in our (close) environment

Groupwork

- Identification of applied services
- Assessment of applied services
- Identification of future application areas
- Assessment of potentials and risks

Presentation

- Identified applied services
- Proposal for future applications
- Forecast/Outlook including risk assessment

Critical Discussion

- Discussion of different views

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Guidance to further knowledge acquisition

Suggested literature

- Gnap, J., et al. (n.d.): Improving of information for passengers of urban public transport in Košice, University of Zilina, Faculty of Operation and Economics of Transport and Communications, Department of Road and Urban Transport, available online at: www.southeast-europe.net/document.cmt?id=848 (accessed on 10 Oct. 2016).
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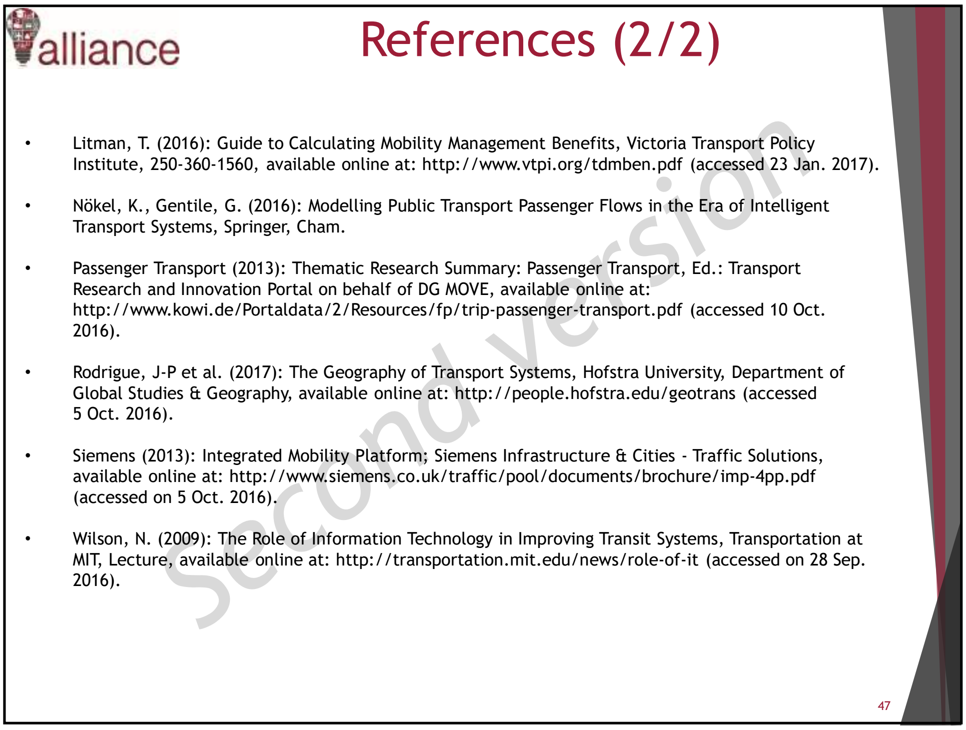

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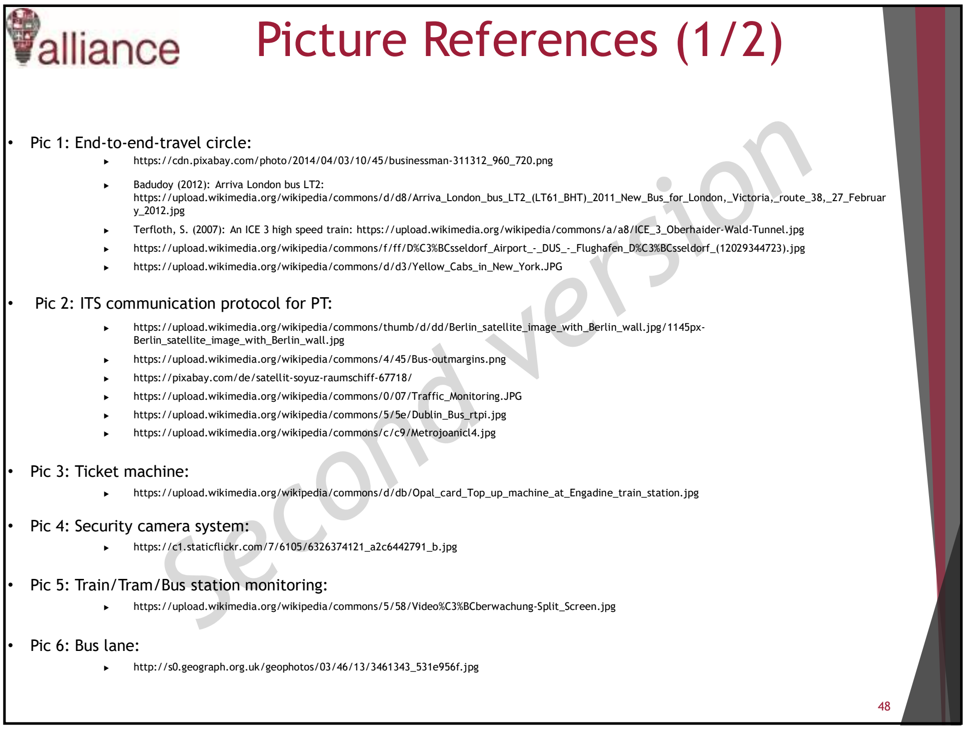

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  - https://upload.wikimedia.org/wikipedia/commons/c/c9/Metrojoanicl4.jpg
- Pic 3: Ticket machine:
  - https://upload.wikimedia.org/wikipedia/commons/d/db/Opal_card_Top_up_machine_at_Engadine_train_station.jpg
- Pic 4: Security camera system:
  - https://c1.staticflickr.com/7/6105/6326374121_a2c6442791_b.jpg
- Pic 5: Train/Tram/Bus station monitoring:
  - https://upload.wikimedia.org/wikipedia/commons/5/58/Video%C3%BCberwachung-Split_Screen.jpg
- Pic 6: Bus lane:
  - http://s0.geograph.org.uk/geophotos/03/46/13/3461343_531e956f.jpg

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- Pic 7: Bus light signal:
    - https://c2.staticflickr.com/4/3373/3491791644_cb7178befc_b.jpg
- Pic 8: Ticket/Smart card validation machine:
    - https://upload.wikimedia.org/wikipedia/commons/c/ca/The_Tide_Light_Rail_-_Ticket_Vending_Machine_TVM.jpg
- Pic 9: On-board smart card system:
    - https://upload.wikimedia.org/wikipedia/commons/d/da/Validateur_Lignes_d'Azur_P1010154.JPG
- Pic 10: On-board smart card system:
    - https://upload.wikimedia.org/wikipedia/commons/6/6f/Validateur_Navigo_Bus-Tram.JPG
- Pic 11: Real-time information panel at a bus stop:
    - https://upload.wikimedia.org/wikipedia/commons/2/29/Purewell_Stony_Lane_bus_stop_Real_Time_information_display.JPG
- Pic 12: Real-time smartphone routing-app:
    - https://c2.staticflickr.com/2/1337/1270723762_7e75937616_b.jpg
- Pic13: Check-in / Check-out:
    - http://www.publicdomainpictures.net/pictures/100000/velka/train-clipart.jpg
    - https://pixabay.com/de/gesch%C3%A4ftsleute-gesch%C3%A4ftsmann-530331/
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    - TDM Promotes efficient street space, Photo from Nordrhein-Westfalen/Germany, In: Broaddus, A. et al. (2009): Transportation Demand Management, Training Document, Division 44, Water, Energy and Transport, Sustainable Urban Transport Project (SUTP), gtz, Federal Ministry for Economic Cooperation and Development, available online at: http://www.sutp.org/files/contents/documents/resources/H_Training-Material/GIZ_SUTP_TM_Transportation-Demand-Management_EN.pdf (accessed 23 Jan. 2017).p.12.

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C7 – Smart Information Technologies in Freight Transport Logistics

Olaf Poenicke
Fraunhofer Institute for Factory Operation and Automation IFF Magdeburg, Germany

Oliver Meier
Otto von Guericke University Magdeburg, Germany

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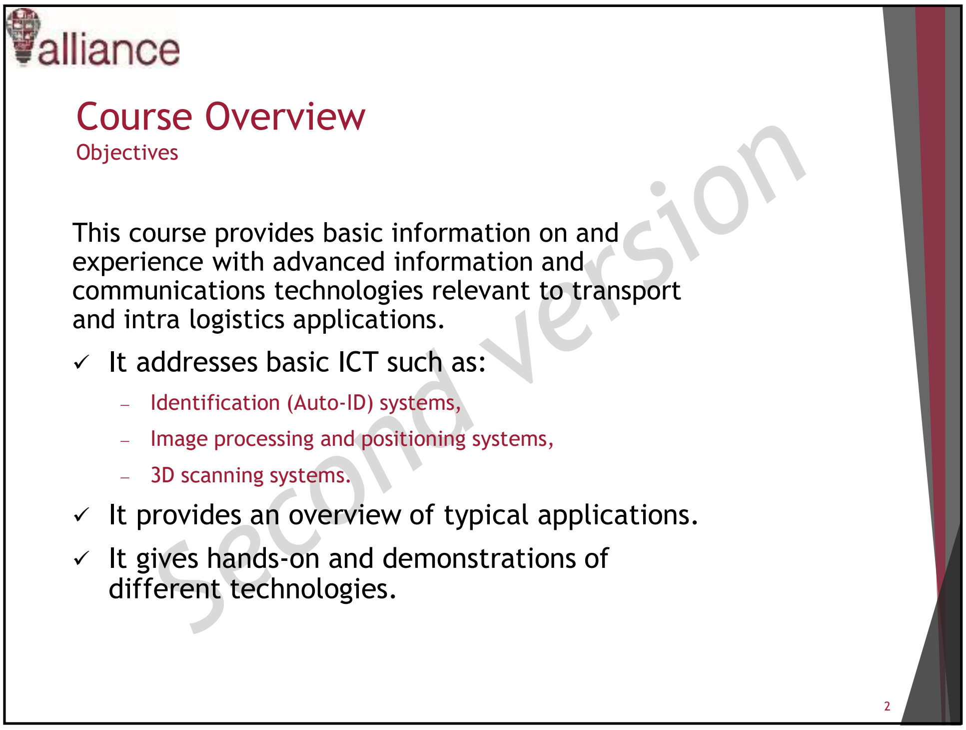

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Course Overview

Objectives

This course provides basic information on and experience with advanced information and communications technologies relevant to transport and intra logistics applications.

- ✓ It addresses basic ICT such as:
  - Identification (Auto-ID) systems,
  - Image processing and positioning systems,
  - 3D scanning systems.
- ✓ It provides an overview of typical applications.
- ✓ It gives hands-on and demonstrations of different technologies.

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Course Overview

Structure

The course is divided into three modules:

Lecture on technology basics and applications

- Information systems
- Auto-ID Technologies
- Image Processing
  - Image based localisation
  - 3D Scanning
- Tracking & Tracing

Hands-on and demonstration

- Hands-on RFID
- Demonstration tracking & tracing
- Demonstration 3D scanning

Questions and Discussion

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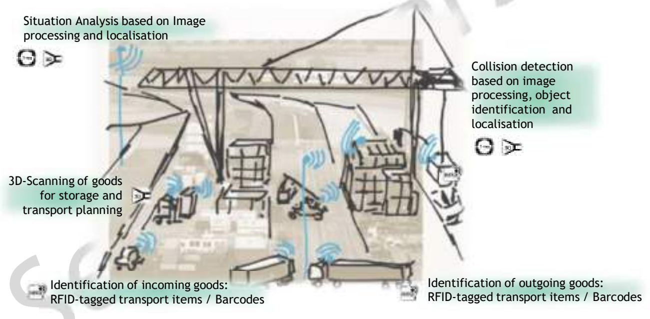
Course Overview

Application fields

The technologies discussed are relevant to the basic logistics processes in transport and intra logistics operation – e.g.:



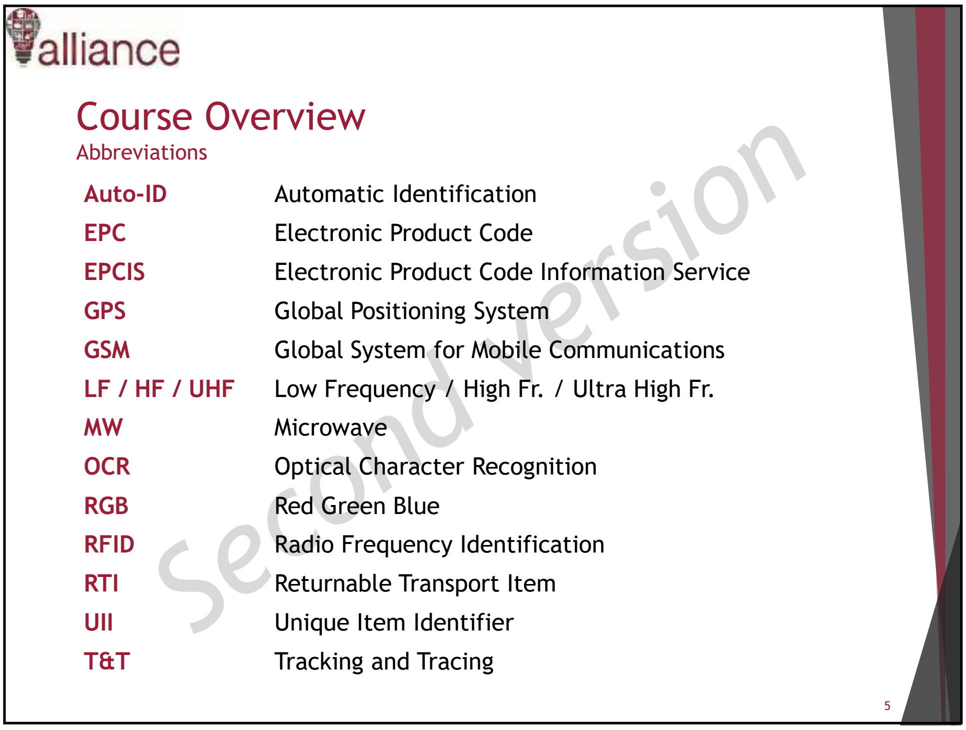
Situation Analysis based on Image processing and localisation

Collision detection based on image processing, object identification and localisation

3D-Scanning of goods for storage and transport planning

Identification of incoming goods: RFID-tagged transport items / Barcodes

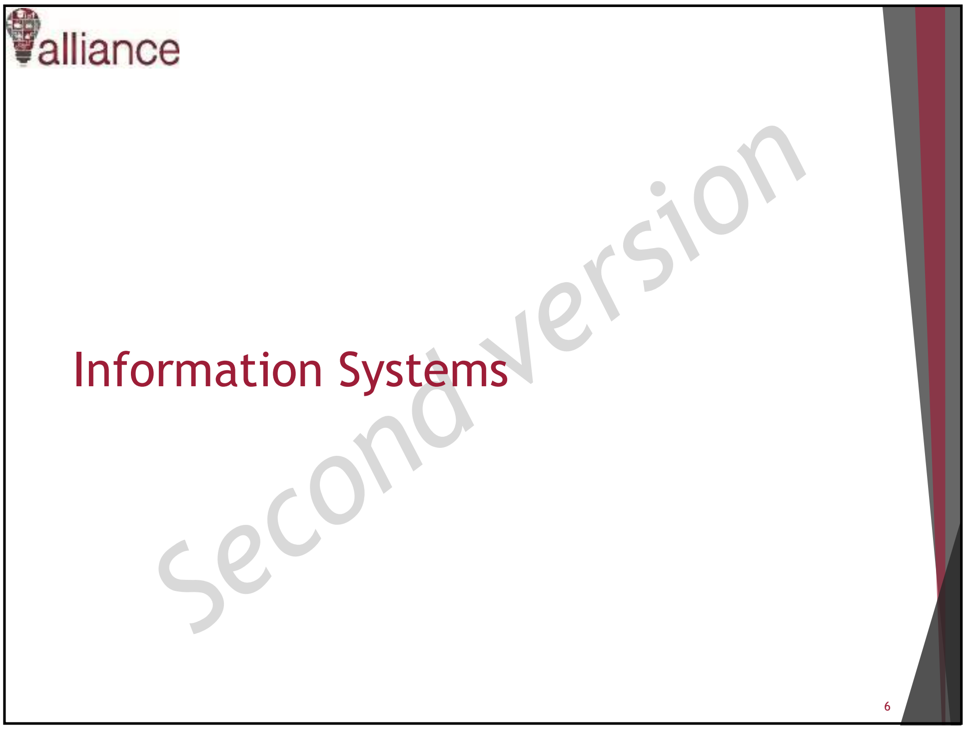
Identification of outgoing goods: RFID-tagged transport items / Barcodes



Course Overview

Abbreviations

Auto-ID	Automatic Identification
EPC	Electronic Product Code
EPCIS	Electronic Product Code Information Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
LF / HF / UHF	Low Frequency / High Fr. / Ultra High Fr.
MW	Microwave
OCR	Optical Character Recognition
RGB	Red Green Blue
RFID	Radio Frequency Identification
RTI	Returnable Transport Item
UII	Unique Item Identifier
T&T	Tracking and Tracing

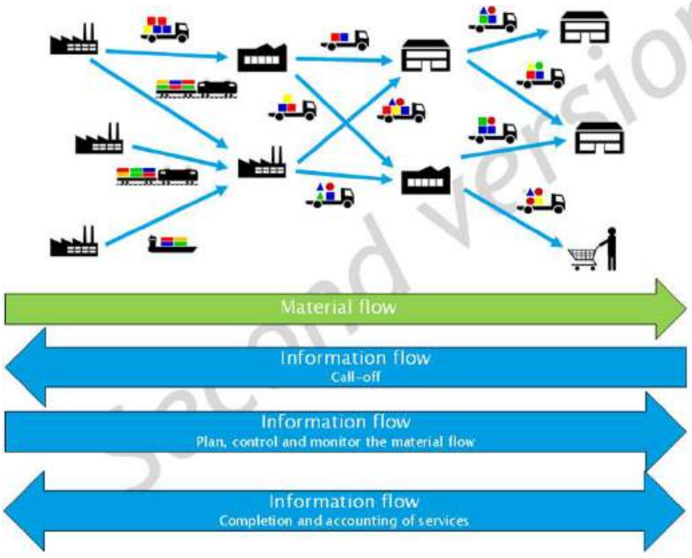


Information Systems

Information systems in intermodal transport

- The information system supports the information flow.
- Subject of operational information systems for intermodal transports is the operational, chronological and quantitative planning, controlling and monitoring of all processes, which are needed for the transport of products and goods.
- These Information systems contains methods, models and software for the planning, controlling, monitoring and accounting of the transport as well as the needed hardware for the data collection, data transmission, data backup, data processing and data output.

Information flows in logistics

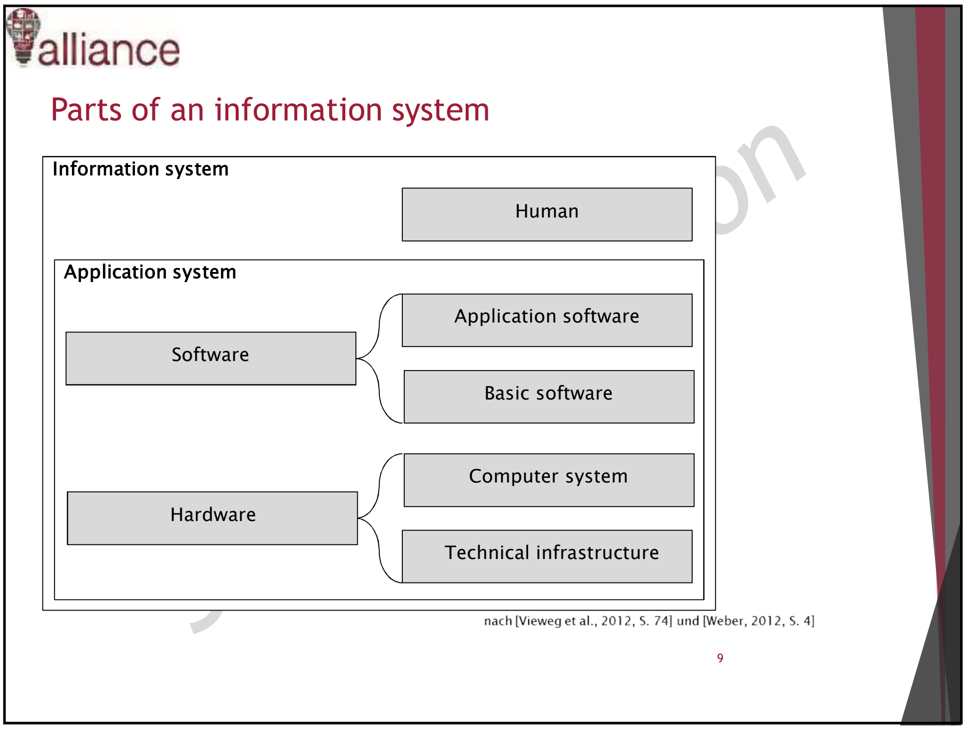

Material flow

Information flow
Call-off

Information flow
Plan, control and monitor the material flow

Information flow
Completion and accounting of services

i. A. a. [Schenk et al. 2015, S. 99]



Parts of an information system

Information system

Human

Application system

Software

Application software

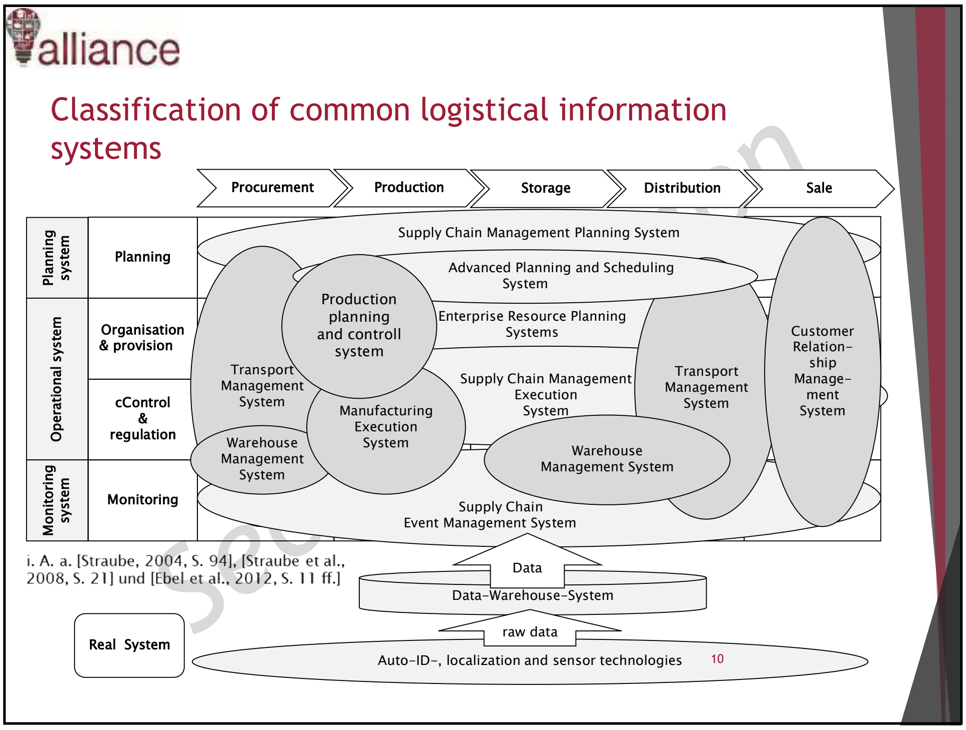
Basic software

Hardware

Computer system

Technical infrastructure

nach [Vieweg et al., 2012, S. 74] und [Weber, 2012, S. 4]



Classification of common logistical information systems

Procurement
Production
Storage
Distribution
Sale

Planning system
Planning

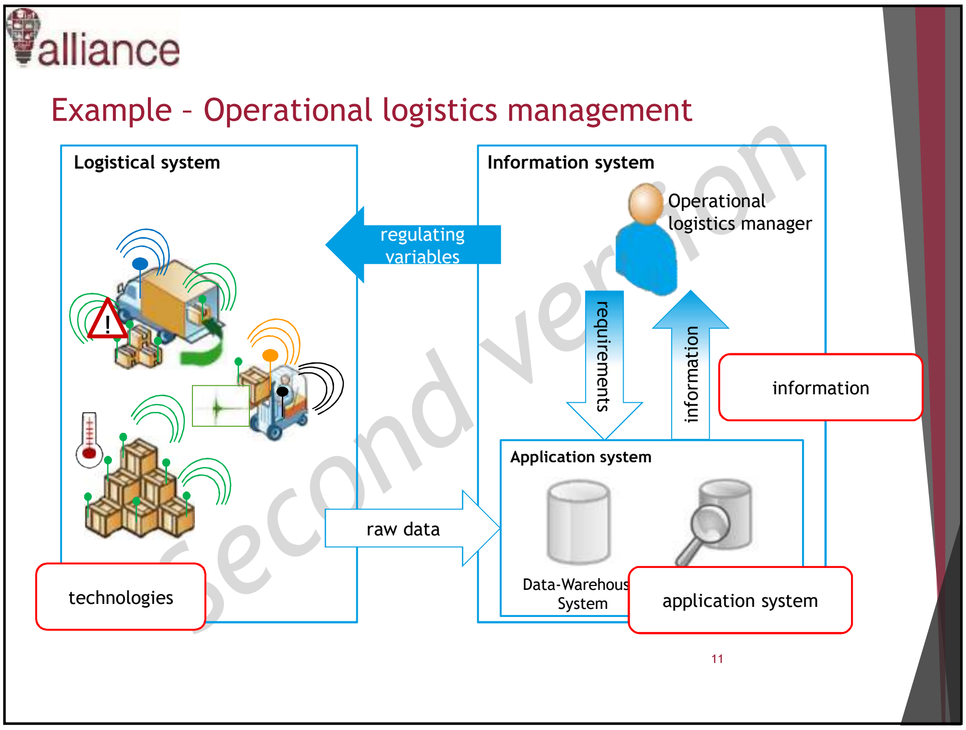
Operational system
Organisation & provision
cControl & regulation

Monitoring system
Monitoring

Supply Chain Management Planning System
Advanced Planning and Scheduling System
Production planning and controll system
Enterprise Resource Planning Systems
Transport Management System
Supply Chain Management Execution System
Manufacturing Execution System
Transport Management System
Customer Relation-ship Manage-ment System
Warehouse Management System
Warehouse Management System
Supply Chain Event Management System

Data
Data-Warehouse-System
raw data
Auto-ID-, localization and sensor technologies
Real System

i. A. a. [Straube, 2004, S. 94], [Straube et al., 2008, S. 21] und [Ebel et al., 2012, S. 11 ff.]



Example – Operational logistics management

Auto-ID Technologies

AUTO-ID Basics

Overview of Auto-ID Technologies

The term automatic identification and data capture or simply automatic identification (**Auto-ID**) refers to methods of identifying objects, capturing and collecting data on them and transmitting that data.

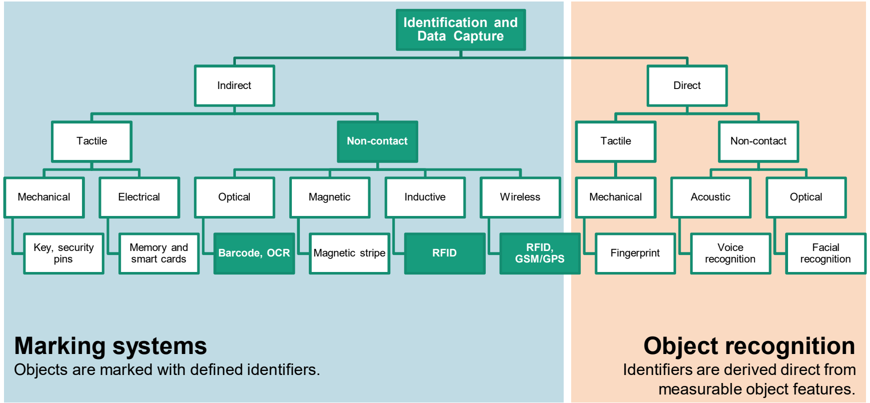
It is primarily used in:

- Retail → product marking
- Manufacturing and logistics → tracking and tracing throughout supply chains → **production - storage - dispatch - delivery**
- Security → access control systems
- Corporate data → industrial data acquisition

Within Logistics operations either the product itself or the transport unit (parcel / pallet / …) is identified by Auto-ID.

AUTO-ID Basics

Overview of Auto-ID Technologies



Identification and Data Capture

- Indirect
  - Tactile
    - Mechanical
      - Key, security pins
    - Electrical
      - Memory and smart cards
  - **Non-contact**
    - Optical
      - **Barcode, OCR**
    - Magnetic
      - Magnetic stripe
    - Inductive
      - **RFID**
    - Wireless
      - **RFID, GSM/GPS**
- Direct
  - Tactile
    - Mechanical
      - Fingerprint
  - Non-contact
    - Acoustic
      - Voice recognition
    - Optical
      - Facial recognition

Marking systems

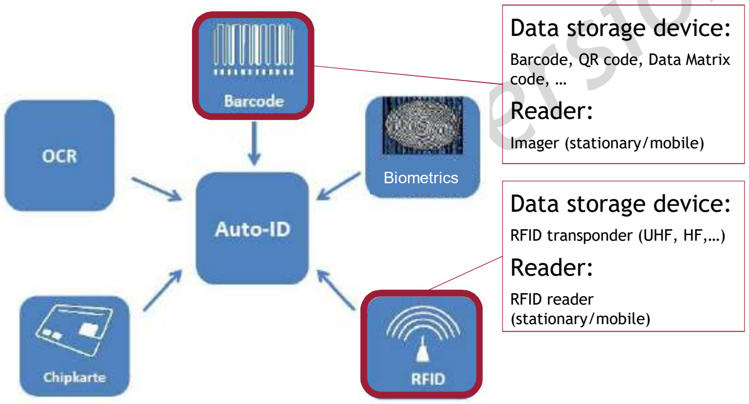
Objects are marked with defined identifiers.

Object recognition

Identifiers are derived direct from measurable object features.

AUTO-ID Basics

Overview of Auto-ID Technologies



Data storage device:
Barcode, QR code, Data Matrix code, …
Reader:
Imager (stationary/mobile)

Data storage device:
RFID transponder (UHF, HF,…)
Reader:
RFID reader (stationary/mobile)

The processing and management of Auto-ID based logistics data are discussed in C7!

AUTO-ID Basics

Optical Auto-ID Systems

Optical Auto-ID systems operate with optical coded markers and corresponding readers (pen reader, laser scanner, camera, etc.). They are based on machine readable codes of digits (and text) in the form of sequences of high-contrast bars (and surfaces) and spaces.

There are different types of optical codes:

1D Codes
- EAN-8-barcode
- EAN-13-barcode
- Code 39
- Code 128
- …

2D Codes
- Data Matrix code
- QR code
- MaxiCode
- Aztec code
- …

"3D Codes"
- High Capacity Color Barcode (HCCB)
- …

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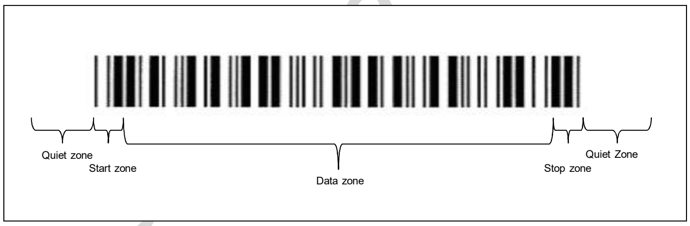
AUTO-ID Basics

Optical Auto-ID Systems

1D and 2D codes consist of black and white that give off different reflections when scanned by a reader, which reads the different arrangements of sections:

- Barcode → width of bars and spaces in a sequence
- 2D code → black and white surface at defined points



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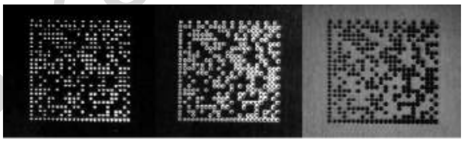
AUTO-ID Basics

Optical Auto-ID Systems

Along with the individual subfields filled in, 2D codes always also have orientation marks used to align the code read by the reader.

Other industrial marking systems have been developed in addition to optical codes printed on paper. To an extent, the lighting has to be right when codes are being read.



AUTO-ID Basics

Optical Auto-ID Systems

The different types of optical codes were developed over time

- to code larger quantities of data and
- to boost robustness against damage and soiling.

		QR Code	DataMatrix	Maxi Code
Type		Matrix	Matrix	Matrix
Data capacity	Numeric	7,089	3,116	138
	Alphanum	4,296	2,355	93
	Binary	2,953	1,556	
Main features		Large capacity, small printout size High speed scan	Small printout size	High speed scan
Standardization		AIM International JIS ISO	AIM International ISO	AIM International ISO

Note:
EAN-13-code codes12 digits (+ 1 check digit)

AUTO-ID Basics

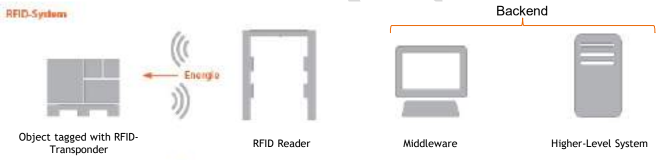
RFID Overview

RFID (radio-frequency identification) is a wireless Auto-ID technology. An RFID system consists of several components:

RFID transponder (tag) → marker on an identified object

Reader (read-write device) with antenna(s) → device that scans and reads one or more transponders

Back end (application/ database) → like barcode, the IT system that uses Auto-ID data



1. RFID Reader emits energy for reading
2. Transponder containing EPC transmits EPC to RFID Reader
3. RFID Reader receives EPC data
4. Middleware receives EPCs and based on logics and filters decides which EPCs are forwarded to the higher-level system
5. EPCs are further processed - e.g. based on business logic steps like good receiving / goods shipping

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AUTO-ID Basics

RFID Overview

Using RFID for wireless transmission of transponder data has advantages over other Auto-ID technologies:

- Data transmission does not require direct or visual contact
- Depending on the frequency range, greater read ranges of >10m are achievable (even >100m for active RFID systems)
- Apart from single reading, several RFID-tagged objects can be scanned (primarily in the UHF range) at the same time, too → bulk reading
- Apart from using it as identification technology, RFID can be combined with other sensor functions → data logger / condition monitoring

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AUTO-ID Basics

RFID Overview

Barcode and RFID Compared

Optical codes und RFID systems have different pros and cons.

These have to be considered in each use case and allowed for when selecting the suitable technology.

Characteristics	**Barcode**		**RFID**	
	1D-Code	2D-Code	active	passive
transmission	optical		electromagnetic	
data capacity	very low	low	high	
line of sight	required		not required	
shape and size	fixed		flexible	
critical environ-mental factors	dirt, humidity, high temperature		metal, liquids, very high temperature	
reading rates	low	medium	high	
data security	very low	low	very high	
information	static		dynamic (read + write)	
costs for identifier	very low		very high	high
costs for readers	comparable			
bulk reading	not possible		possible	
reading distance	low (few cm)		very high (>> 10m possible)	high (up to 10m)
security against counterfeiting	low		high	
level of industrial use	very high	medium	low	

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AUTO-ID Basics

Types of RFID technology

Transponders, a word conflating transmitter and responder, are used as identifiers on identified objects.

A transponder consists of:

- a microchip → data storage
- an antenna
- a protective housing

Transponders primarily differ in terms of the frequency range they use and their power supplies. Moreover, designs vary greatly depending on usage and requirements.

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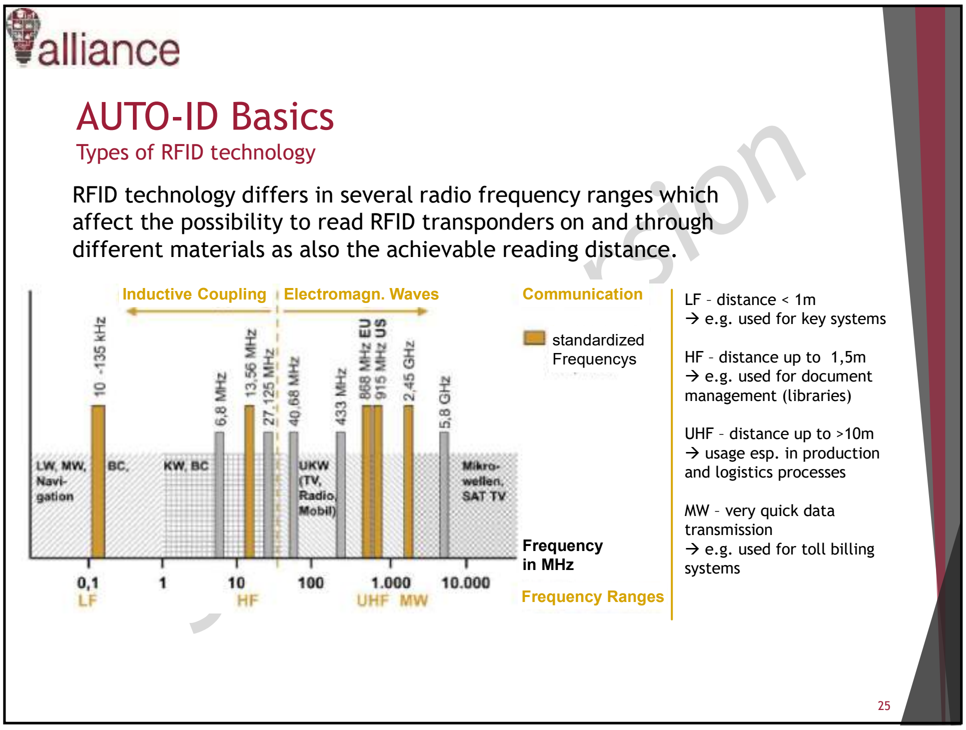
AUTO-ID Basics

Types of RFID technology

Transponders have three modes of operation that support different uses:

- Passive transponders
  - Transponder without internal power supply
  - Power from the electromagnetic field of the reader’s antenna is used for data processing and transmission
  - → Primarily used for object marking und event-driven identification
- Semi-active transponders
  - Internal power is used to process data processing (partly also for sensors)
  - Power for data transmission is taken from the antenna field
  - → Used, for instance, for data loggers shipped with freight
- Active transponders
  - All power for data processing and transmission is taken from the internal power supply
  - → Used, for instance, for continuous localization of equipment in a defined setting



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AUTO-ID Basics

Types of RFID technology

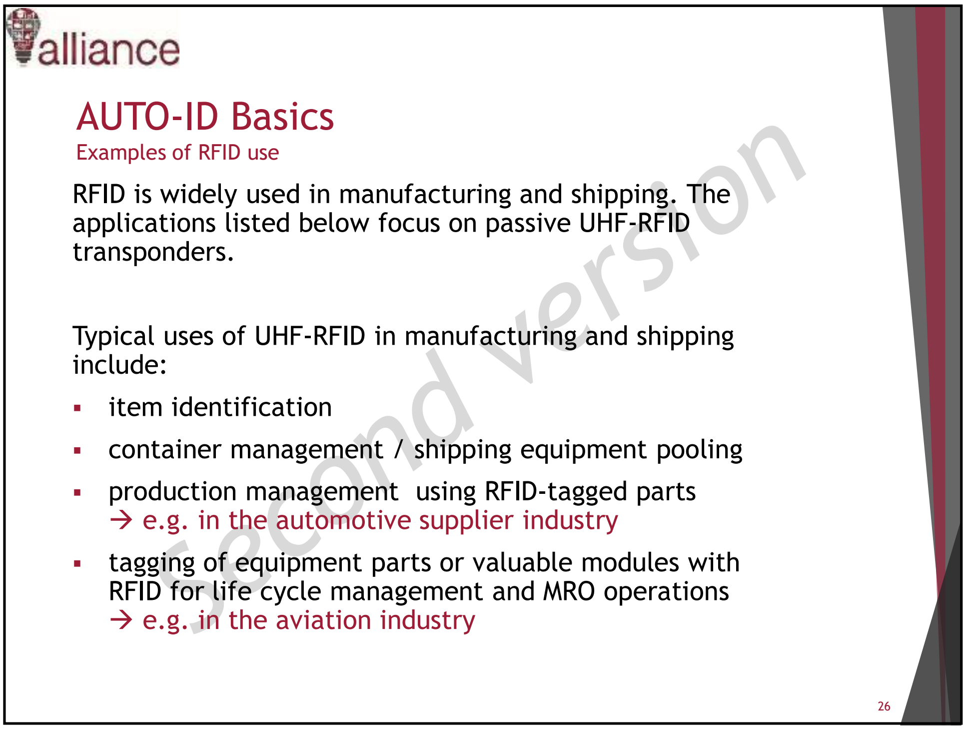
RFID technology differs in several radio frequency ranges which affect the possibility to read RFID transponders on and through different materials as also the achievable reading distance.

LF - distance < 1m
→ e.g. used for key systems

HF - distance up to 1,5m
→ e.g. used for document management (libraries)

UHF - distance up to >10m
→ usage esp. in production and logistics processes

MW - very quick data transmission
→ e.g. used for toll billing systems



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AUTO-ID Basics

Examples of RFID use

RFID is widely used in manufacturing and shipping. The applications listed below focus on passive UHF-RFID transponders.

Typical uses of UHF-RFID in manufacturing and shipping include:

- item identification
- container management / shipping equipment pooling
- production management using RFID-tagged parts
  → e.g. in the automotive supplier industry
- tagging of equipment parts or valuable modules with RFID for life cycle management and MRO operations
  → e.g. in the aviation industry

AUTO-ID Basics

Examples of RFID use

RFID is used extensively in retail to

- identify items (e.g. apparel industry)
- track items throughout the supply chain
- surveil items in shops (also UHF-RFID)
- Pool containers and other shipping equipment

Identification on item and shipping level in goods receiving / storage / dispatch.

RFID tags in garments from GERRY WEBER

Scanning items tagged with RFID in so-called RFID Tunnel Gates

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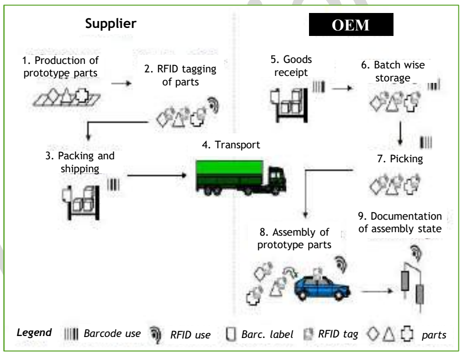
AUTO-ID Basics

Examples of RFID use

One example of use is prototyping in the automotive industry:

- Control of the complexity of varying parts
- Early incorporation of RFID in the design phase
- Parallel testing of durability and readability of RFID tags during trials



→ The goal is widespread use RFID in automotive mass production.

AUTO-ID Basics

Examples of RFID use

The tracking and tracing von RTIs is an important use in the shipping industry:

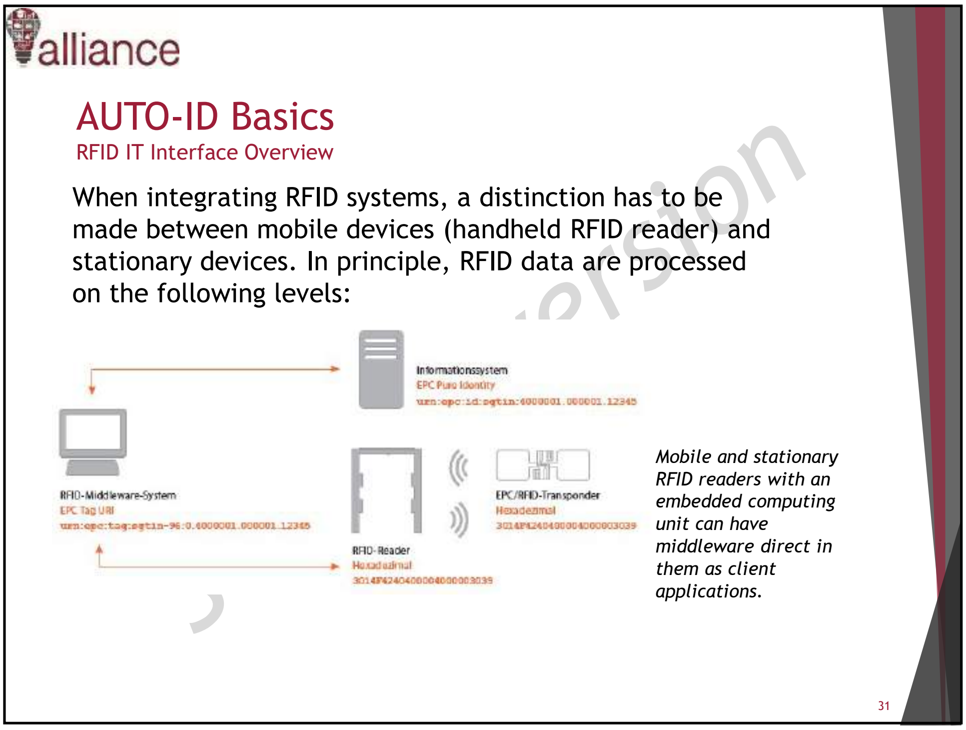
- Shipping equipment is tagged with
  - in retail (e.g. Düsseldorfer Paletten)
  - in automotive manufacturing
- Industry-specific data are used in part as identifiers RTIs (e.g. VDA standard)
- VDA is overseeing development of new generations of small containers (KLT) with integrated RFID
  - → Over 100 mill. KLTs are in circulation
  - → New generation of KLTs in 2017

AUTO-ID Basics

RFID Hardware Overview

Based on the application and the application’s environment the selection of the best fitting RFID hardware is immanent!

- The RFID processes need to be defined and tested □ feasibility
- RFID transponders need to be selected (active / passive; smart label / hard tag / flag tag / …)
- The reader hardware needs to be selected (stationary / mobile; antenna characteristics and orientation)
- IT integration of RFID systems (interfaces)



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AUTO-ID Basics

RFID IT Interface Overview

When integrating RFID systems, a distinction has to be made between mobile devices (handheld RFID reader) and stationary devices. In principle, RFID data are processed on the following levels:

Mobile and stationary RFID readers with an embedded computing unit can have middleware direct in them as client applications.

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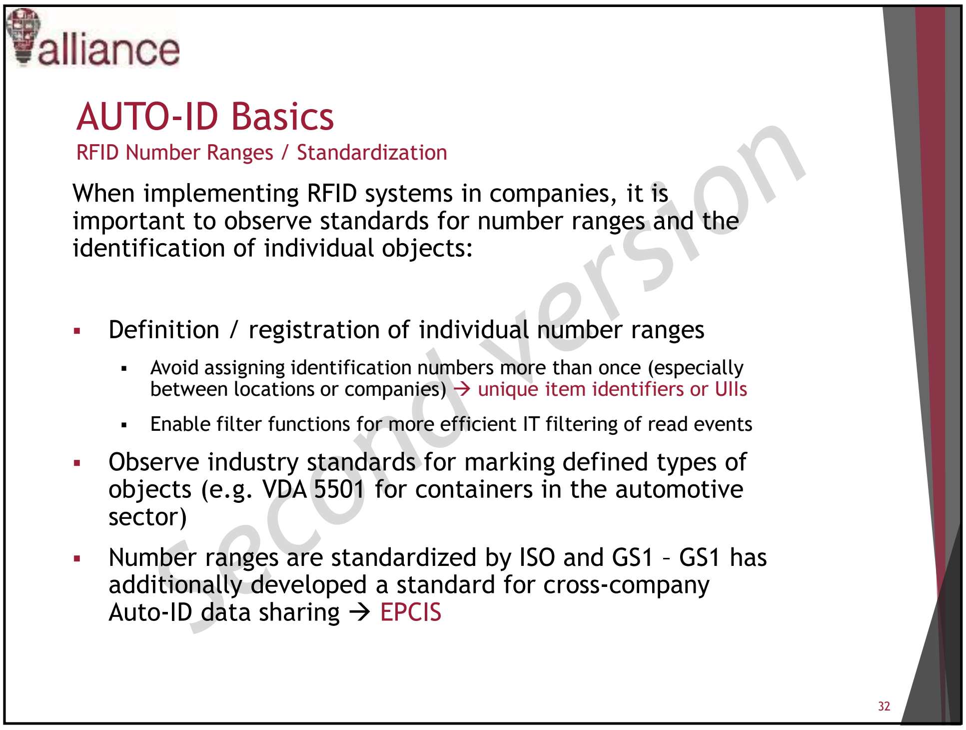

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AUTO-ID Basics

RFID Number Ranges / Standardization

When implementing RFID systems in companies, it is important to observe standards for number ranges and the identification of individual objects:

- Definition / registration of individual number ranges
    - Avoid assigning identification numbers more than once (especially between locations or companies) → unique item identifiers or UIIs
    - Enable filter functions for more efficient IT filtering of read events
- Observe industry standards for marking defined types of objects (e.g. VDA 5501 for containers in the automotive sector)
- Number ranges are standardized by ISO and GS1 – GS1 has additionally developed a standard for cross-company Auto-ID data sharing → EPCIS

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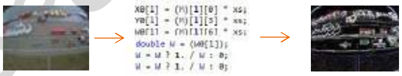
Image Processing

Image Processing

Introduction

Image processing is the generation, transmission and analysis of images in order to extract information on concrete objects.

Image processing is the processing of images.



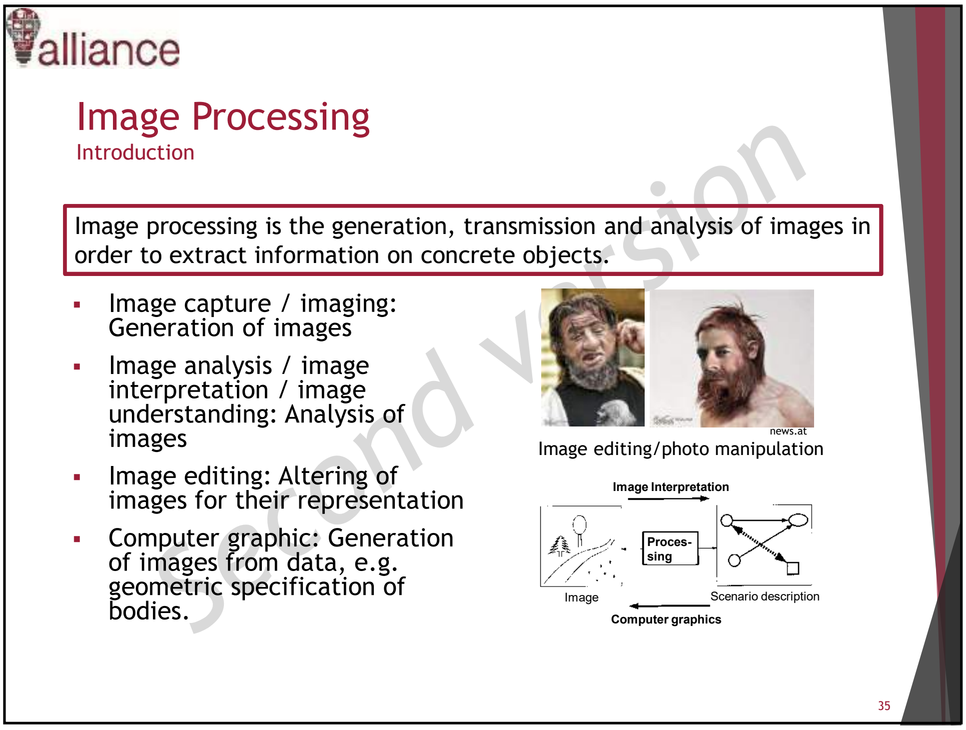


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Image Processing

Introduction

Image processing is the generation, transmission and analysis of images in order to extract information on concrete objects.

- Image capture / imaging: Generation of images
- Image analysis / image interpretation / image understanding: Analysis of images
- Image editing: Altering of images for their representation
- Computer graphic: Generation of images from data, e.g. geometric specification of bodies.

news.at

Image editing/photo manipulation

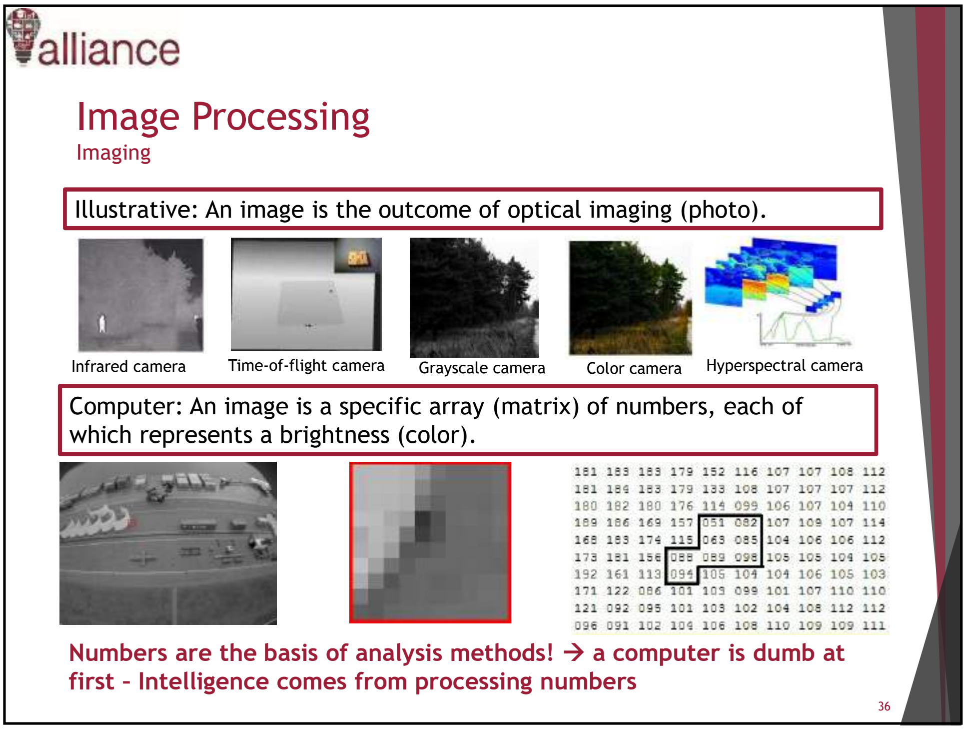

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Image Processing

Imaging

Illustrative: An image is the outcome of optical imaging (photo).

Infrared camera

Time-of-flight camera

Grayscale camera

Color camera

Hyperspectral camera

Computer: An image is a specific array (matrix) of numbers, each of which represents a brightness (color).

181	183	183	179	152	116	107	107	108	112
181	184	183	179	133	108	107	107	107	112
180	182	180	176	114	099	106	107	104	110
189	186	169	157	051	082	107	109	107	114
168	183	174	115	063	085	104	106	106	112
173	181	156	088	089	098	105	105	104	105
192	161	113	094	105	104	104	106	105	103
171	122	086	101	103	099	101	107	110	110
121	092	095	101	103	102	104	108	112	112
096	091	102	104	106	108	110	109	109	111

Numbers are the basis of analysis methods! → a computer is dumb at first - Intelligence comes from processing numbers

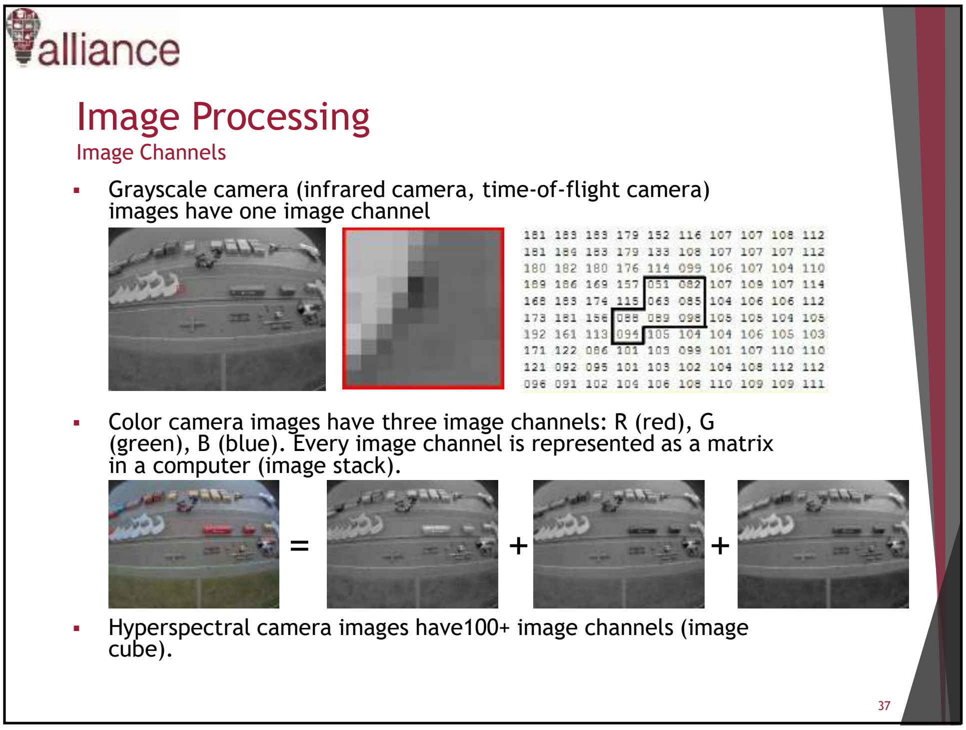

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Image Processing

Image Channels

- Grayscale camera (infrared camera, time-of-flight camera) images have one image channel

181	183	183	179	152	116	107	107	108	112
181	184	183	179	133	108	107	107	107	112
180	182	180	176	114	099	106	107	104	110
189	186	169	157	051	082	107	109	107	114
168	183	174	115	063	085	104	106	106	112
173	181	156	088	089	098	105	105	104	105
192	161	113	094	105	104	104	106	105	103
171	122	086	101	103	099	101	107	110	110
121	092	095	101	103	102	104	108	112	112
096	091	102	104	106	108	110	109	109	111

- Color camera images have three image channels: R (red), G (green), B (blue). Every image channel is represented as a matrix in a computer (image stack).

= + +

- Hyperspectral camera images have100+ image channels (image cube).

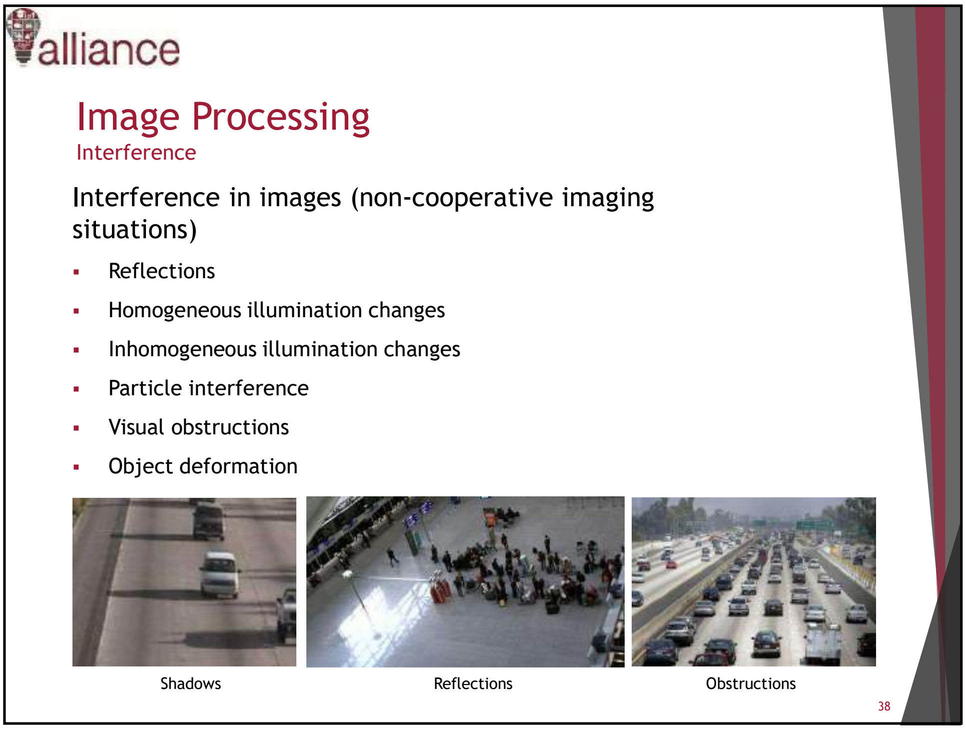

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Image Processing

Interference

Interference in images (non-cooperative imaging situations)

- Reflections
- Homogeneous illumination changes
- Inhomogeneous illumination changes
- Particle interference
- Visual obstructions
- Object deformation

Shadows Reflections Obstructions

Image Processing

Practical Relevance for Logistics Applications

Image Processing is a basic technical principle which is used in various Logistics Applications – such as:

- Identification of vehicles (OCR-based)
- Identification of products and other objects (Barcode, 2D-codes)
- Classification of vehicles and other objects
- Localization of vehicles and other objects
- Monitoring of spatial areas (e.g. occupation of storage areas)
- 3D imaging as emerging technology for logistics applications

OCR-based number plate recognition

Marker-based localization

3D-imaging for dimensioning

Application of Image Processing in Logistics

Image-Based Localization

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Image-Based Localization

Introduction

- Logistical background
  - Chaotic warehousing: Shipping units are stored in the most convenient storage bin (no assigned locations)
  - Maintenance: Forklifts have to be serviced periodically (operating time)
  - → Focus on warehousing operations → storage / removal
- Technical and environmental conditions
  - Storage facilities are mostly indoors (weatherproof storage)
  - The absolute accuracy required is between 25cm to several meters
  - Metallic environment with moving metal bodies such as forklifts, cranes or coils
  - Device frequently cannot be mounted on forklifts because they are rental vehicles
- Image-based solution: Vehicle Positioning System
  - Passive planar image markers atop vehicles
  - Cameras on the ceiling

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Image-Based Localization

Introduction

Camera on vehicle	Camera to vehicle
Advantages – Cost efficient if only a few vehicles are located in a particular area – Only a small amount of data has to be sent through the network	**Advantages** – No electronic devices on vehicles – Cost efficient if many vehicles are located in a particular area – Combinable with other image processing systems (documentation, visualization, object detection)
Disadvantages – Electronic devices on vehicle – Not combinable with other image processing systems (documentation, visualization, object detection)	**Disadvantages** – Not cost efficient if only a few vehicles are located in a particular area – A large amount of data has to be sent through the network

After weighing all of the pros and cons, the decision was made to implement a **camera-to-vehicle** system.

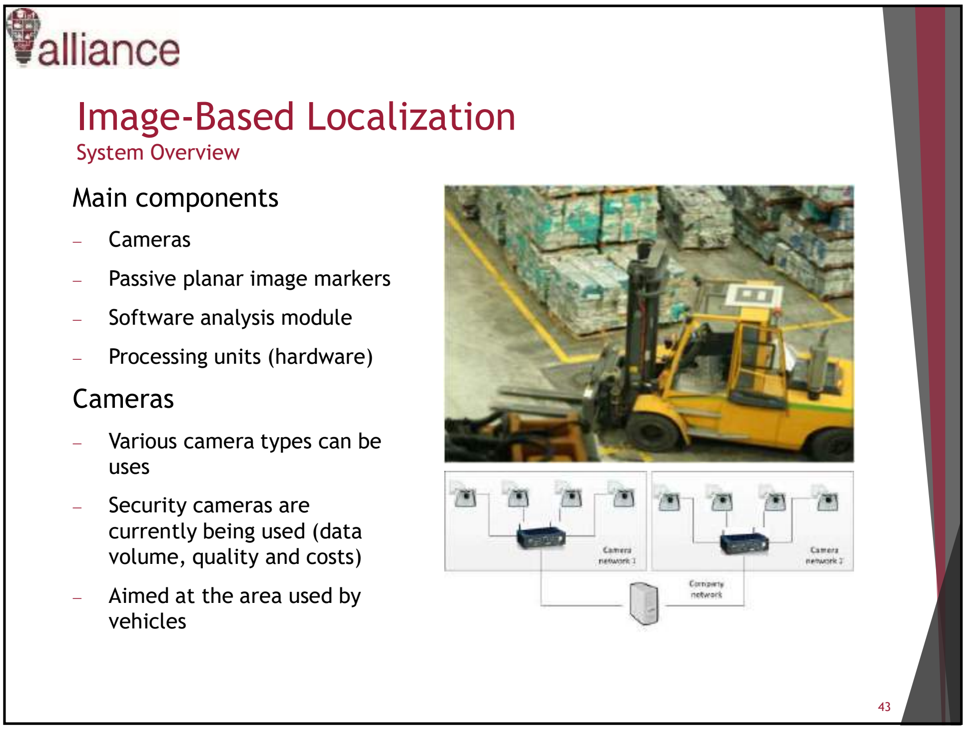


Image-Based Localization

System Overview

Main components

- Cameras
- Passive planar image markers
- Software analysis module
- Processing units (hardware)

Cameras

- Various camera types can be uses
- Security cameras are currently being used (data volume, quality and costs)
- Aimed at the area used by vehicles

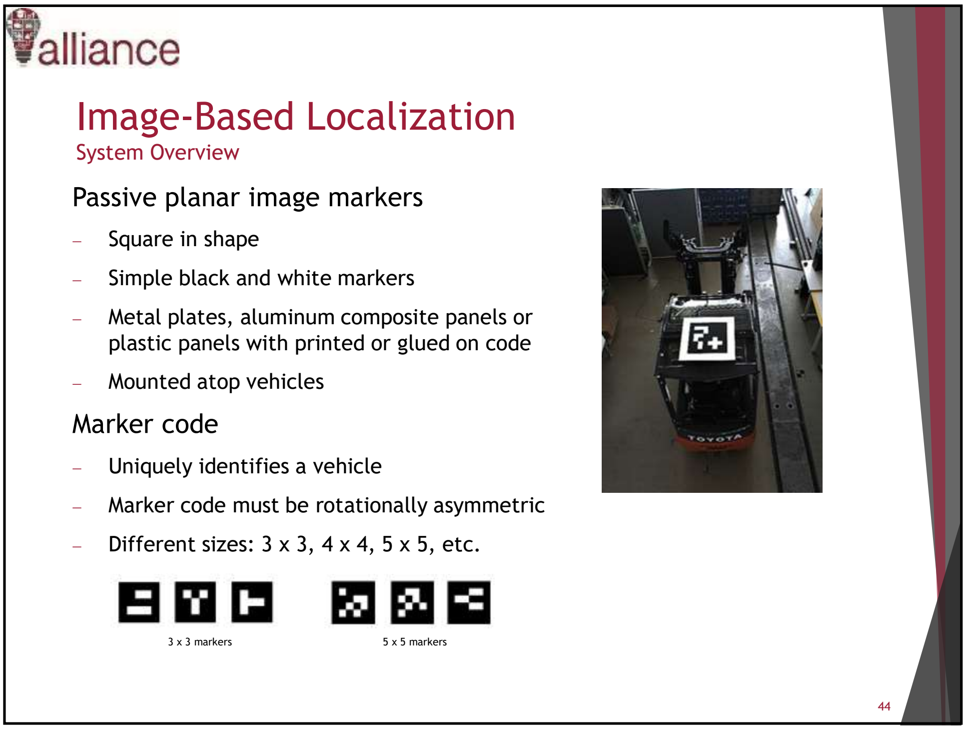


Image-Based Localization

System Overview

Passive planar image markers

- Square in shape
- Simple black and white markers
- Metal plates, aluminum composite panels or plastic panels with printed or glued on code
- Mounted atop vehicles

Marker code

- Uniquely identifies a vehicle
- Marker code must be rotationally asymmetric
- Different sizes: 3 x 3, 4 x 4, 5 x 5, etc.

Image-Based Localization

Marker Recognition

- Marker recognition entails searching top-view images for markers.
- Static marker recognition
  - Finds markers in well-defined zones, e.g. entrances, exits, or other critical points
- Dynamic marker recognition
  - Finds any undetected markers in zones, which, rather than being known a priori are predicted continuously based on a vehicle's trajectory
- Advantages
  - Reduction of false positives in hard-to-read zones
  - Increase in the detection rate of true positives in hard-to-read zones
  - Performance

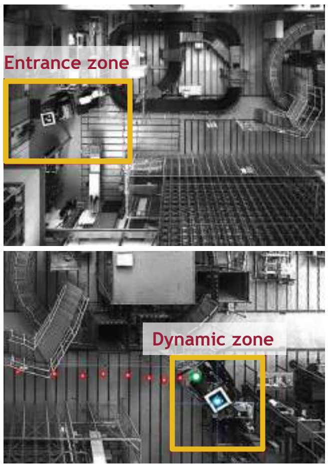
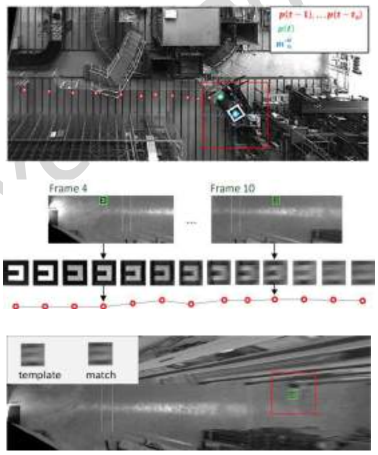


Image-Based Localization

Marker Recognition

- Goal
  - To find markers in dynamic zones
- Search zone definition
  - Tracking and trajectory generation for every vehicle
  - Prediction of vehicle position
  - Calculation of marker position in image
  - Searching of zone inside the quadrangle
- Recognition
  - The static method (masking, thresholding, filtering, etc.) is applied to dynamic search zones
  - Template matching

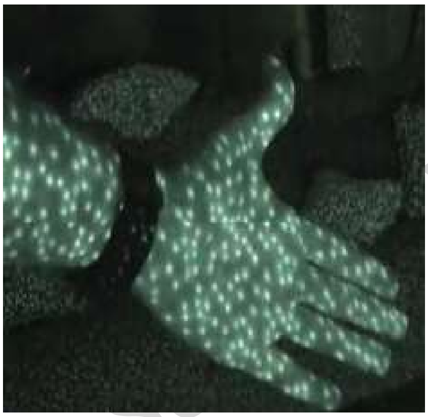


Application of Image Processing in Logistics

3D Scanning

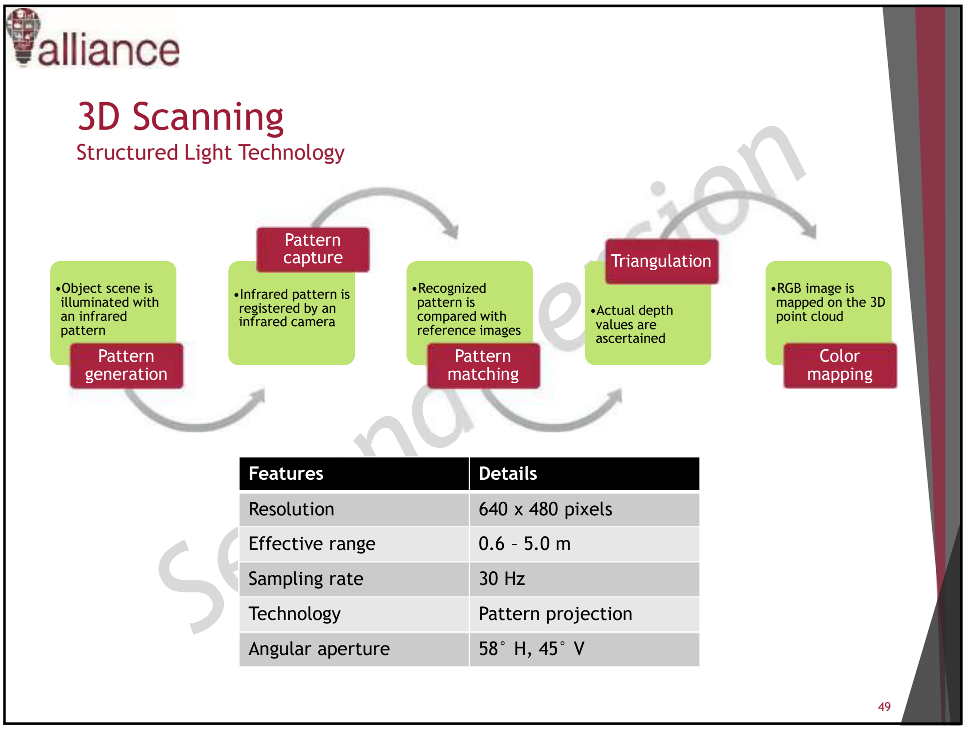
3D Scanning

Structured Light Technology



The Underlying Principle
3D Deep Scanning:
Structured Light

- A projector and a camera are needed to generate 3D surface structures. The projector generates a point matrix in a defined space. The camera analyzes the projected point matrix, calculating the coordinates in the space.
- The camera takes color 2D pictures. Generated structures can also be filled with texture.



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3D Scanning

Structured Light Technology

Pattern generation
- Object scene is illuminated with an infrared pattern

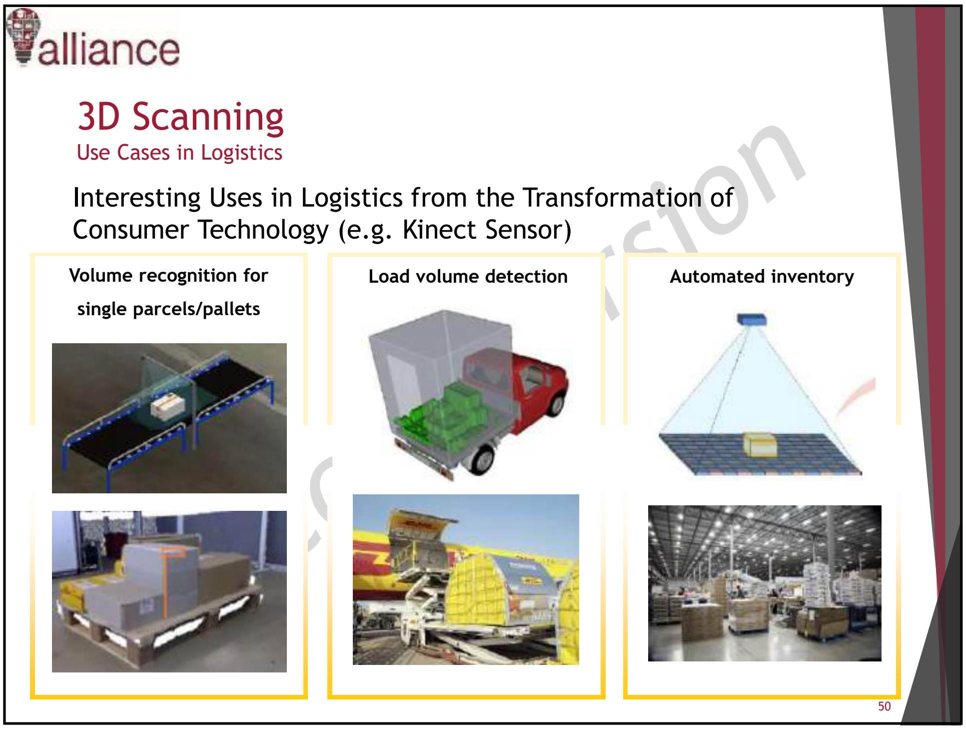
Pattern capture
- Infrared pattern is registered by an infrared camera

Pattern matching
- Recognized pattern is compared with reference images

Triangulation
- Actual depth values are ascertained

Color mapping
- RGB image is mapped on the 3D point cloud

Features	Details
Resolution	640 x 480 pixels
Effective range	0.6 – 5.0 m
Sampling rate	30 Hz
Technology	Pattern projection
Angular aperture	58° H, 45° V



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3D Scanning

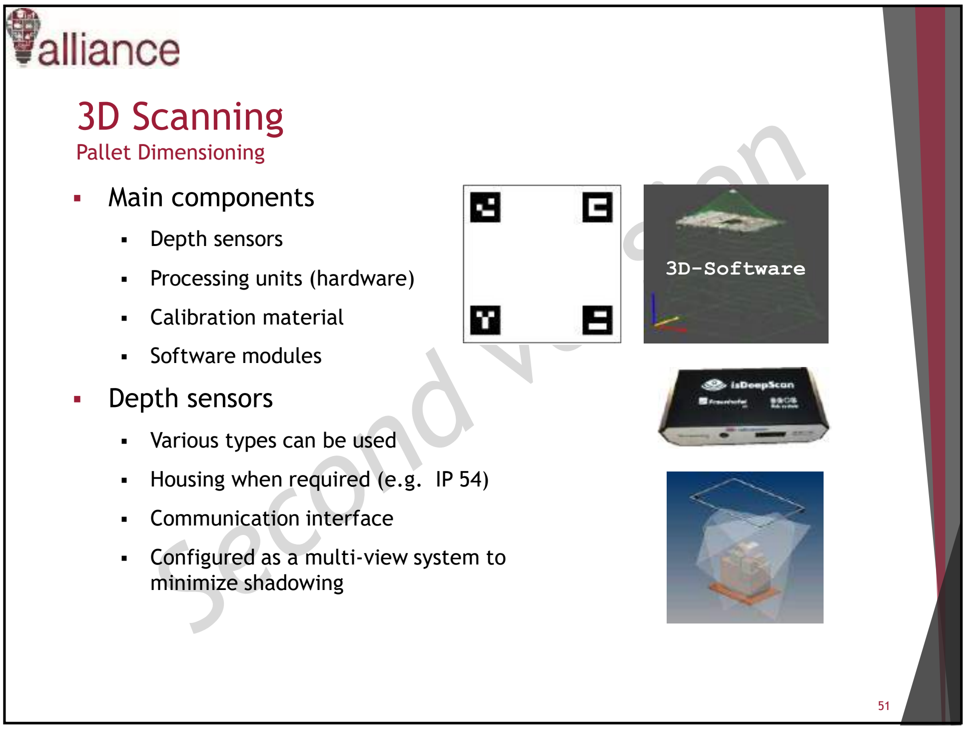
Use Cases in Logistics

Interesting Uses in Logistics from the Transformation of Consumer Technology (e.g. Kinect Sensor)

Volume recognition for single parcels/pallets

Load volume detection

Automated inventory



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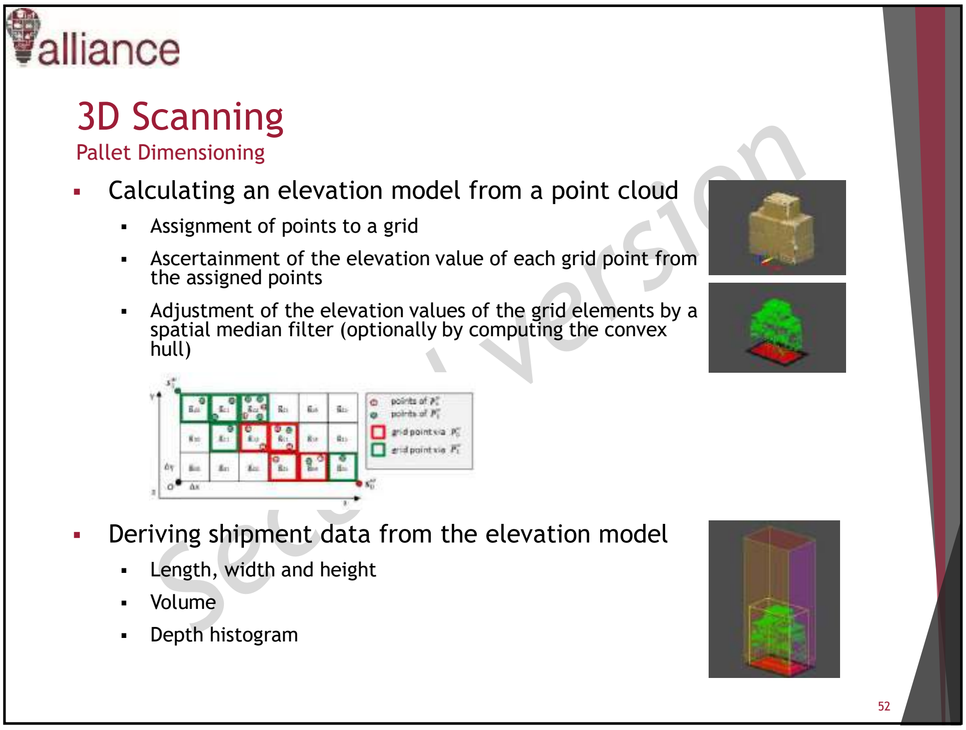
3D Scanning

Pallet Dimensioning

- Main components
  - Depth sensors
  - Processing units (hardware)
  - Calibration material
  - Software modules
- Depth sensors
  - Various types can be used
  - Housing when required (e.g. IP 54)
  - Communication interface
  - Configured as a multi-view system to minimize shadowing



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3D Scanning

Pallet Dimensioning

- Calculating an elevation model from a point cloud
  - Assignment of points to a grid
  - Ascertainment of the elevation value of each grid point from the assigned points
  - Adjustment of the elevation values of the grid elements by a spatial median filter (optionally by computing the convex hull)
- Deriving shipment data from the elevation model
  - Length, width and height
  - Volume
  - Depth histogram

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Tracking & Tracing

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Tracking and Tracing

The tracking and tracing concept:

“Tracking” concerns the continuous electronic monitoring of shipments. “Tracing” denotes the storing of data recorded during tracking.

Process organization	Process step-based	Continuous
Types of T&T	Active	Passive

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Tracking and Tracing – Process step based

In a typical groupage service network, the following statuses can be identified:

S1: Pick-up of goods at sender (pre-carriage)

S2: Arrival of goods at consolidation point; dispatch for long-distance travel

S3: Loading for long-distance travel

S4: Arrival of goods at deconsolidation point; dispatch for short-distance travel

S5: Loading for short-distance travel

S6: Deliver goods to recipient (on-haulage)

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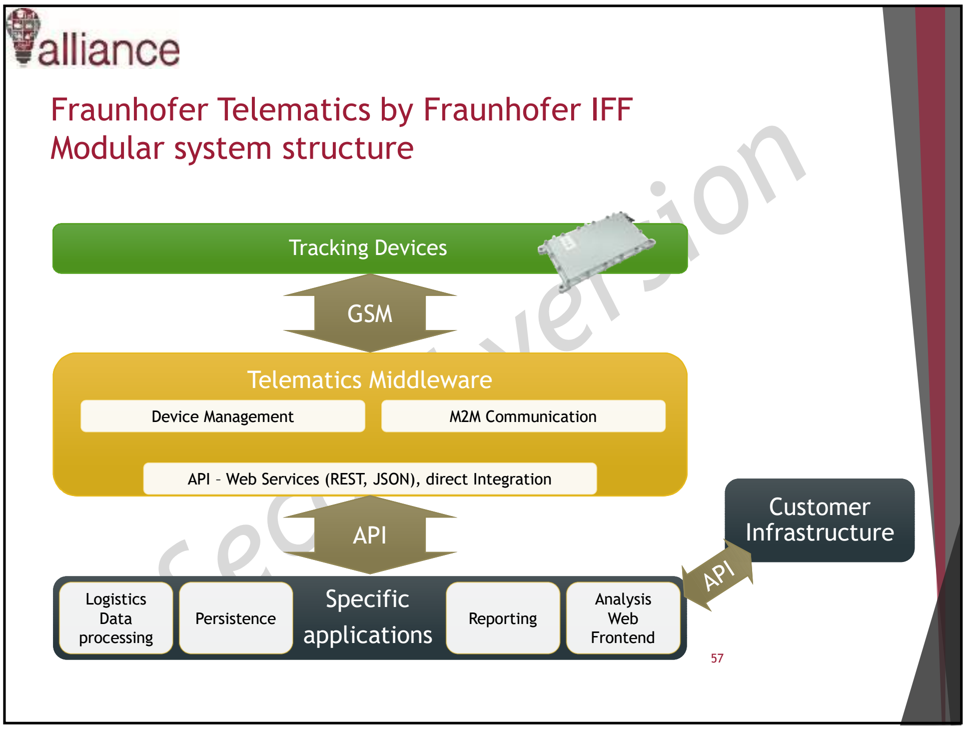
Fraunhofer Telematics

by

Fraunhofer Institute for Factory Operation and Automation IFF



Fraunhofer Telematics by Fraunhofer IFF
Modular system structure

Tracking Devices

GSM

Telematics Middleware

Device Management

M2M Communication

API – Web Services (REST, JSON), direct Integration

API

Customer Infrastructure

API

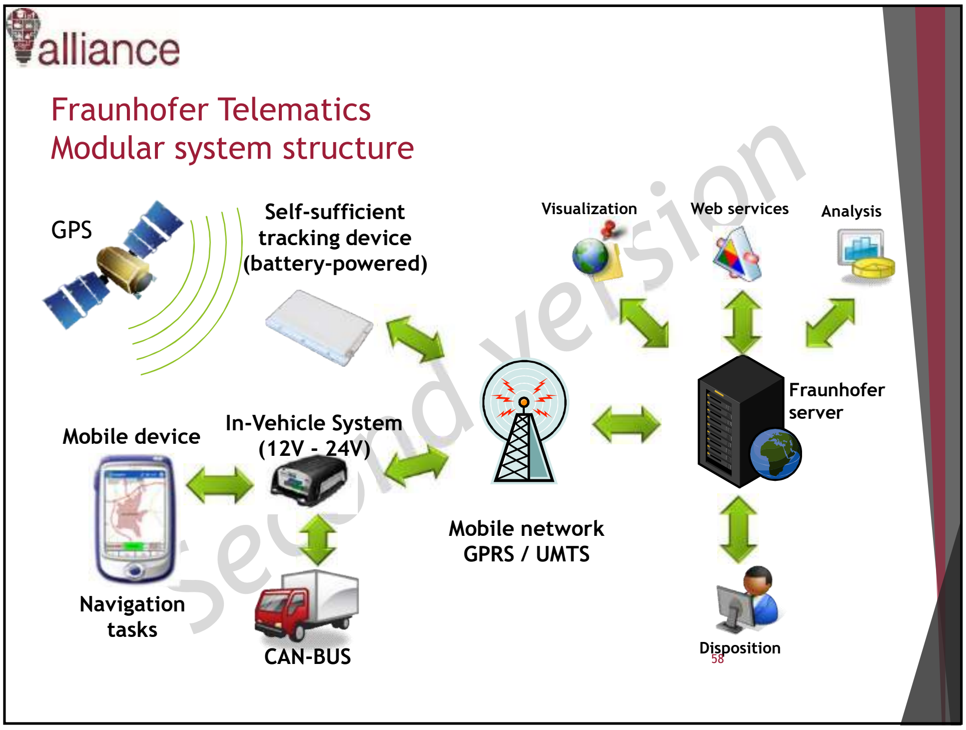
Logistics Data processing

Persistence

Specific applications

Reporting

Analysis Web Frontend



Fraunhofer Telematics
Modular system structure

GPS

Self-sufficient tracking device (battery-powered)

Visualization

Web services

Analysis

Fraunhofer server

Mobile device

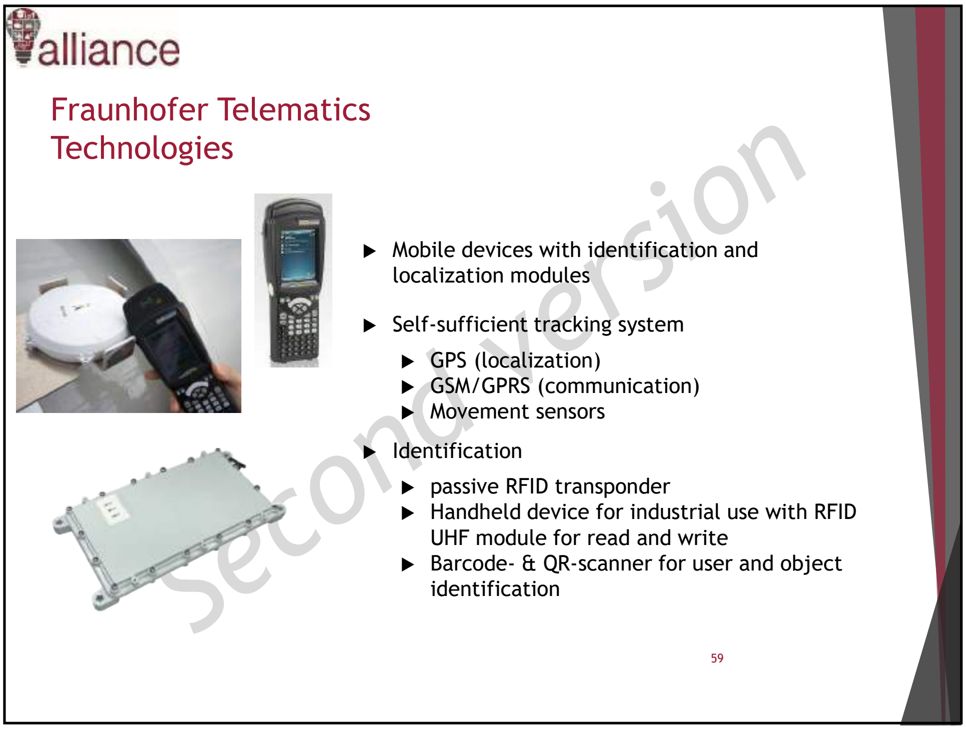
In-Vehicle System (12V - 24V)

Mobile network GPRS / UMTS

Navigation tasks

CAN-BUS

Disposition



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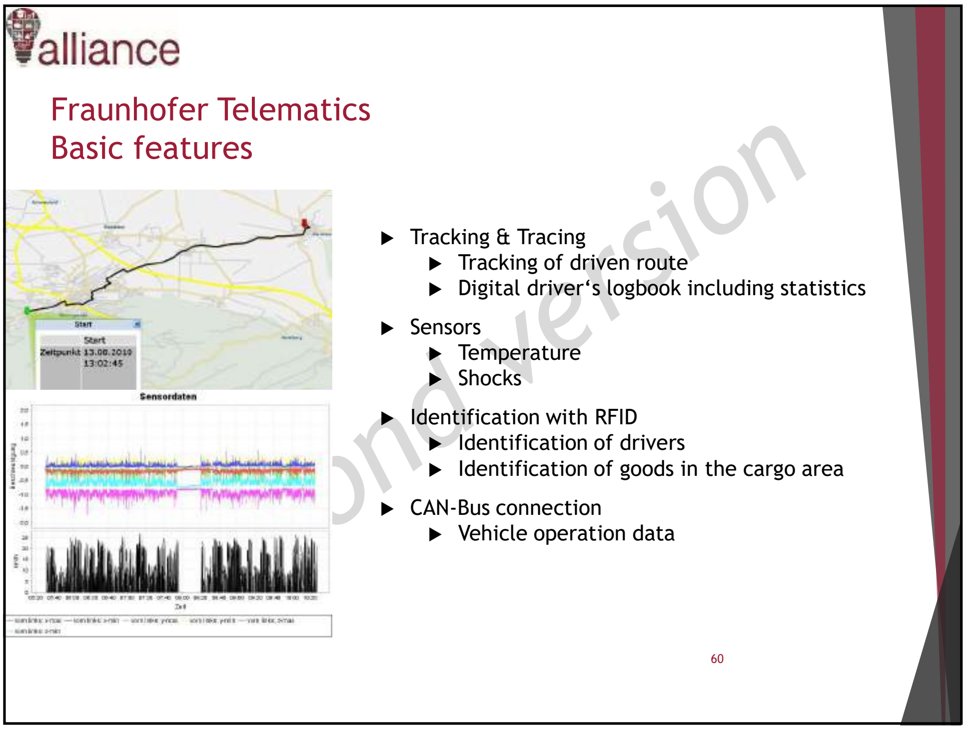
Fraunhofer Telematics Technologies

- Mobile devices with identification and localization modules
- Self-sufficient tracking system
  - GPS (localization)
  - GSM/GPRS (communication)
  - Movement sensors
- Identification
  - passive RFID transponder
  - Handheld device for industrial use with RFID UHF module for read and write
  - Barcode- & QR-scanner for user and object identification



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Fraunhofer Telematics Basic features

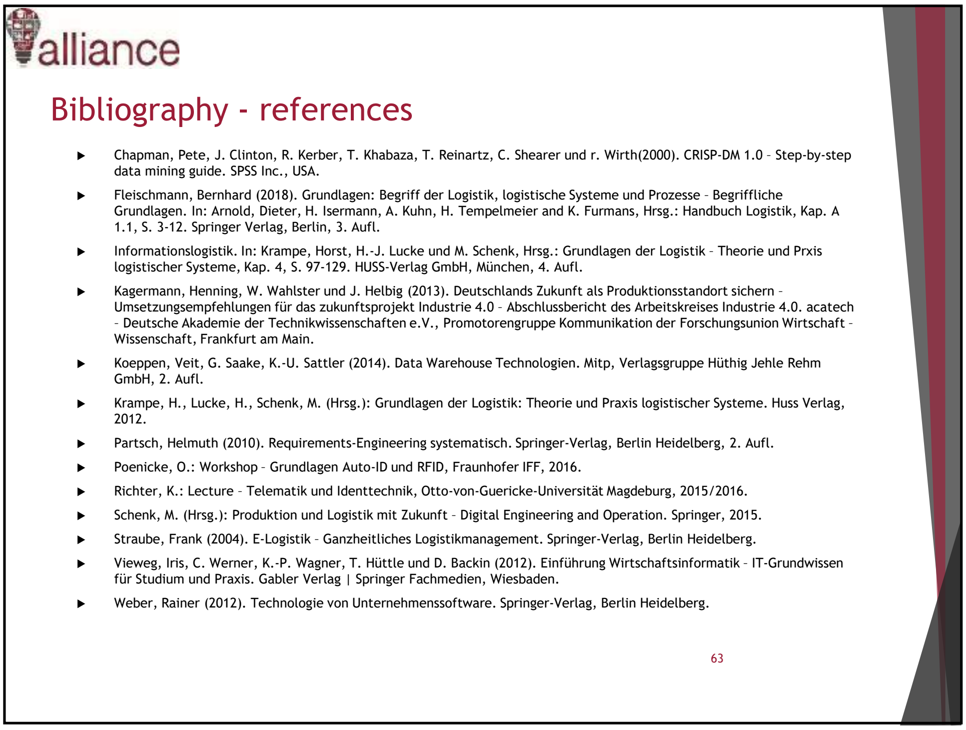
- Tracking & Tracing
  - Tracking of driven route
  - Digital driver's logbook including statistics
- Sensors
  - Temperature
  - Shocks
- Identification with RFID
  - Identification of drivers
  - Identification of goods in the cargo area
- CAN-Bus connection
  - Vehicle operation data

Fraunhofer Telematics
Example 1 – inventory management for large components

- Battery powered self-sufficient tracking system for direct localization
- Identification with RFID
- Tracking and monitoring
  - Container
  - Components
- Area of application
  - Transport
  - Factory site
  - Construction site

Fraunhofer Telematics
Example 2 – ChemLog T&T

- Tracking und Tracing of chemical goods
- Improvement of intermodal transport chains
  - safety
  - reliability
  - efficiency
- Identification of requirements
- Verification of possible application by testing existing telematics solutions
- Pilot test: transport of chemical goods from Oberhausen to England and back via Germany to Ukraine



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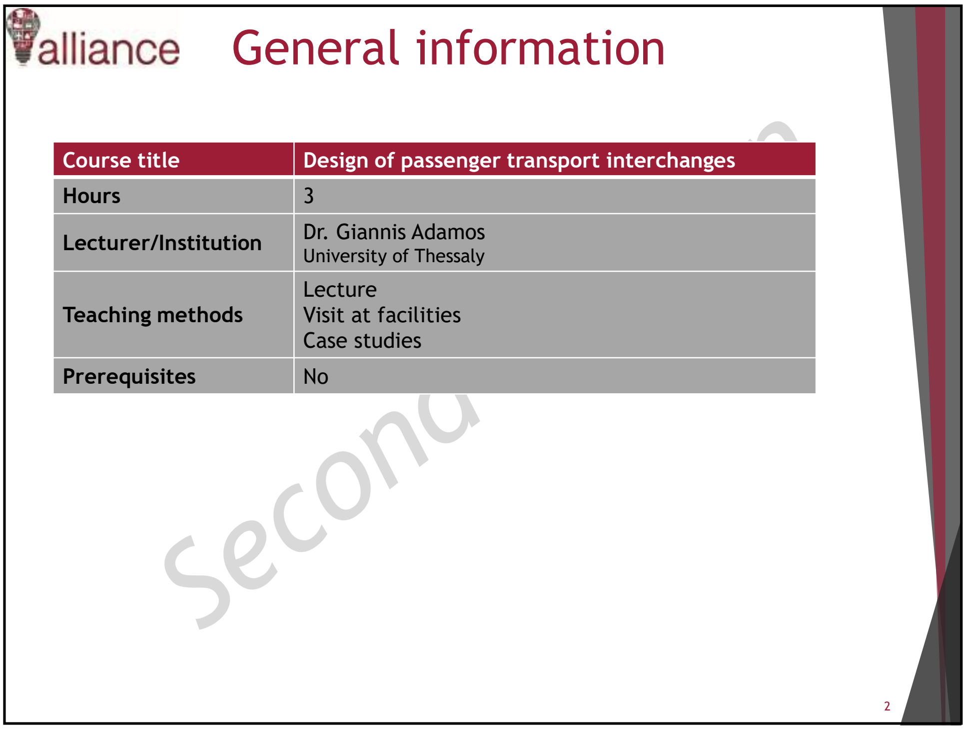
Design of passenger transport interchanges

University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



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General information

Course title	Design of passenger transport interchanges
Hours	3
Lecturer/Institution	Dr. Giannis Adamos University of Thessaly
Teaching methods	Lecture Visit at facilities Case studies
Prerequisites	No

Aim and learning outcomes

- **Aim:**
  - Gain skills to design medium and large scale infrastructure and increase the perception of creating effective and efficient solutions that rely on safety principles
  - Understand the design requirements and special characteristics of passenger interchanges for designing accessible infrastructure
  - The course aims at achieving a synergy between substantive technical knowledge and safety consideration knowledge
- **Learning outcomes:**
  - Acquire practical knowledge of design aspects for passenger transport interchanges
  - Possess a good understanding of passenger transport interchanges, know design principles of accessibility and acquire basic engineering skills in interchange planning
  - Provide an understanding of the fundamental relationships involved in the design of passenger interchanges by integrating facilities, retailing, passenger transfer and considering interactions with other sectors and future challenges
  - Ensure that students have a sound understanding of the key issues affecting the planning, safety and comfort of passenger terminals

Content

- **Background**
- **Components of transport interchanges**
- Basic concepts in design
- Interchange zones
- Interchange design
- Transport operators and managers viewpoint
- Policy and governance viewpoint
- Users’ viewpoint
- **Guidance and recommendations**
- Access/egress
- Transport and transfer
- Design principles
- Facilities and retailing
- Safety and security
- Accessibility
- Inclusive information
- Comfort
- ITS in interchange design
- **Design typologies and requirements**
- **Applications**
- Case studies
- **Guidance to further knowledge acquisition**
- Suggested literature

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Background

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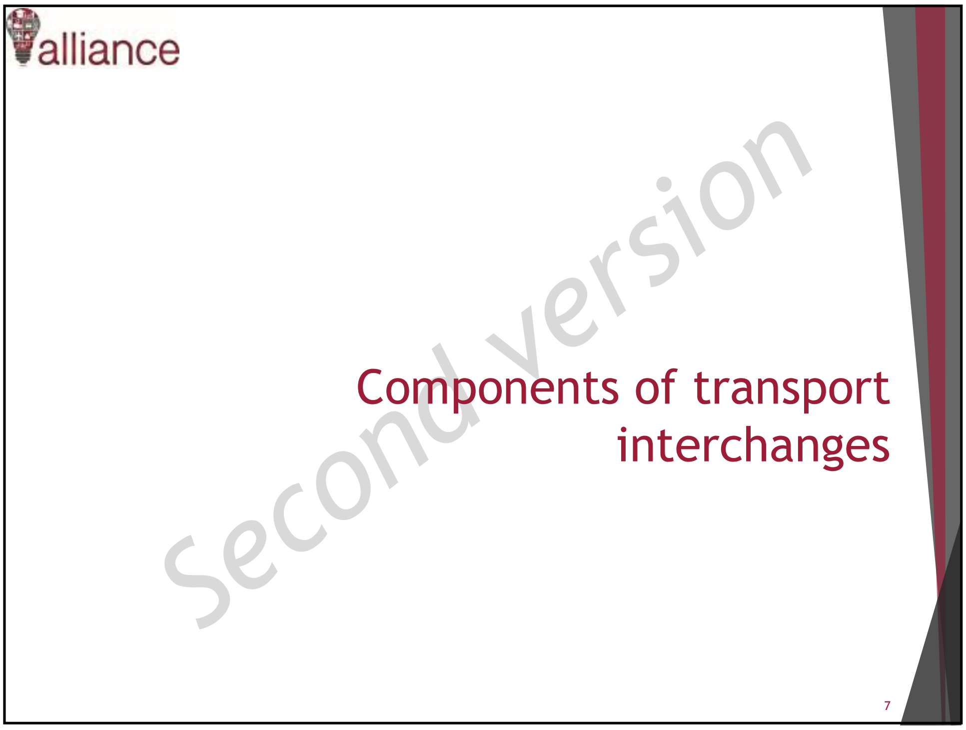
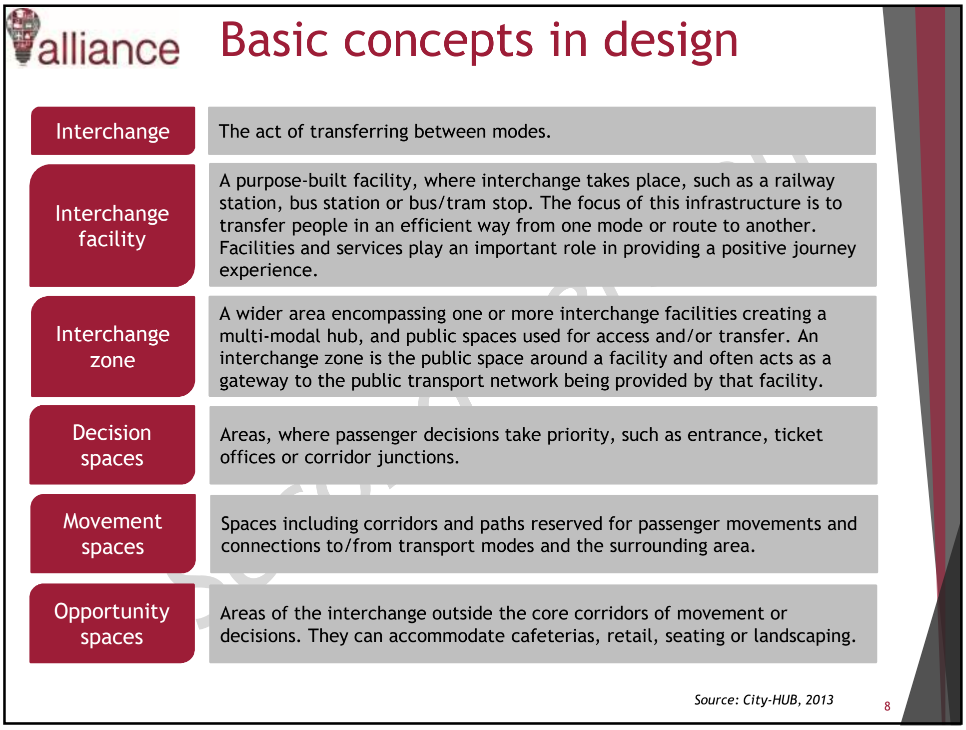
Background

- Transport interchanges play a crucial role in urban development facilitating links between different modes, routes and destinations
- An interchange is characterized by:
  - Its position in the transport network
  - The surrounding urban environment
  - The integration of different modes
  - The legislative framework that is in force
- Key interchange factors:
  - Coordination and management
  - Accessibility to all
  - Quality to traveller
  - Safety
- The design of interchanges should ensure that transport system is:
  - Seamless
  - Smart
  - Clean
  - Safe
  - Accessible by all users



Components of transport interchanges



Basic concepts in design

Interchange	The act of transferring between modes.
Interchange facility	A purpose-built facility, where interchange takes place, such as a railway station, bus station or bus/tram stop. The focus of this infrastructure is to transfer people in an efficient way from one mode or route to another. Facilities and services play an important role in providing a positive journey experience.
Interchange zone	A wider area encompassing one or more interchange facilities creating a multi-modal hub, and public spaces used for access and/or transfer. An interchange zone is the public space around a facility and often acts as a gateway to the public transport network being provided by that facility.
Decision spaces	Areas, where passenger decisions take priority, such as entrance, ticket offices or corridor junctions.
Movement spaces	Spaces including corridors and paths reserved for passenger movements and connections to/from transport modes and the surrounding area.
Opportunity spaces	Areas of the interchange outside the core corridors of movement or decisions. They can accommodate cafeterias, retail, seating or landscaping.

Source: City-HUB, 2013

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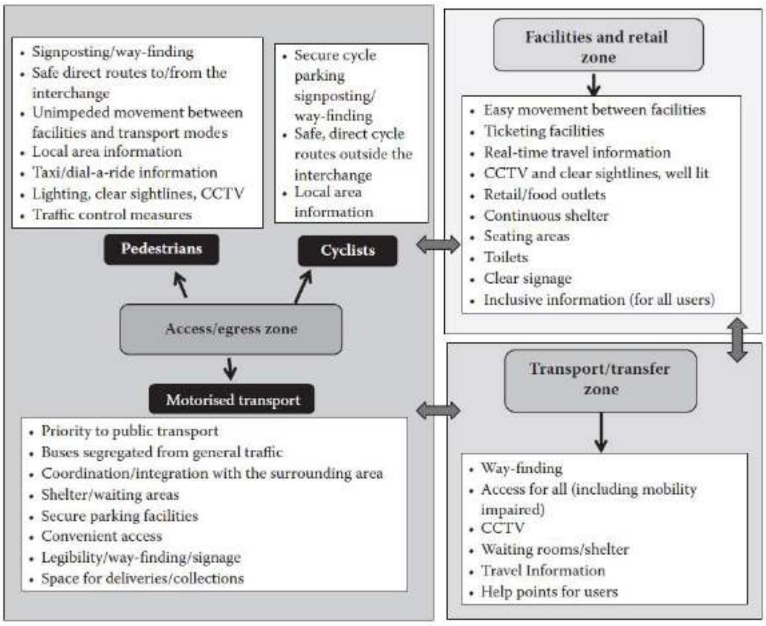
Interchange zones



- Signposting/way-finding
- Safe direct routes to/from the interchange
- Unimpeded movement between facilities and transport modes
- Local area information
- Taxi/dial-a-ride information
- Lighting, clear sightlines, CCTV
- Traffic control measures

- Secure cycle parking signposting/ way-finding
- Safe, direct cycle routes outside the interchange
- Local area information

Pedestrians

Cyclists

Access/egress zone

Motorised transport

- Priority to public transport
- Buses segregated from general traffic
- Coordination/integration with the surrounding area
- Shelter/waiting areas
- Secure parking facilities
- Convenient access
- Legibility/way-finding/signage
- Space for deliveries/collections

Facilities and retail zone

- Easy movement between facilities
- Ticketing facilities
- Real-time travel information
- CCTV and clear sightlines, well lit
- Retail/food outlets
- Continuous shelter
- Seating areas
- Toilets
- Clear signage
- Inclusive information (for all users)

Transport/transfer zone

- Way-finding
- Access for all (including mobility impaired)
- CCTV
- Waiting rooms/shelter
- Travel Information
- Help points for users

Source: Monzon, A. & Di Ciommo, F., 2015

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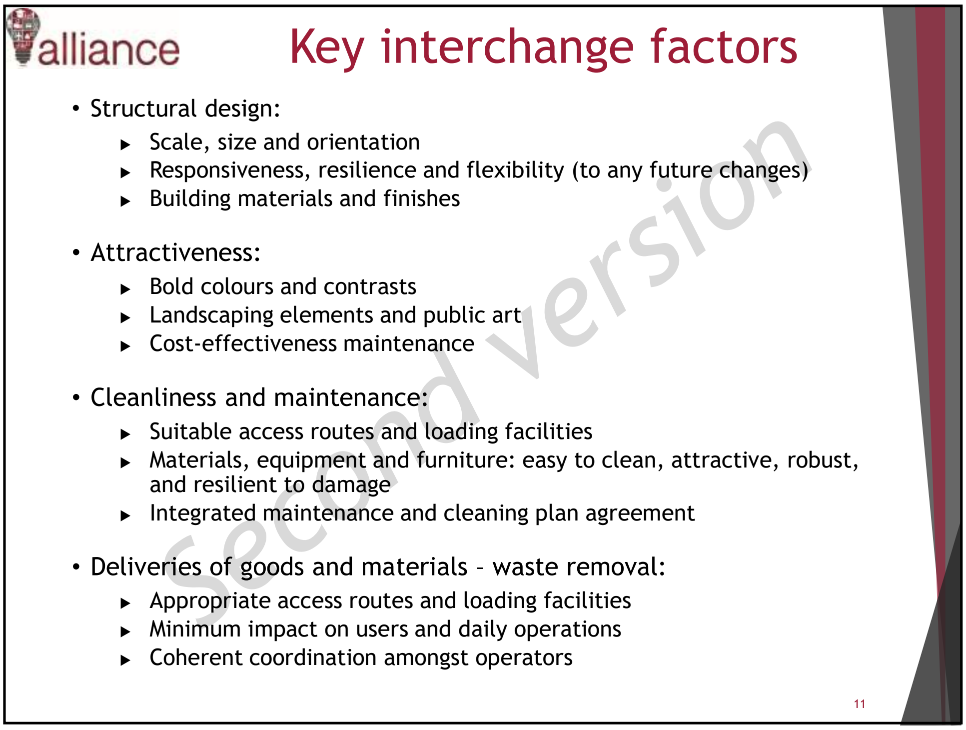
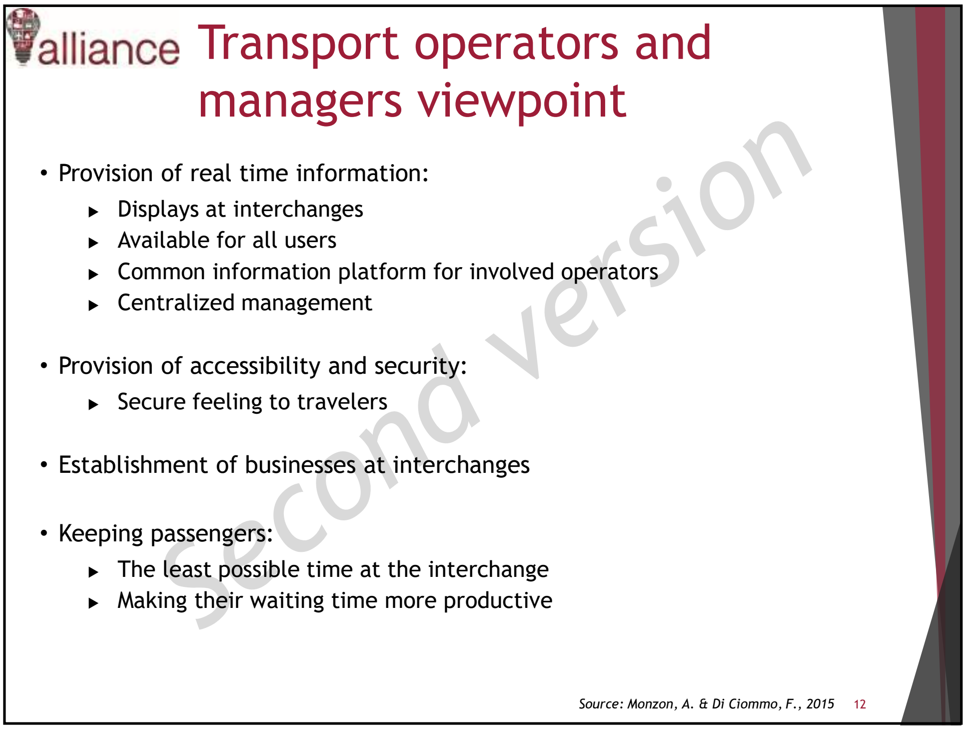
Interchange zones

- Access/egress zone:
  - Different types of users arriving at and leaving from the interchange
  - Safe and efficient movement in and out of the interchange should be provided
- Transport/transfer zone:
  - Users waiting for transport modes within the interchange
  - Waiting rooms, up-to-date travel information and help points should be available
- Facilities and retail zone:
  - Users having more time available to spend
  - Shops, food outlets, toilets, seating areas, ticketing facilities and real-time information should be available



Key interchange factors

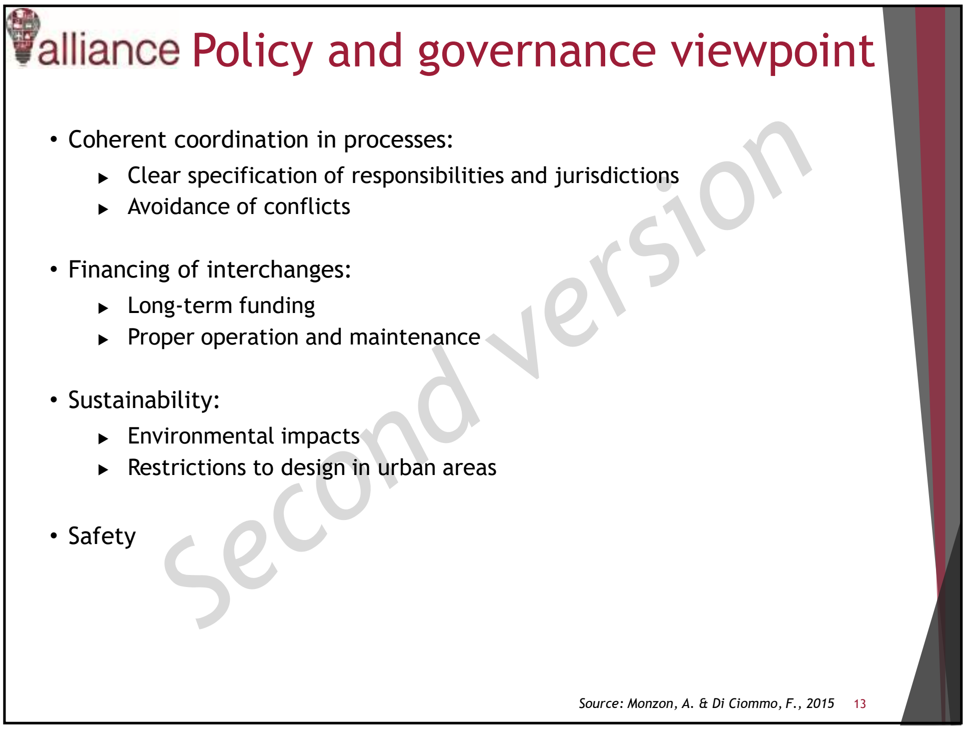
- Structural design:
  - Scale, size and orientation
  - Responsiveness, resilience and flexibility (to any future changes)
  - Building materials and finishes
- Attractiveness:
  - Bold colours and contrasts
  - Landscaping elements and public art
  - Cost-effectiveness maintenance
- Cleanliness and maintenance:
  - Suitable access routes and loading facilities
  - Materials, equipment and furniture: easy to clean, attractive, robust, and resilient to damage
  - Integrated maintenance and cleaning plan agreement
- Deliveries of goods and materials - waste removal:
  - Appropriate access routes and loading facilities
  - Minimum impact on users and daily operations
  - Coherent coordination amongst operators



Transport operators and managers viewpoint

- Provision of real time information:
  - Displays at interchanges
  - Available for all users
  - Common information platform for involved operators
  - Centralized management
- Provision of accessibility and security:
  - Secure feeling to travelers
- Establishment of businesses at interchanges
- Keeping passengers:
  - The least possible time at the interchange
  - Making their waiting time more productive

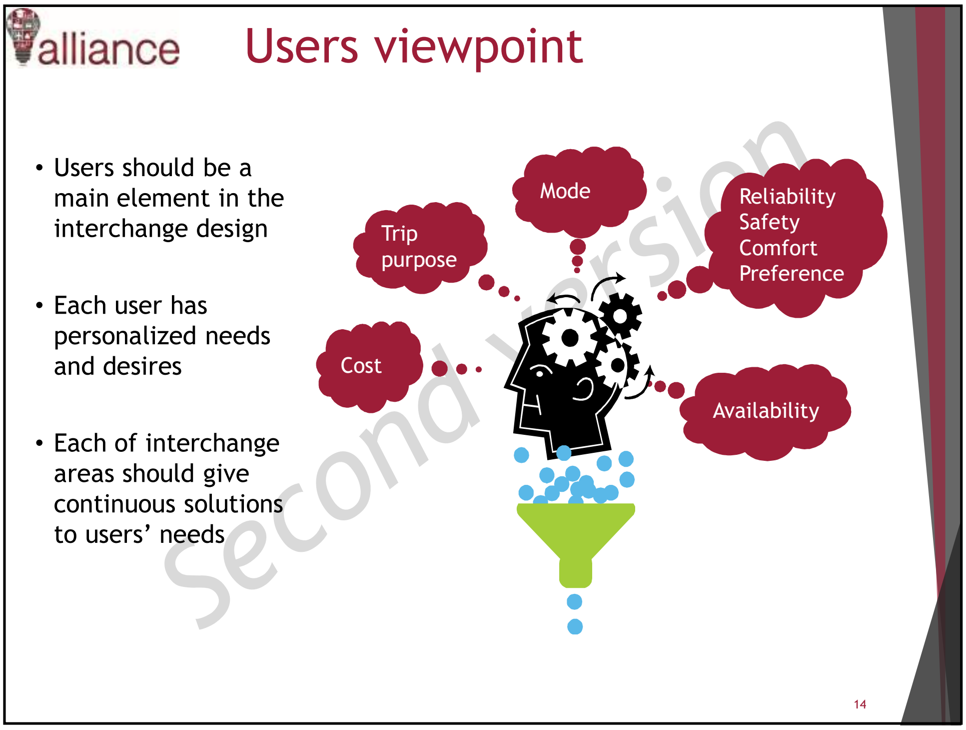
Source: Monzon, A. & Di Ciommo, F., 2015



alliance Policy and governance viewpoint

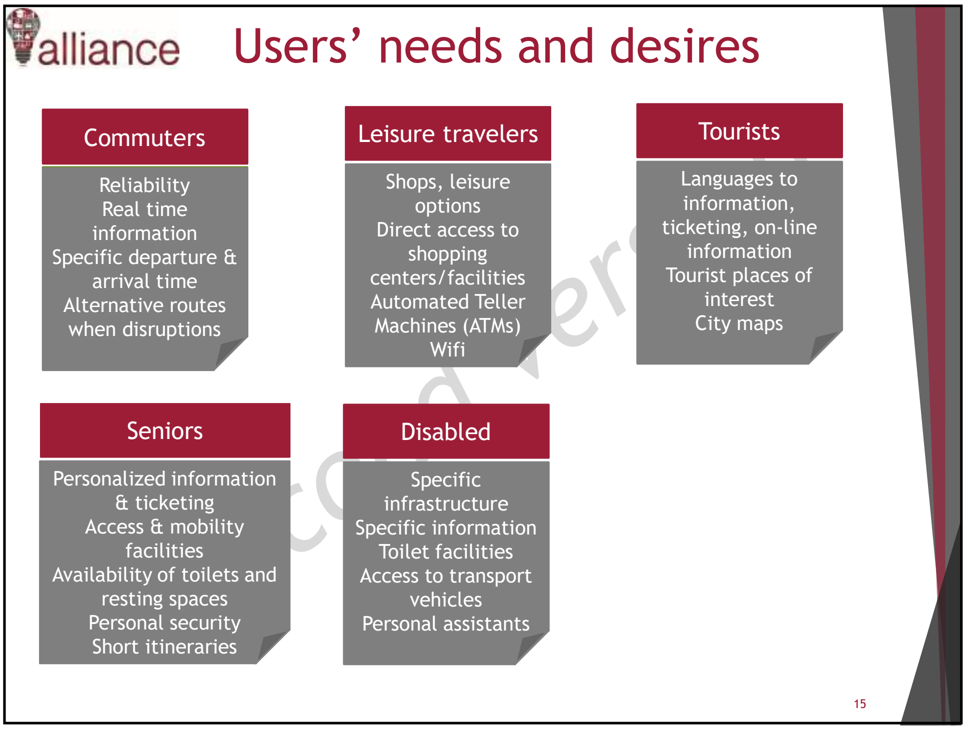
- Coherent coordination in processes:
  - Clear specification of responsibilities and jurisdictions
  - Avoidance of conflicts
- Financing of interchanges:
  - Long-term funding
  - Proper operation and maintenance
- Sustainability:
  - Environmental impacts
  - Restrictions to design in urban areas
- Safety

Source: Monzon, A. & Di Ciommo, F., 2015



alliance Users viewpoint

- Users should be a main element in the interchange design
- Each user has personalized needs and desires
- Each of interchange areas should give continuous solutions to users' needs



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Users' needs and desires

Commuters

Reliability
Real time information
Specific departure & arrival time
Alternative routes when disruptions

Leisure travelers

Shops, leisure options
Direct access to shopping centers/facilities
Automated Teller Machines (ATMs)
Wifi

Tourists

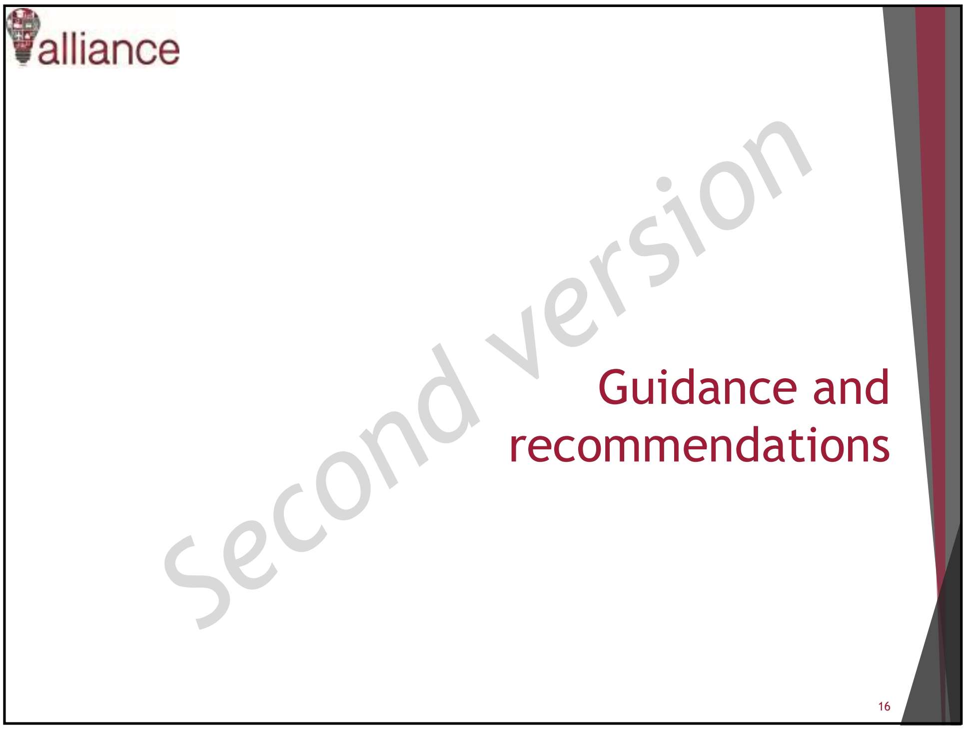
Languages to information, ticketing, on-line information
Tourist places of interest
City maps

Seniors

Personalized information & ticketing
Access & mobility facilities
Availability of toilets and resting spaces
Personal security
Short itineraries

Disabled

Specific infrastructure
Specific information
Toilet facilities
Access to transport vehicles
Personal assistants



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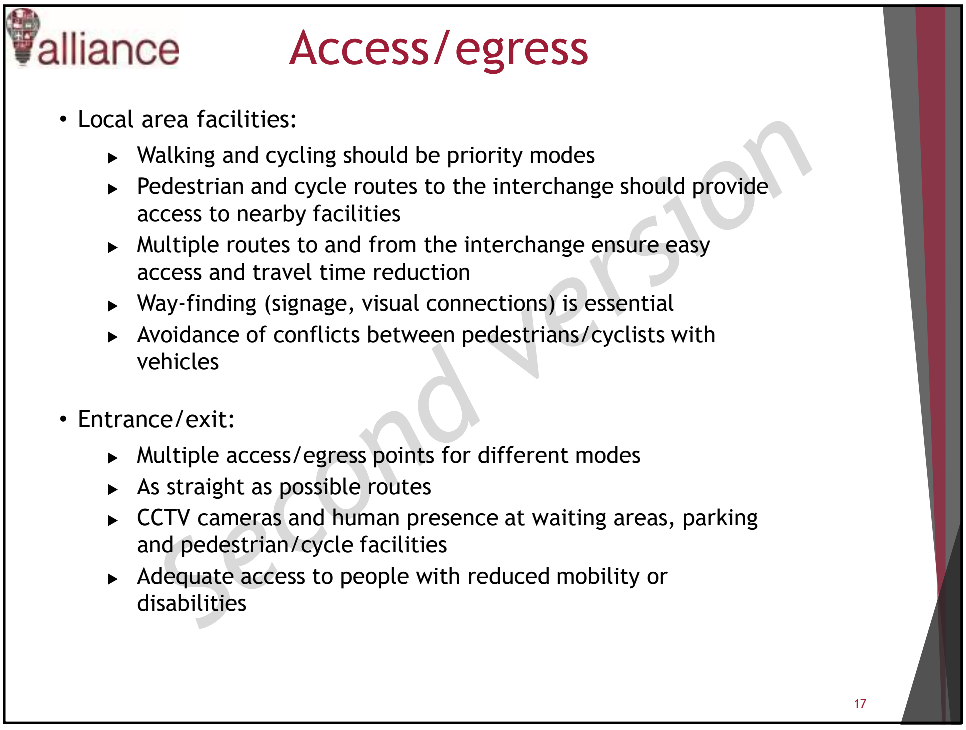
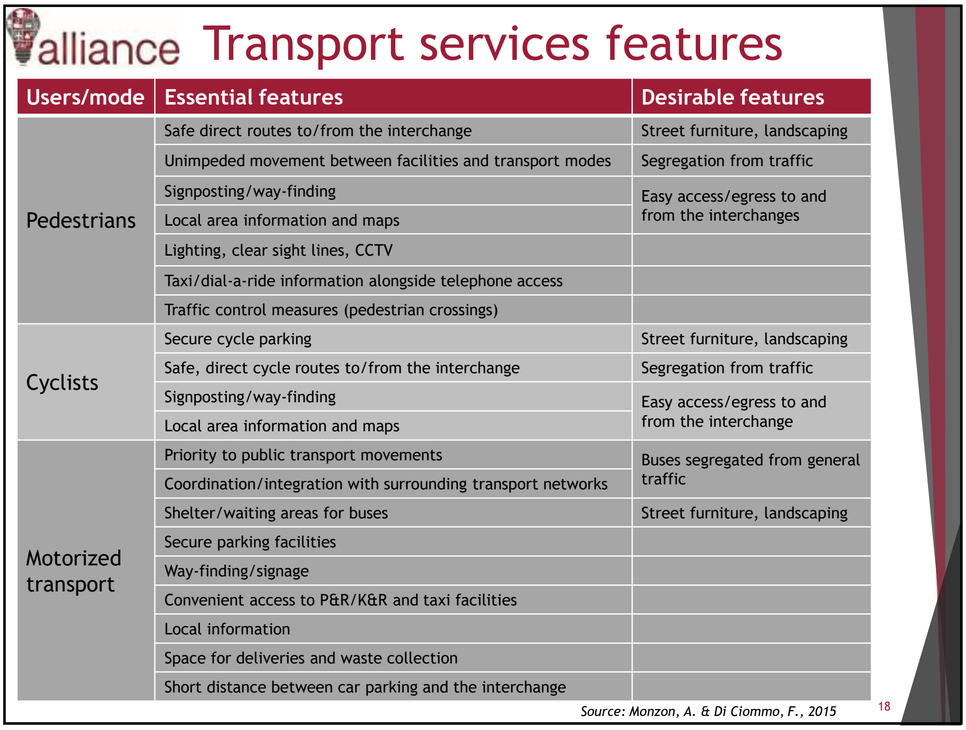
Guidance and recommendations



Access/egress

- Local area facilities:
  - Walking and cycling should be priority modes
  - Pedestrian and cycle routes to the interchange should provide access to nearby facilities
  - Multiple routes to and from the interchange ensure easy access and travel time reduction
  - Way-finding (signage, visual connections) is essential
  - Avoidance of conflicts between pedestrians/cyclists with vehicles
- Entrance/exit:
  - Multiple access/egress points for different modes
  - As straight as possible routes
  - CCTV cameras and human presence at waiting areas, parking and pedestrian/cycle facilities
  - Adequate access to people with reduced mobility or disabilities



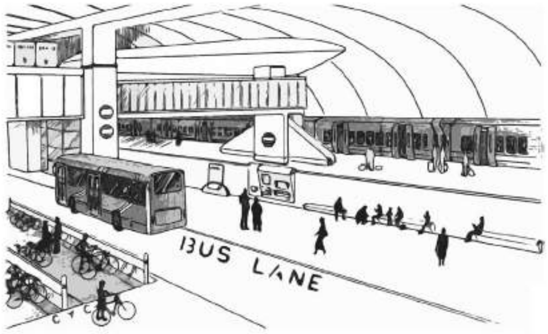
Transport services features

Users/mode	Essential features	Desirable features
Pedestrians	Safe direct routes to/from the interchange	Street furniture, landscaping
	Unimpeded movement between facilities and transport modes	Segregation from traffic
	Signposting/way-finding	Easy access/egress to and from the interchanges
	Local area information and maps	
	Lighting, clear sight lines, CCTV	
	Taxi/dial-a-ride information alongside telephone access	
	Traffic control measures (pedestrian crossings)	
Cyclists	Secure cycle parking	Street furniture, landscaping
	Safe, direct cycle routes to/from the interchange	Segregation from traffic
	Signposting/way-finding	Easy access/egress to and from the interchange
	Local area information and maps	
Motorized transport	Priority to public transport movements	Buses segregated from general traffic
	Coordination/integration with surrounding transport networks	
	Shelter/waiting areas for buses	Street furniture, landscaping
	Secure parking facilities	
	Way-finding/signage	
	Convenient access to P&R/K&R and taxi facilities	
	Local information	
	Space for deliveries and waste collection	
	Short distance between car parking and the interchange	

Source: Monzon, A. & Di Ciommo, F., 2015

Transport & transfer

- Distances between different modes should look to emulate similar distances where possible

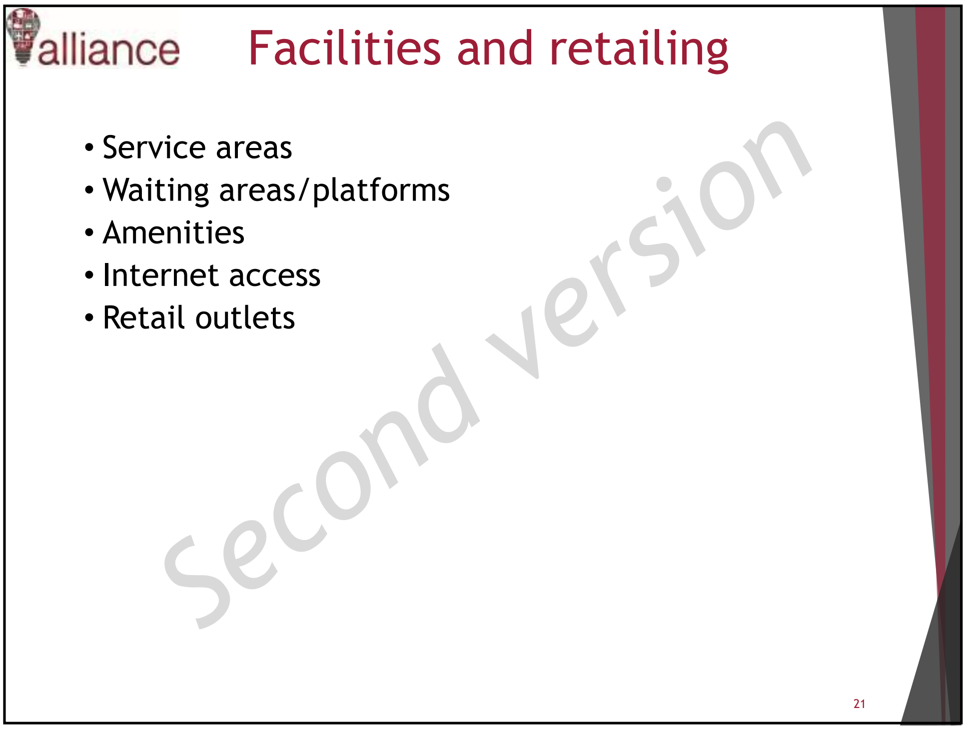


Source: Monzon, A. & Di Ciommo, F., 2015

- Capacity, open space and logical passenger movements are crucial
- Coordination between transport modes and waiting time are important for passengers
- Integration of timetables of different modes can be an efficient solution

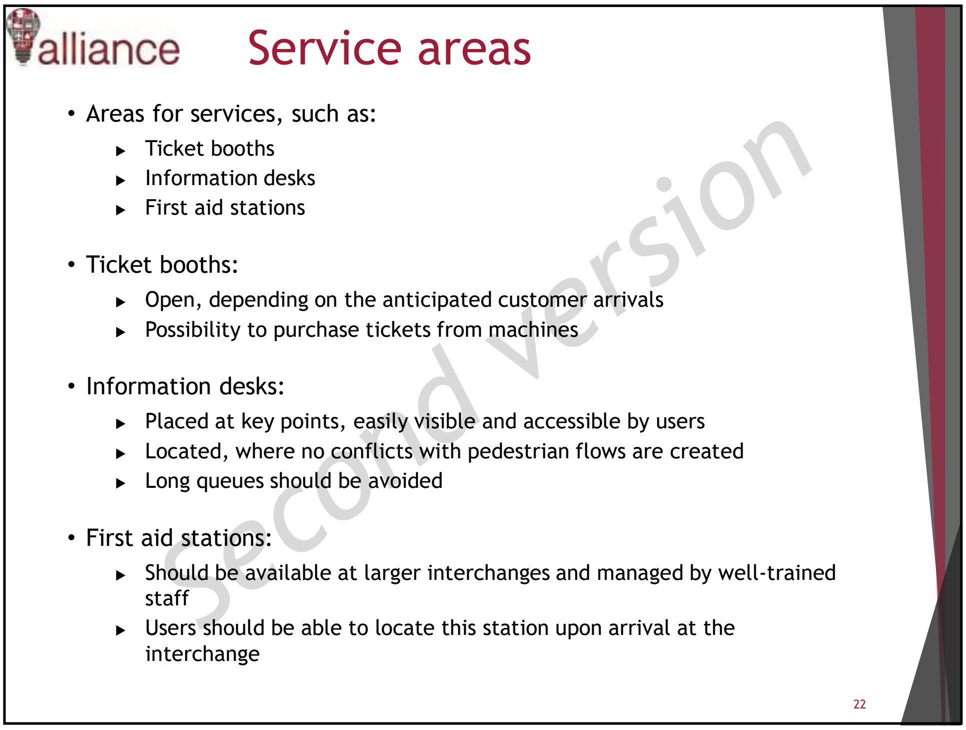
Design principles

- **Way-finding:**
  - Assists people with navigating aids so they can find their way from where they are to where they want to go
  - Key elements: legible and well laid out spaces, adequate signing and information, surface treatments, appropriate materials and lighting
  - Preparation of Way-finding Plan at the early stages of design
  - Not only within the interchange, but also in the surrounding area
- **Legibility:**
  - Ensures the easy and seamless navigation and movement of users
  - Minimizes the vulnerability that users may feel in a new unfamiliar environment due to confusion and/or uncertainty
  - Key elements: layout, lighting, surfaces and materials, finishes and furniture
- **Permeability:**
  - Allows users to move around the interchange under several alternatives
  - Key elements: multiple routes, route size, public realm, safety
  - Smart and best practice design to mitigate problems from severance and barriers from transport functions
- **Inclusivity:**
  - Provides adequate access to all travelers
  - Key elements: step-free routes, natural surveillance, signing
  - Access/entrance to lifts and escalators clear of any obstacles
  - Trained staff



Facilities and retailing

- Service areas
- Waiting areas/platforms
- Amenities
- Internet access
- Retail outlets



Service areas

- Areas for services, such as:
  - Ticket booths
  - Information desks
  - First aid stations
- Ticket booths:
  - Open, depending on the anticipated customer arrivals
  - Possibility to purchase tickets from machines
- Information desks:
  - Placed at key points, easily visible and accessible by users
  - Located, where no conflicts with pedestrian flows are created
  - Long queues should be avoided
- First aid stations:
  - Should be available at larger interchanges and managed by well-trained staff
  - Users should be able to locate this station upon arrival at the interchange

Waiting areas/platforms

- Users need to feel comfortable and secure while waiting
- The interchange should provide comfortable seating and areas for standing and leaning
- Waiting rooms should be well lit, heated and/or ventilated
- Passenger information should be provided on screens and through audio announcements
- Passengers need to be protected from bad weather
- Continuous shelter should be provided throughout the interchange and the transfer areas
- Restrooms should be available for all users and in convenient locations.

Good example: Train platform at Lille, France

Source: Monzon, A. & Di Ciommo, F., 2015

Amenities

- Allow waiting time to be usefully spent:
  - Coffee shops
  - Restaurants
  - Entertainment
  - Play areas
  - Pharmacies
  - Tourist information desks
  - Bank branches
  - Automated Teller Machines (ATMs)
  - Post boxes

Internet access

- Enables travelers to use internet, browse, check their emails, etc.
- Useful at interchanges with high volumes of commuters

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Retail outlets

- When deciding which outlets to provide within an interchange, the size, location and level of service need to be considered
- Retail services available nearby affect business opportunities for shops in new interchanges
- Local demand should be considered when selecting the location of shops
- Direct employment in the interchange affects the regeneration of the surrounding area
- Retail outlets should be complementary to one another and improve the attractiveness of the interchange

Example of retailing: Kamppi Interchange, Helsinki, Finland

The interchange is in a very central location in downtown Helsinki, combined with a shopping centre with an area of approximately four hectares. A total of 170 businesses operate in the interchange shopping centre, including 106 stores, 35 restaurants and cafes, and 29 services such as beauty salons, gyms, banks and laundry.

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Safety & security

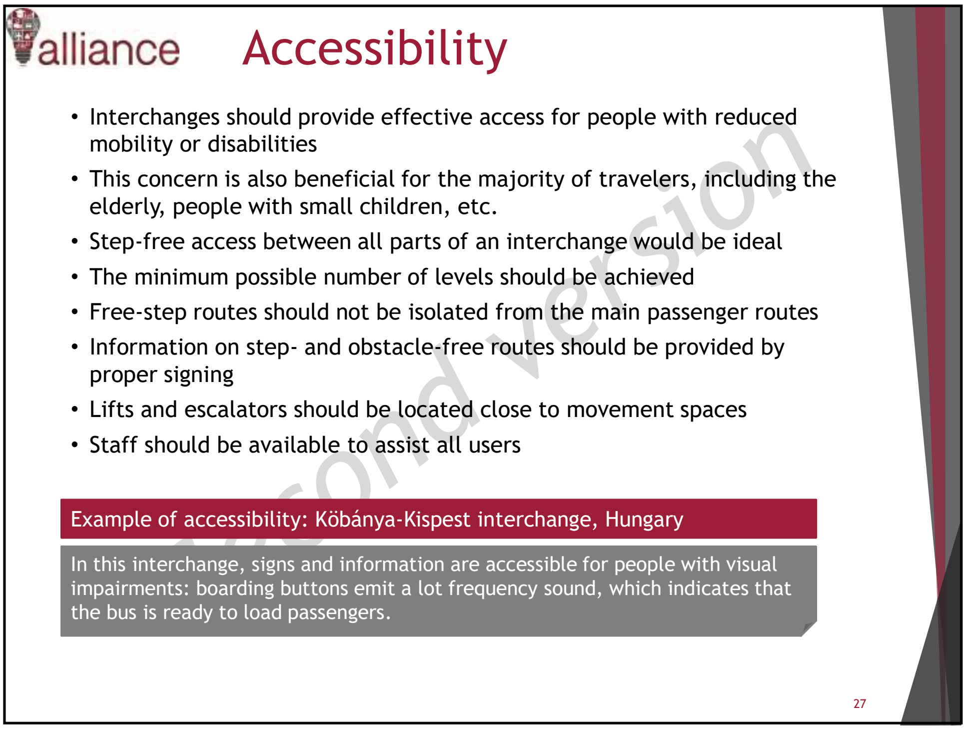
- The interchange must comply with regulations and provide adequate precautions, in order to prevent any accidents
- Areas of conflict between pedestrians and vehicles should be minimized
- Emergency exits should be clearly indicated
- Fully trained staff in emergency response
- Adequate levels of security: technical and human presence

Examples of safety: Moncloa station, Spain / Kamppi interchange, Finland

In Moncloa station, bus bays ensure that passengers do not use areas of the buses' operation.
In Kamppi interchange, doors open only when it is time for the buses to depart.

Example of security: Birkenhead bus station, United Kingdom

The station was designed with passenger security foresight, and therefore much of the station's structure is made from large panels of clear, toughened glass, providing clear sight lines to the surrounding area.



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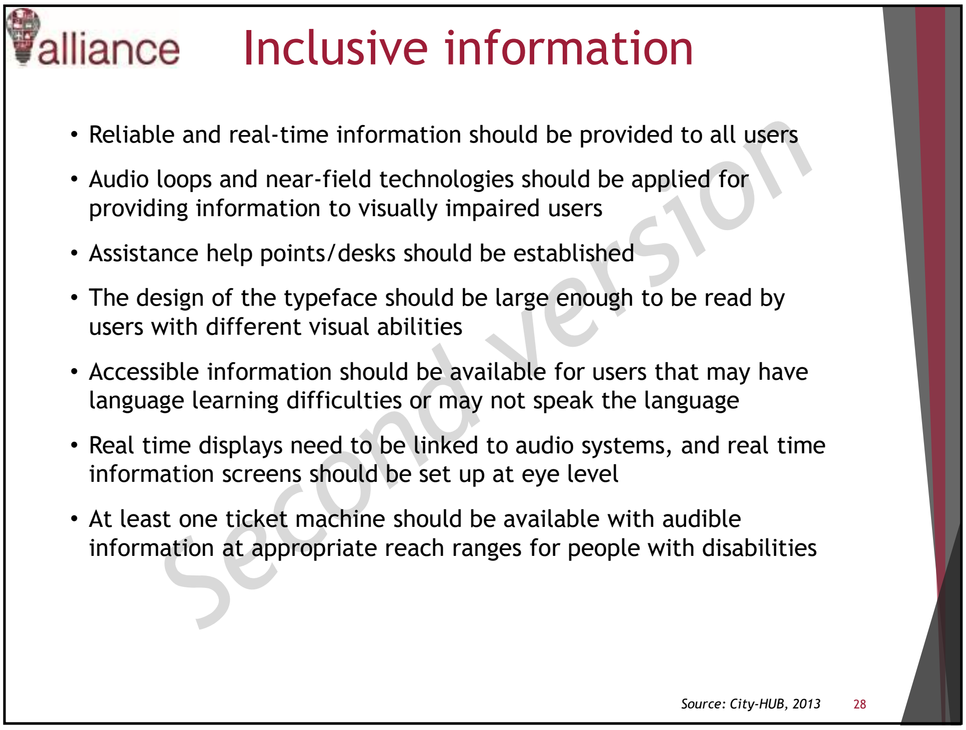
Accessibility

- Interchanges should provide effective access for people with reduced mobility or disabilities
- This concern is also beneficial for the majority of travelers, including the elderly, people with small children, etc.
- Step-free access between all parts of an interchange would be ideal
- The minimum possible number of levels should be achieved
- Free-step routes should not be isolated from the main passenger routes
- Information on step- and obstacle-free routes should be provided by proper signing
- Lifts and escalators should be located close to movement spaces
- Staff should be available to assist all users

Example of accessibility: Kőbánya-Kispest interchange, Hungary

In this interchange, signs and information are accessible for people with visual impairments: boarding buttons emit a lot frequency sound, which indicates that the bus is ready to load passengers.



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Inclusive information

- Reliable and real-time information should be provided to all users
- Audio loops and near-field technologies should be applied for providing information to visually impaired users
- Assistance help points/desks should be established
- The design of the typeface should be large enough to be read by users with different visual abilities
- Accessible information should be available for users that may have language learning difficulties or may not speak the language
- Real time displays need to be linked to audio systems, and real time information screens should be set up at eye level
- At least one ticket machine should be available with audible information at appropriate reach ranges for people with disabilities

Source: City-HUB, 2013

Comfort

- Even if comfort is subjective, it is significantly dependent of the availability of facilities in an interchange and makes the time user spends there more pleasant
- Issues related to comfort:
    - Space and seating arrangements
    - Temperature
    - Noise levels
    - Cleanliness
    - Lighting
    - Access to amenities

ITS in interchange design

Christchurch Bus Exchange, New Zealand, showing dynamic stop allocation and passenger transport information in a central passenger waiting lounge

Well-designed and positioned information panels at the railway station of Sint-Niklaas, Belgium. Photo: TTB

Paddington one stop shop. Intermodal transport interchange for London, Best practice guidelines January 2001 Issue 1

Waiting room, Birkenhead bus station, Merseyside, UK. Photo: Alan Murray Rust

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Design typologies and requirements

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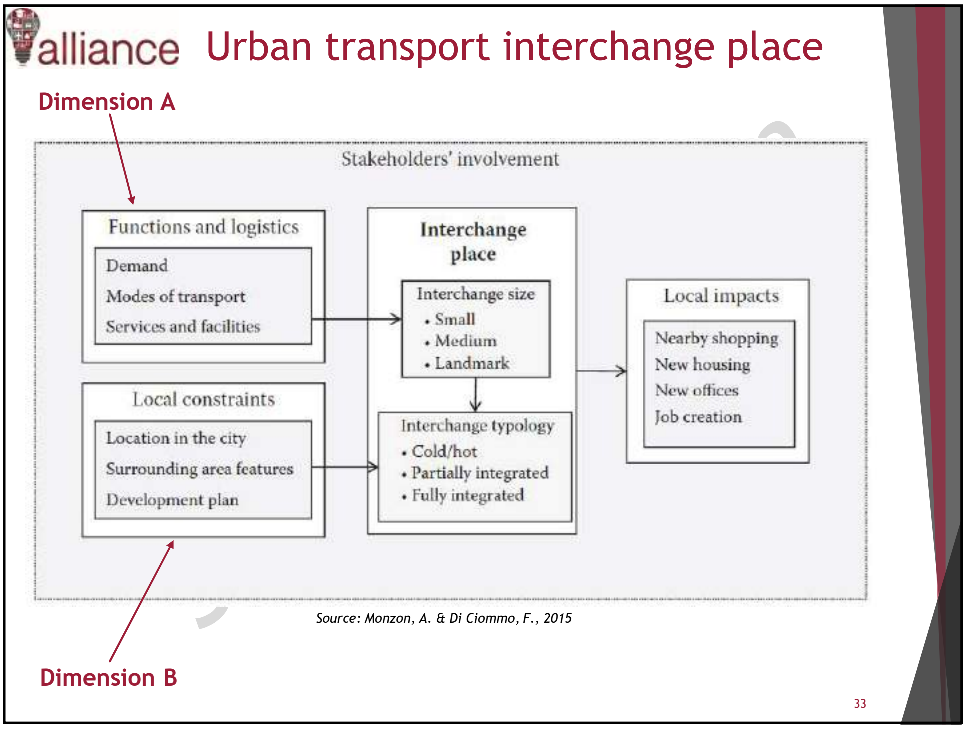
Scaling of services at the interchange

- 3 types of interchanges depending on size:
  - Small
  - Medium
  - City landmark
- Small:
  - Less demand, fewer facilities/modes/stakeholders/local impacts
  - Often suburban
- Medium:
  - Moderate demand, more facilities/modes/stakeholders/impacts
  - Located in more urban settings and provide access to cities
- City landmark:
  - High demand, high number of facilities/stakeholders, many different modes, high local impacts
  - Located in the city centre with national, long-distance and international links



Urban transport interchange place

Dimension A

Stakeholders' involvement

Functions and logistics
- Demand
- Modes of transport
- Services and facilities

Local constraints
- Location in the city
- Surrounding area features
- Development plan

Interchange place

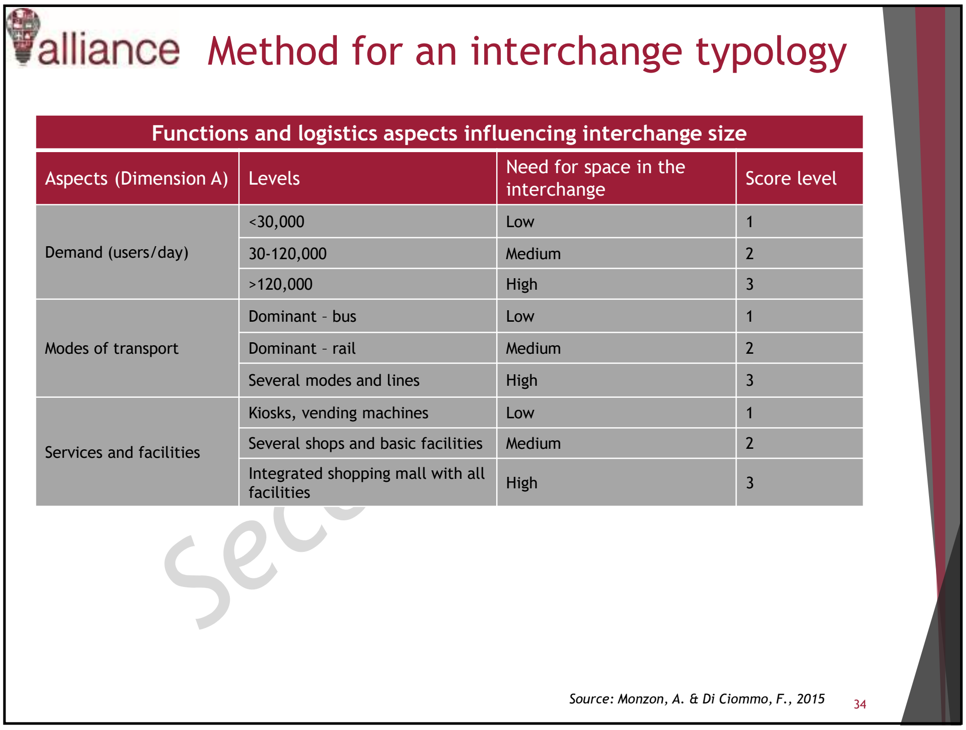
Interchange size
- Small
- Medium
- Landmark

Interchange typology
- Cold/hot
- Partially integrated
- Fully integrated

Local impacts
- Nearby shopping
- New housing
- New offices
- Job creation

Source: Monzon, A. & Di Ciommo, F., 2015

Dimension B

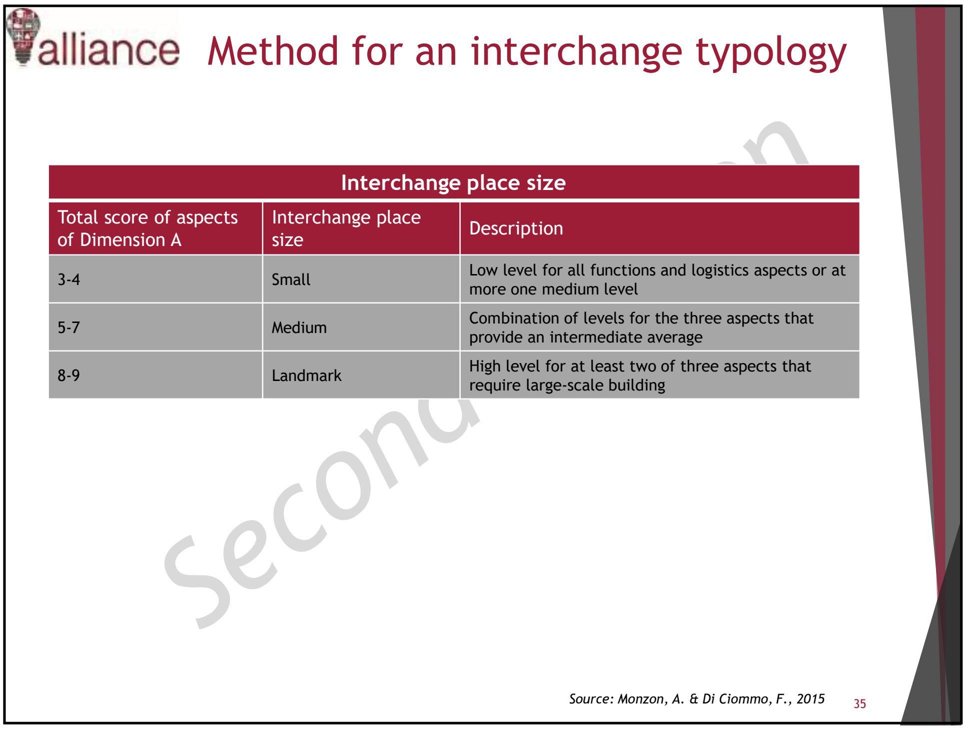


Method for an interchange typology

Functions and logistics aspects influencing interchange size

Aspects (Dimension A)	Levels	Need for space in the interchange	Score level
Demand (users/day)	<30,000	Low	1
	30-120,000	Medium	2
	>120,000	High	3
Modes of transport	Dominant - bus	Low	1
	Dominant - rail	Medium	2
	Several modes and lines	High	3
Services and facilities	Kiosks, vending machines	Low	1
	Several shops and basic facilities	Medium	2
	Integrated shopping mall with all facilities	High	3

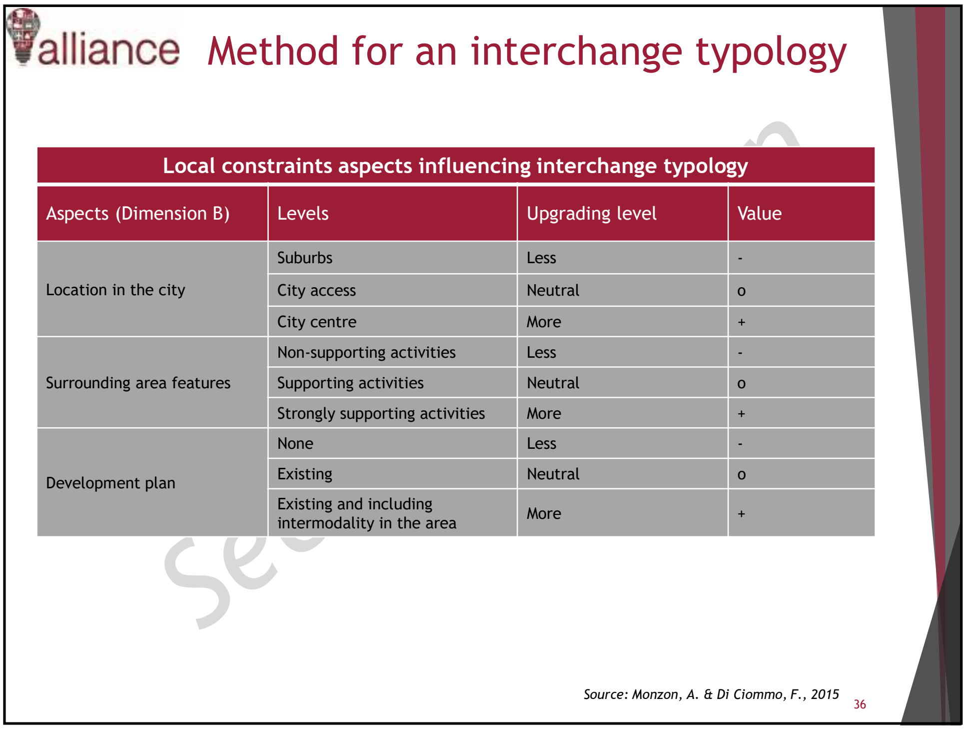
Source: Monzon, A. & Di Ciommo, F., 2015



Method for an interchange typology

Interchange place size		
Total score of aspects of Dimension A	Interchange place size	Description
3-4	Small	Low level for all functions and logistics aspects or at more one medium level
5-7	Medium	Combination of levels for the three aspects that provide an intermediate average
8-9	Landmark	High level for at least two of three aspects that require large-scale building

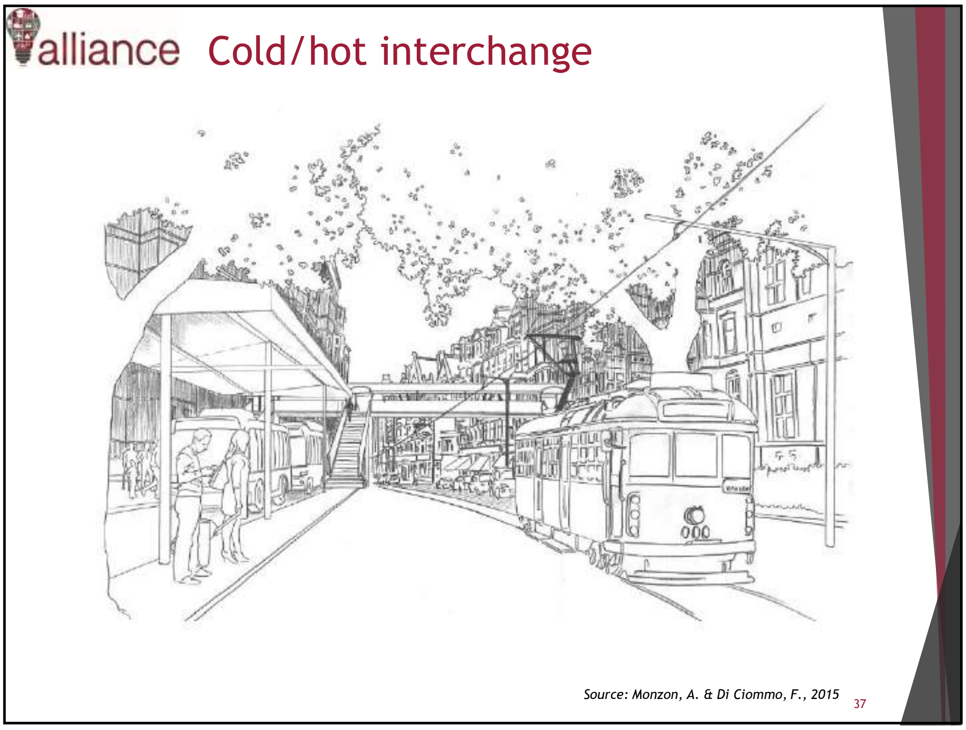
Source: Monzon, A. & Di Ciommo, F., 2015



Method for an interchange typology

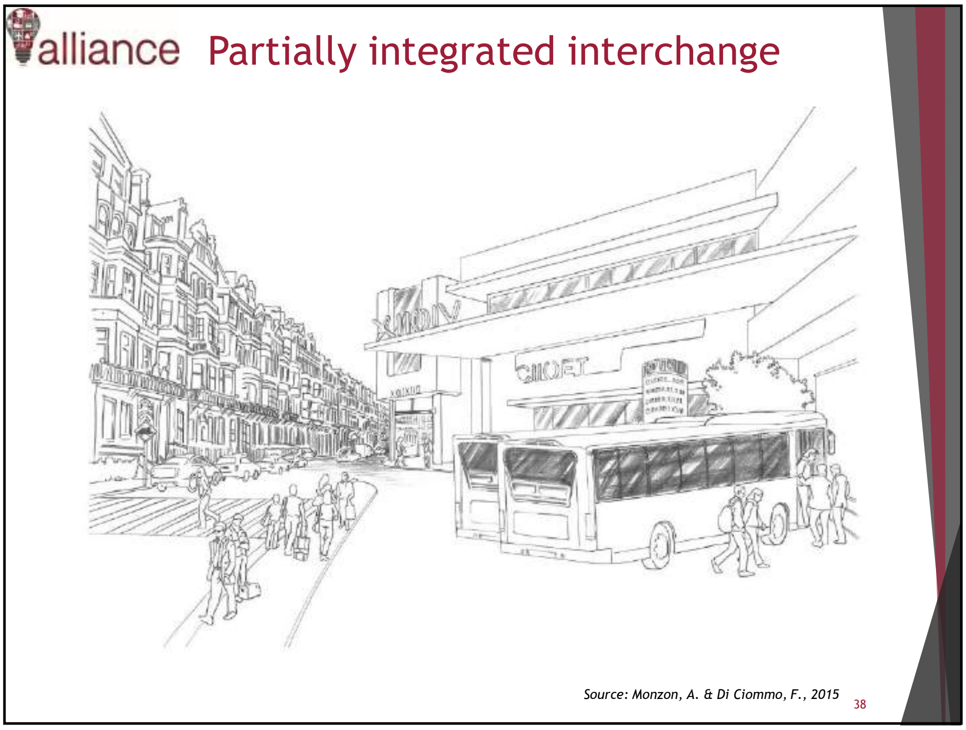
Local constraints aspects influencing interchange typology			
Aspects (Dimension B)	Levels	Upgrading level	Value
Location in the city	Suburbs	Less	-
	City access	Neutral	o
	City centre	More	+
Surrounding area features	Non-supporting activities	Less	-
	Supporting activities	Neutral	o
	Strongly supporting activities	More	+
Development plan	None	Less	-
	Existing	Neutral	o
	Existing and including intermodality in the area	More	+

Source: Monzon, A. & Di Ciommo, F., 2015



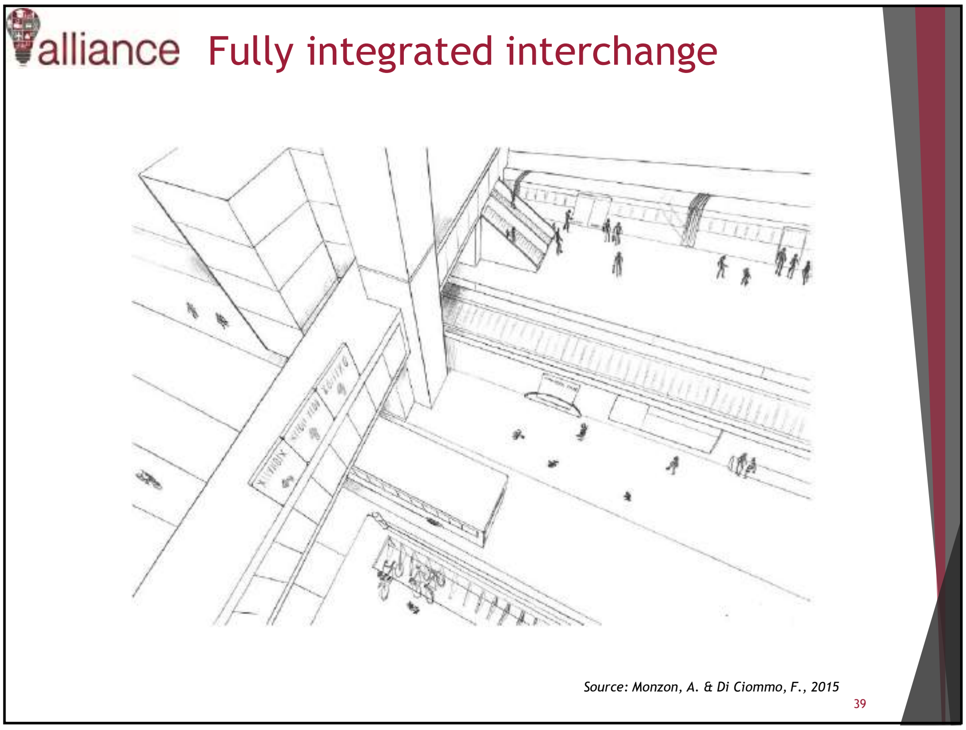
Cold/hot interchange

Source: Monzon, A. & Di Ciommo, F., 2015



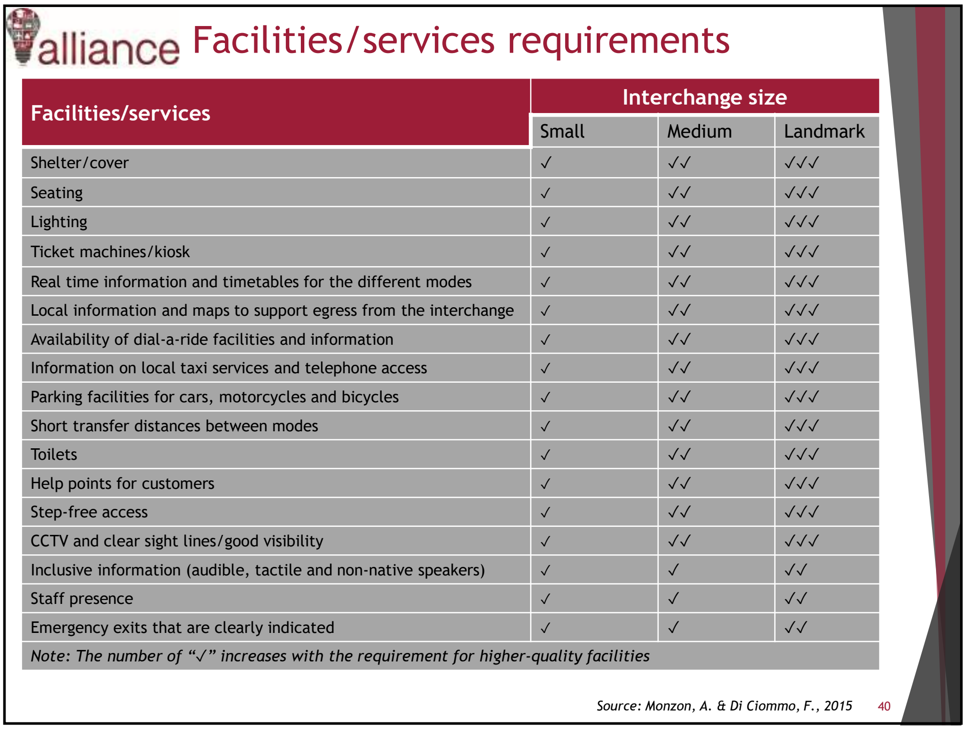
Partially integrated interchange

Source: Monzon, A. & Di Ciommo, F., 2015



alliance Fully integrated interchange

Source: Monzon, A. & Di Ciommo, F., 2015



alliance Facilities/services requirements

Facilities/services	Interchange size		
	Small	Medium	Landmark
Shelter/cover	✓	✓✓	✓✓✓
Seating	✓	✓✓	✓✓✓
Lighting	✓	✓✓	✓✓✓
Ticket machines/kiosk	✓	✓✓	✓✓✓
Real time information and timetables for the different modes	✓	✓✓	✓✓✓
Local information and maps to support egress from the interchange	✓	✓✓	✓✓✓
Availability of dial-a-ride facilities and information	✓	✓✓	✓✓✓
Information on local taxi services and telephone access	✓	✓✓	✓✓✓
Parking facilities for cars, motorcycles and bicycles	✓	✓✓	✓✓✓
Short transfer distances between modes	✓	✓✓	✓✓✓
Toilets	✓	✓✓	✓✓✓
Help points for customers	✓	✓✓	✓✓✓
Step-free access	✓	✓✓	✓✓✓
CCTV and clear sight lines/good visibility	✓	✓✓	✓✓✓
Inclusive information (audible, tactile and non-native speakers)	✓	✓	✓✓
Staff presence	✓	✓	✓✓
Emergency exits that are clearly indicated	✓	✓	✓✓

Note: The number of "✓" increases with the requirement for higher-quality facilities

Source: Monzon, A. & Di Ciommo, F., 2015

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Facilities/services requirements

Facilities/services	Interchange size		
	Small	Medium	Landmark
Wi-Fi (wireless internet) access		✓	✓✓
Regular public address announcements		✓	✓✓
Retail and food outlets		✓	✓✓
Traffic control measures, such as speed bumps, etc.		✓	✓✓
Aesthetically pleasing environment with landscaping and street furniture			✓
Integrated ticketing facilities and smart readers			✓
Luggage storage			✓
Clear signage between adjacent retail and transport facilities			✓
Designated areas for staff and functions such as deliveries and waste collection			✓
Lifts large enough to carry cyclists and pedestrians			✓
Traffic control measures to prioritise bus movements			✓
Bus movements/facilities that fit with the operation of the surrounding road network			✓
Good legibility for transport users through the organization of transport modes geographically			✓
Commercial and retail facilities accessible to non-fare-paying users of the interchange			✓

Note: The number of "✓" increases with the requirement for higher-quality facilities

Source: Monzon, A. & Di Ciommo, F., 2015

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Applications

Case study #1

Understanding travelers’ perceptions in issues such as:

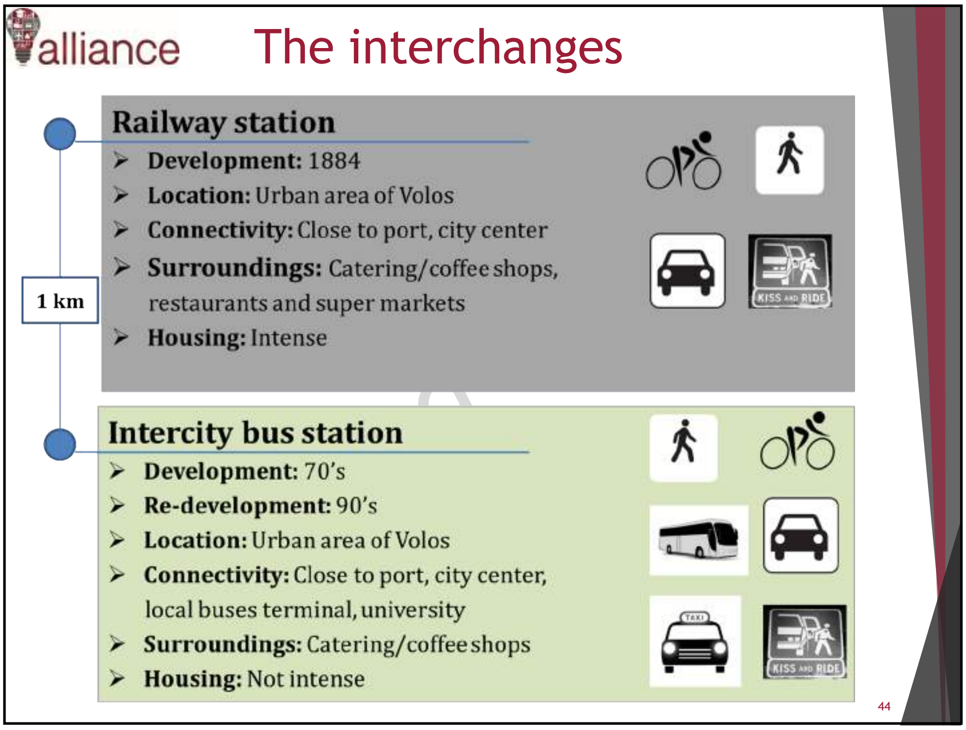
- Travel information
- Wayfinding information
- Access
- Time and movement
- Image and attractiveness
- Comfort and convenience
- Emergency situations
- Overall satisfaction

versus

Railway station, Volos, Greece

Intercity bus station, Volos, Greece

Source: Adamos et al., 2014



The interchanges

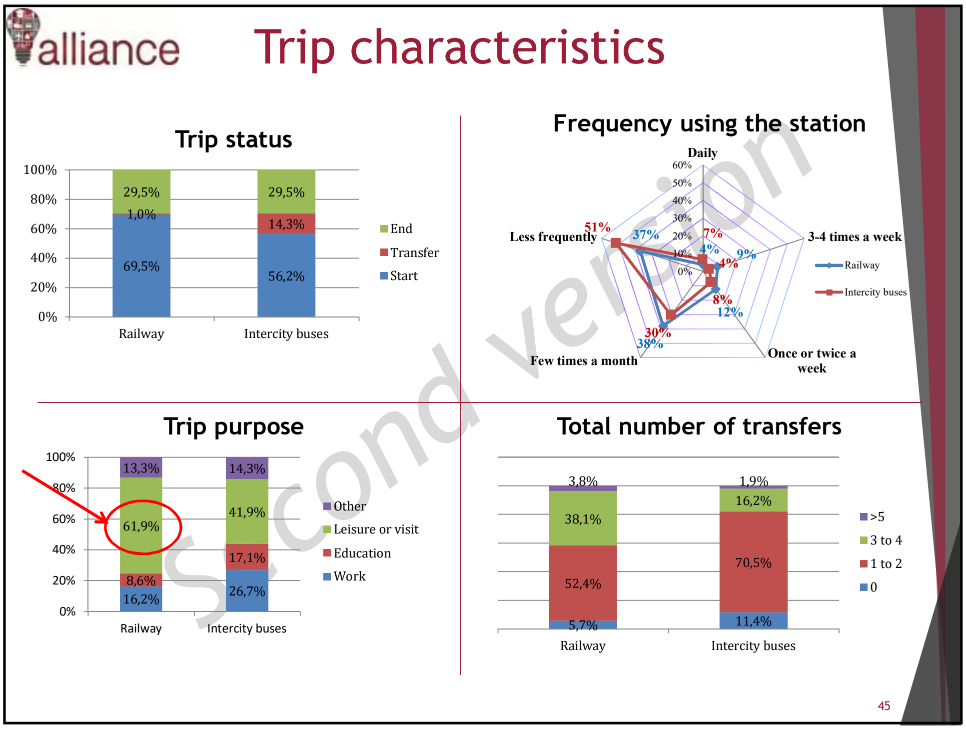
Railway station

- **Development:** 1884
- **Location:** Urban area of Volos
- **Connectivity:** Close to port, city center
- **Surroundings:** Catering/coffee shops, restaurants and super markets
- **Housing:** Intense

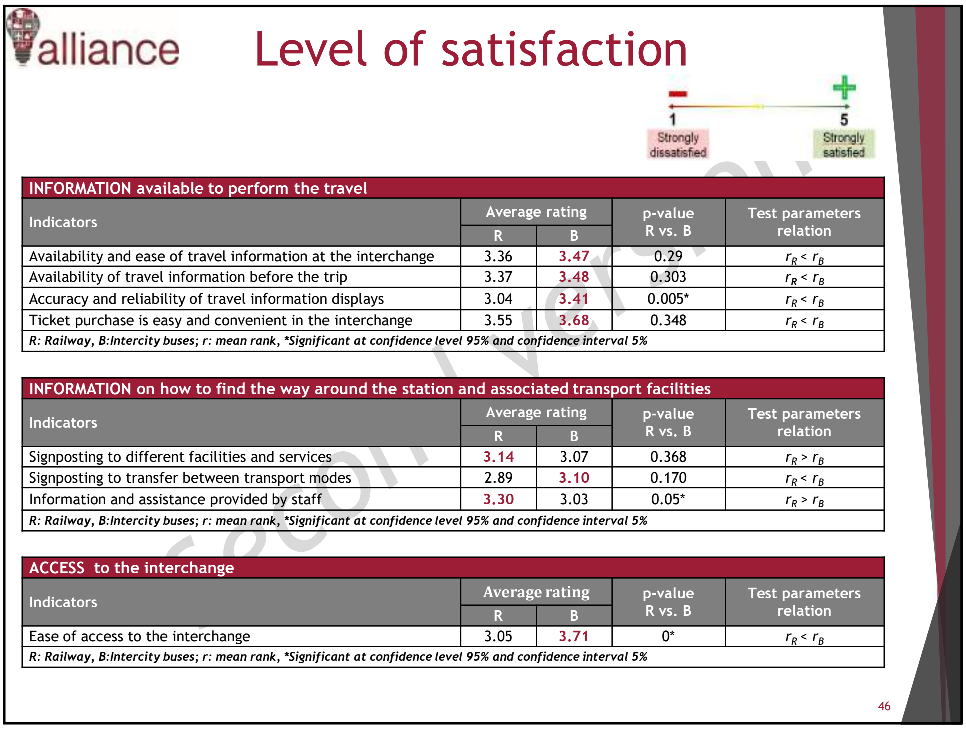
1 km

Intercity bus station

- **Development:** 70’s
- **Re-development:** 90’s
- **Location:** Urban area of Volos
- **Connectivity:** Close to port, city center, local buses terminal, university
- **Surroundings:** Catering/coffee shops
- **Housing:** Not intense



Trip characteristics



Level of satisfaction

INFORMATION available to perform the travel

Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
Availability and ease of travel information at the interchange	3.36	3.47	0.29	$r_R < r_B$
Availability of travel information before the trip	3.37	3.48	0.303	$r_R < r_B$
Accuracy and reliability of travel information displays	3.04	3.41	0.005*	$r_R < r_B$
Ticket purchase is easy and convenient in the interchange	3.55	3.68	0.348	$r_R < r_B$

*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*

INFORMATION on how to find the way around the station and associated transport facilities

Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
Signposting to different facilities and services	3.14	3.07	0.368	$r_R > r_B$
Signposting to transfer between transport modes	2.89	3.10	0.170	$r_R < r_B$
Information and assistance provided by staff	3.30	3.03	0.05*	$r_R > r_B$

*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*

ACCESS to the interchange

Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
Ease of access to the interchange	3.05	3.71	0*	$r_R < r_B$

*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*

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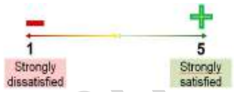
Level of satisfaction



TIME and MOVEMENT inside the interchange

Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
Distances between transport modes	3.02	**3.75**	0*	$r_R < r_B$
Co-ordination between different transport operators or transport services	2.90	**3.19**	0.068	$r_R < r_B$
Use of time at the interchange	2.66	**3.11**	0.001*	$r_R < r_B$
Distance between the facilities and services	2.88	**3.51**	0*	$r_R < r_B$
Ease of movement due to number of people inside the interchange	2.73	**3.58**	0*	$r_R < r_B$

*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*

IMAGE and ATTRACTIVENESS of the station and associated transport facilities

Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
The surrounding area	2.78	**3.11**	0.017*	$r_R < r_B$
The internal design of the interchange	**3.55**	2.78	0*	$r_R > r_B$
The external design of the interchange	**3.88**	2.86	0*	$r_R > r_B$

*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*

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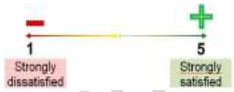
Level of satisfaction



COMFORT and CONVENIENCE inside the interchange

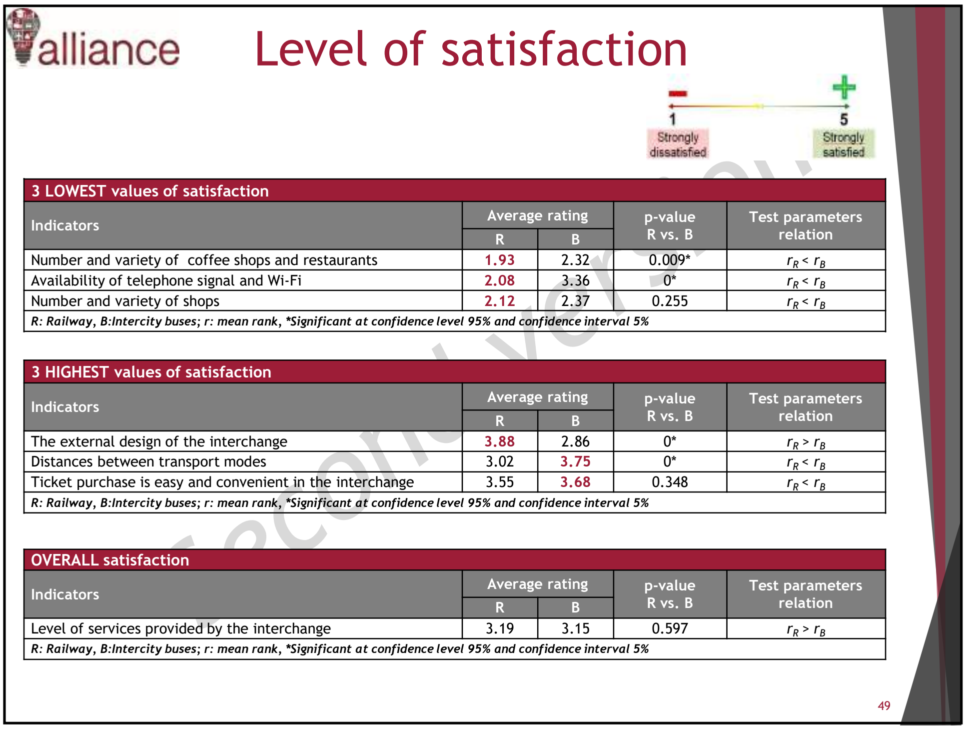
Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
General cleanliness of the interchange	**3.2**	3.02	0.228	$r_R > r_B$
Temperature, shelter from air and wind, etc.	**3.3**	3.14	0.473	$r_R > r_B$
General level of noise of the interchange	**3.3**	2.87	0.002*	$r_R > r_B$
Air quality, pollution, i.e. from vehicles	**3.15**	2.65	0*	$r_R > r_B$
Number and variety of shops	2.12	**2.37**	0.255	$r_R < r_B$
Number and variety of coffee shops and restaurants	1.93	**2.32**	0.009*	$r_R < r_B$
Availability of cash machines	2.28	**2.77**	0.002*	$r_R < r_B$
Availability of machines	2.36	**2.85**	0.001*	$r_R < r_B$
Availability of telephone signal and Wi-Fi	2.08	**3.36**	0*	$r_R < r_B$
General comfort	2.76	**3.04**	0.111	$r_R < r_B$

*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*

EMERGENCY situation in the interchange

Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
Feeling safe based on information displays	**2.81**	2.79	0.557	$r_R > r_B$
Emergency exit signing	2.65	**2.71**	0.832	$r_R < r_B$
Emergency exits in case of fire	2.26	**2.77**	0.002*	$r_R < r_B$

*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*



Level of satisfaction

3 LOWEST values of satisfaction				
Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
Number and variety of coffee shops and restaurants	**1.93**	2.32	0.009*	$r_R < r_B$
Availability of telephone signal and Wi-Fi	**2.08**	3.36	0*	$r_R < r_B$
Number and variety of shops	**2.12**	2.37	0.255	$r_R < r_B$

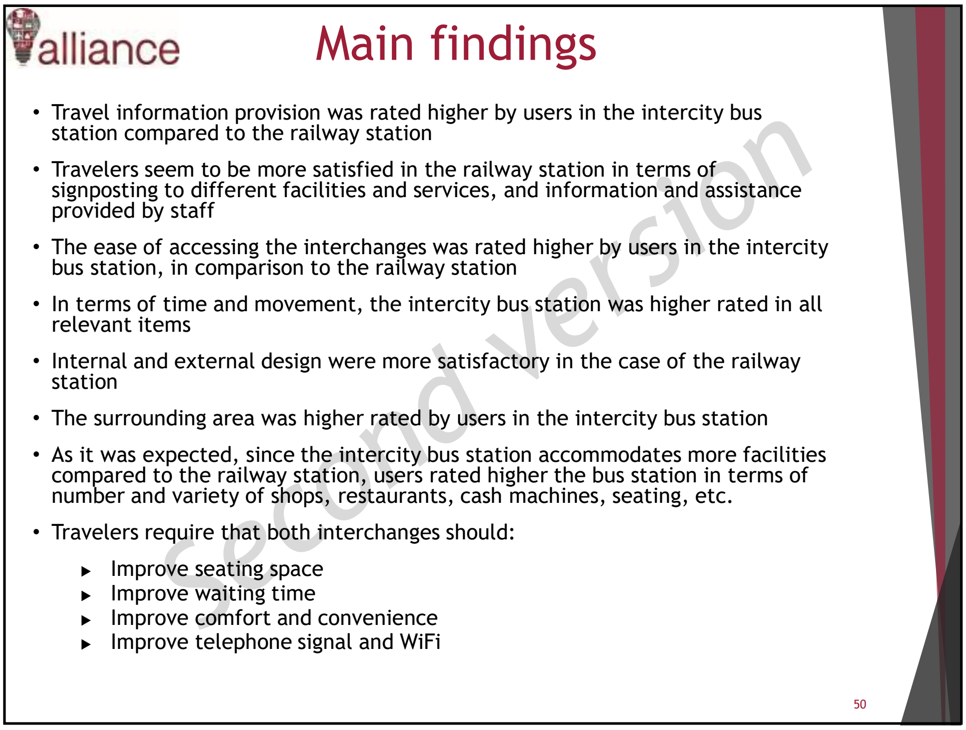
*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*

3 HIGHEST values of satisfaction				
Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
The external design of the interchange	**3.88**	2.86	0*	$r_R > r_B$
Distances between transport modes	3.02	**3.75**	0*	$r_R < r_B$
Ticket purchase is easy and convenient in the interchange	3.55	**3.68**	0.348	$r_R < r_B$

*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*

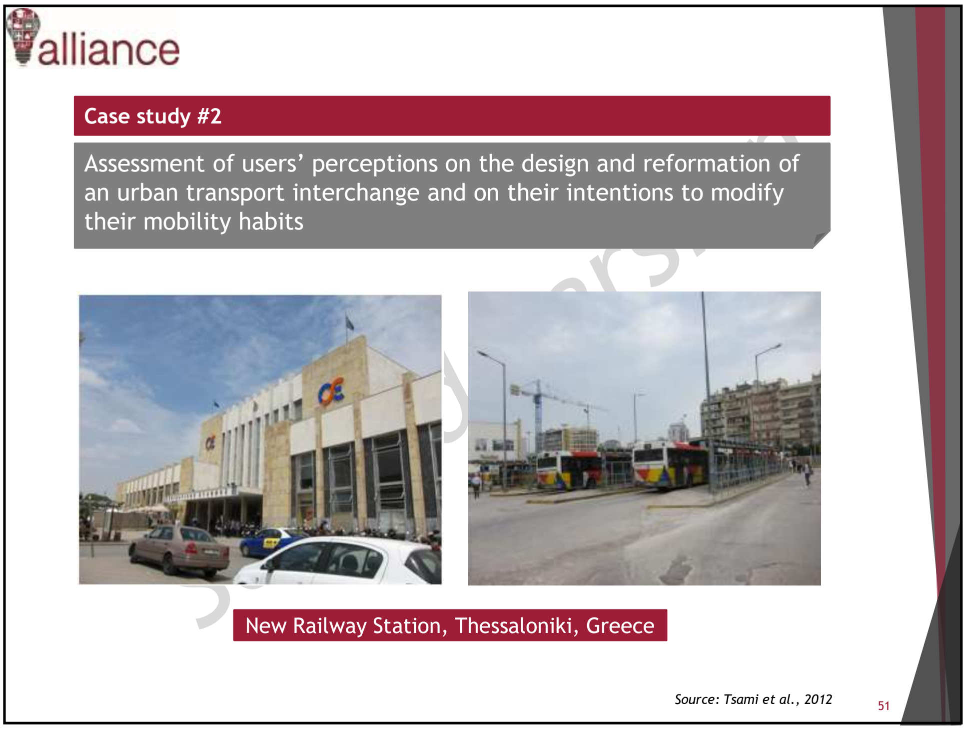
OVERALL satisfaction				
Indicators	Average rating		p-value R vs. B	Test parameters relation
	R	B		
Level of services provided by the interchange	3.19	3.15	0.597	$r_R > r_B$

*R: Railway, B:Intercity buses; r: mean rank, *Significant at confidence level 95% and confidence interval 5%*



Main findings

- Travel information provision was rated higher by users in the intercity bus station compared to the railway station
- Travelers seem to be more satisfied in the railway station in terms of signposting to different facilities and services, and information and assistance provided by staff
- The ease of accessing the interchanges was rated higher by users in the intercity bus station, in comparison to the railway station
- In terms of time and movement, the intercity bus station was higher rated in all relevant items
- Internal and external design were more satisfactory in the case of the railway station
- The surrounding area was higher rated by users in the intercity bus station
- As it was expected, since the intercity bus station accommodates more facilities compared to the railway station, users rated higher the bus station in terms of number and variety of shops, restaurants, cash machines, seating, etc.
- Travelers require that both interchanges should:
  - Improve seating space
  - Improve waiting time
  - Improve comfort and convenience
  - Improve telephone signal and WiFi



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Case study #2

Assessment of users' perceptions on the design and reformation of an urban transport interchange and on their intentions to modify their mobility habits

New Railway Station, Thessaloniki, Greece

Source: Tsami et al., 2012

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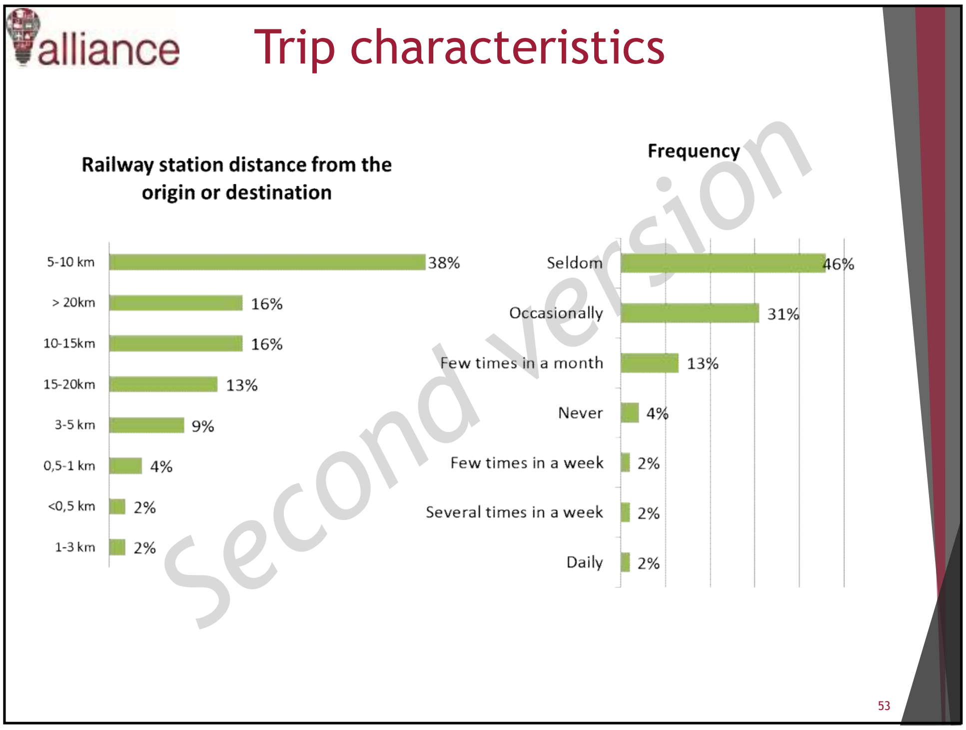
The interchange

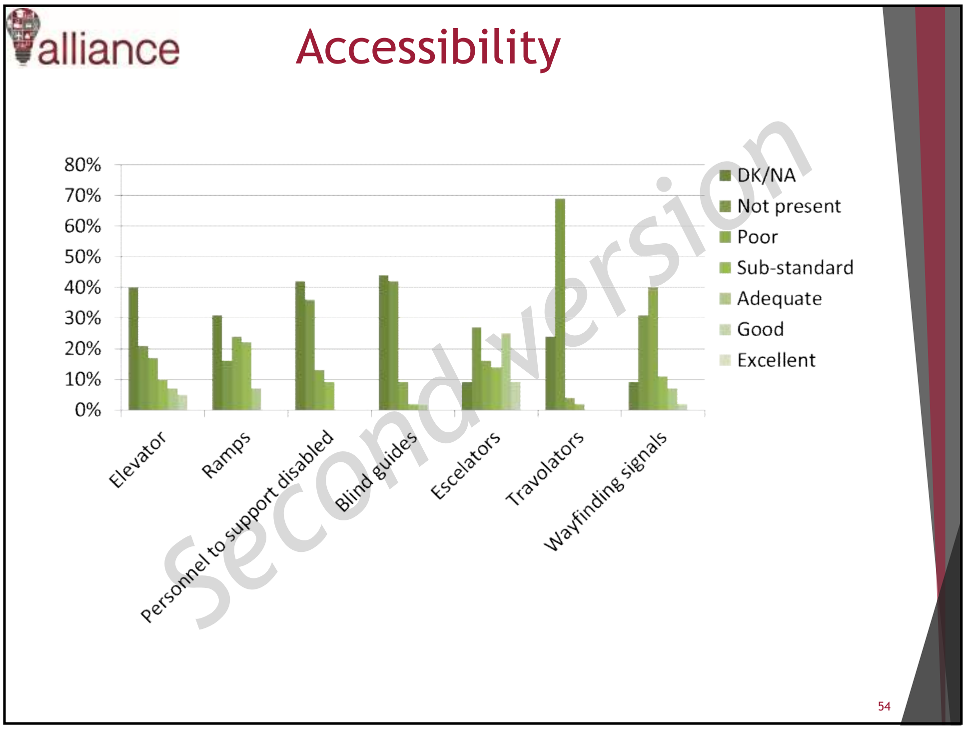
- Location:
  - Thessaloniki urban area
- Transport modes:
  - Commuter rail
  - Interurban rail
  - Metro (under construction)
  - Local buses
  - Suburban buses
  - Interurban buses
  - Taxis
  - Bicycle paths
  - Park and ride
  - Kiss and ride



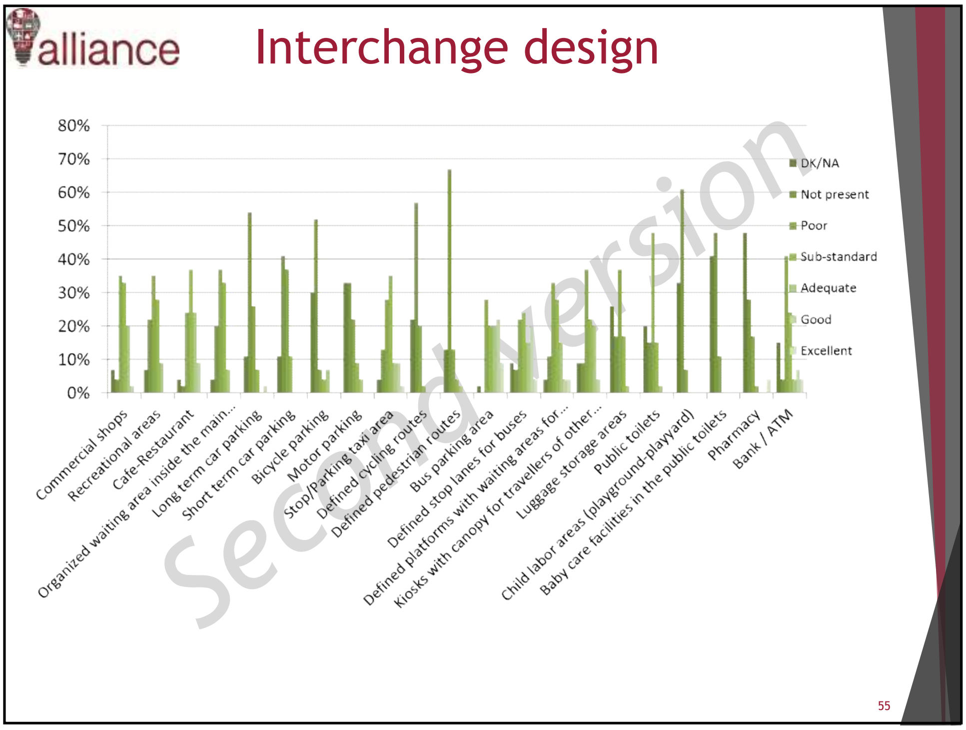
Trip characteristics

Railway station distance from the origin or destination

Frequency



Accessibility



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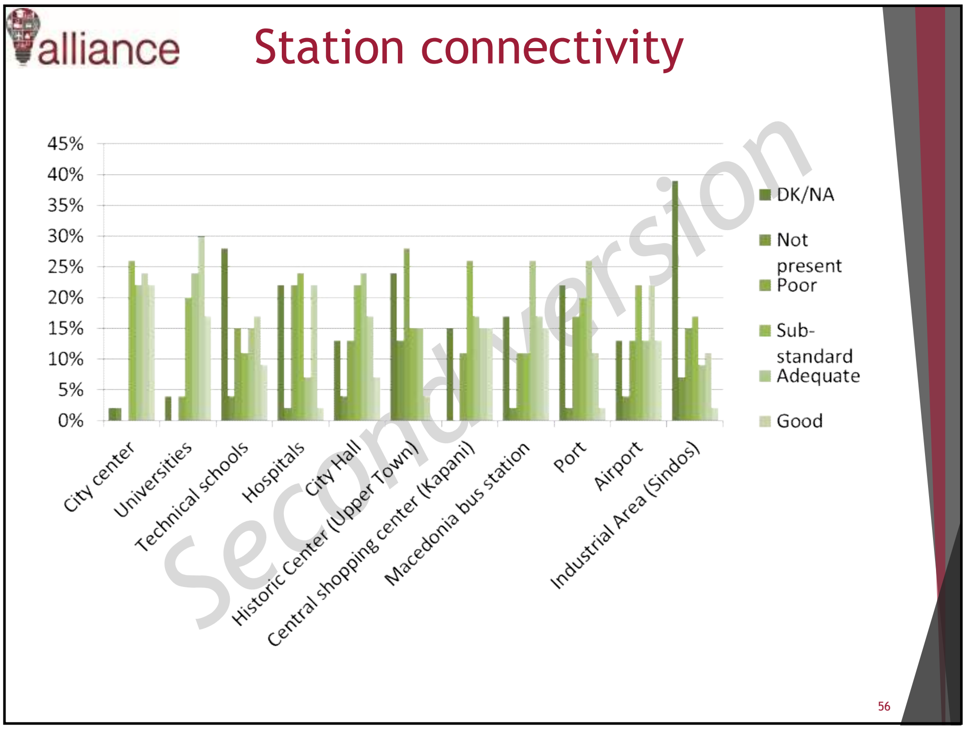
Interchange design



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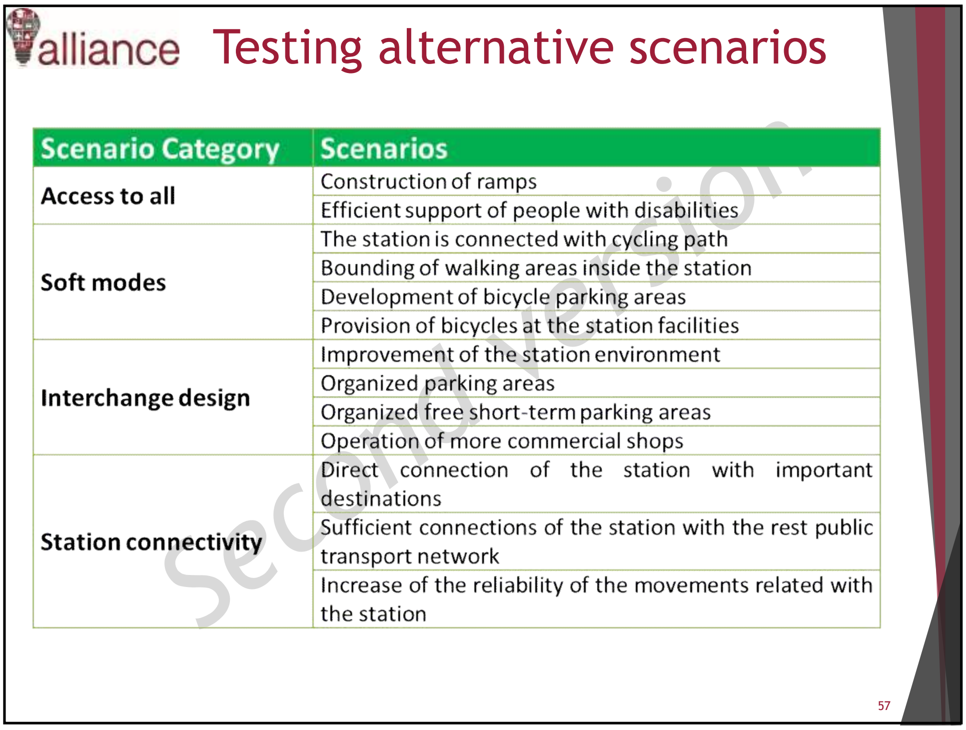
Station connectivity



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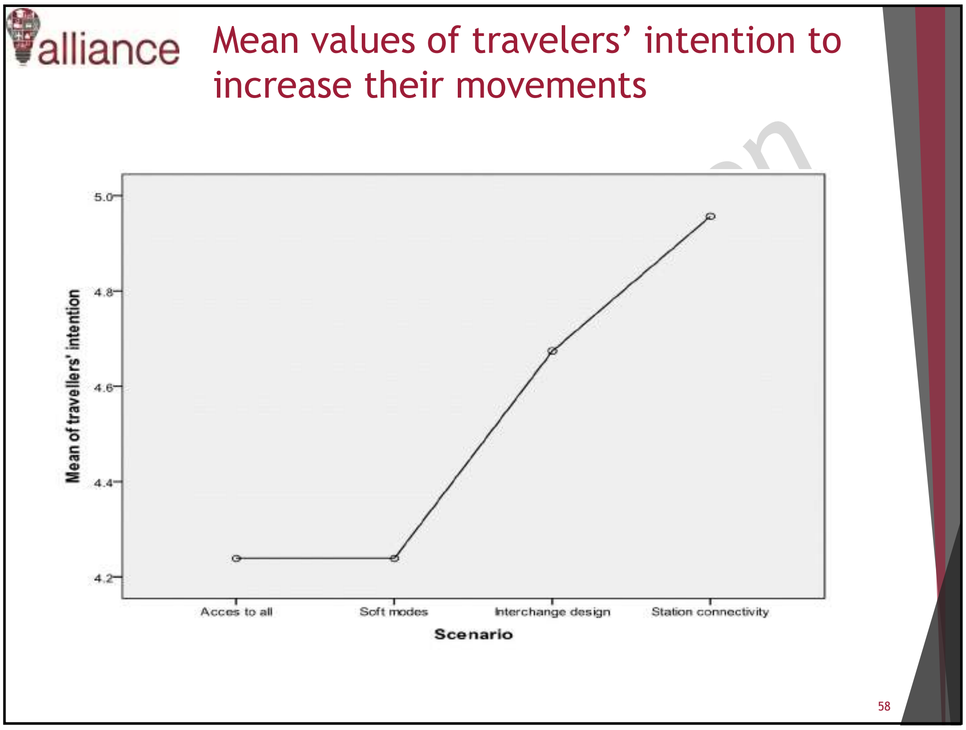
Testing alternative scenarios

Scenario Category	Scenarios
Access to all	Construction of ramps
	Efficient support of people with disabilities
Soft modes	The station is connected with cycling path
	Bounding of walking areas inside the station
	Development of bicycle parking areas
	Provision of bicycles at the station facilities
Interchange design	Improvement of the station environment
	Organized parking areas
	Organized free short-term parking areas
	Operation of more commercial shops
Station connectivity	Direct connection of the station with important destinations
	Sufficient connections of the station with the rest public transport network
	Increase of the reliability of the movements related with the station



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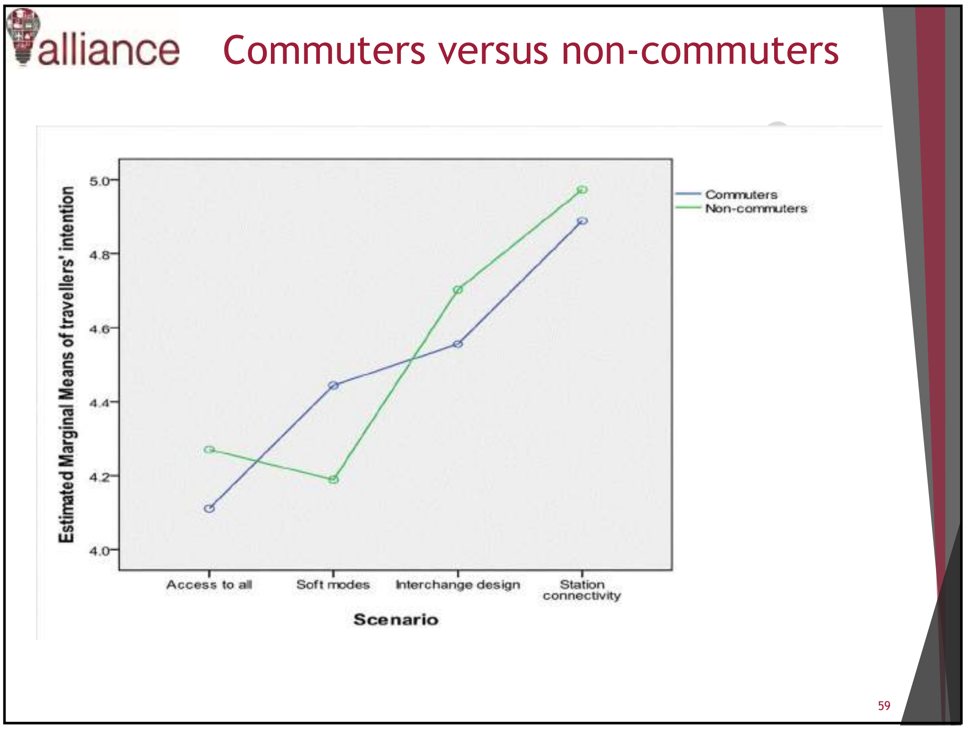
Mean values of travelers' intention to increase their movements



Commuters versus non-commuters

Men versus women

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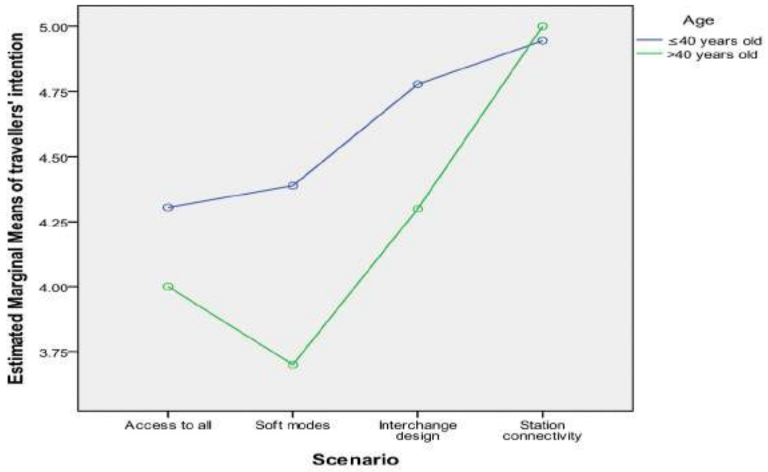
Younger versus older users



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Main findings

- Most of the respondents addressed the absence of appropriate infrastructure for walking and cycling, and highlighted the need for the reformation of the station
- Station connectivity scenarios are the most likely to modify users mobility habits
- Women, compared to men, are more intended to change their mobility behavior under the scenarios testing “access to all”, “interchange design” and “station connectivity”.

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Guidance to further knowledge acquisition

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Suggested literature

- Auckland Transport, 2013. Public Transport Interchange Design Guidelines, Auckland Transport, Auckland.
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- Transport for London, 2009. Interchange Best Practice Guidelines, Transport for London, London.

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- City-HUB, 2013. City-HUB Deliverable D3.2. Guide for efficient and smart design.
- CITY-HUBs: Sustainable and Efficient Interchange Stations. Taylor and Francis Group, 2015.
- Tsami, M., Adamos, G. & Nathanail, E., 2013. Sustainable development design for the transformation of the Thessaloniki's railway station into a city hub. European Transport Conference (ETC) 2013, Frankfurt, Germany, 30 September – 2 October 2013.

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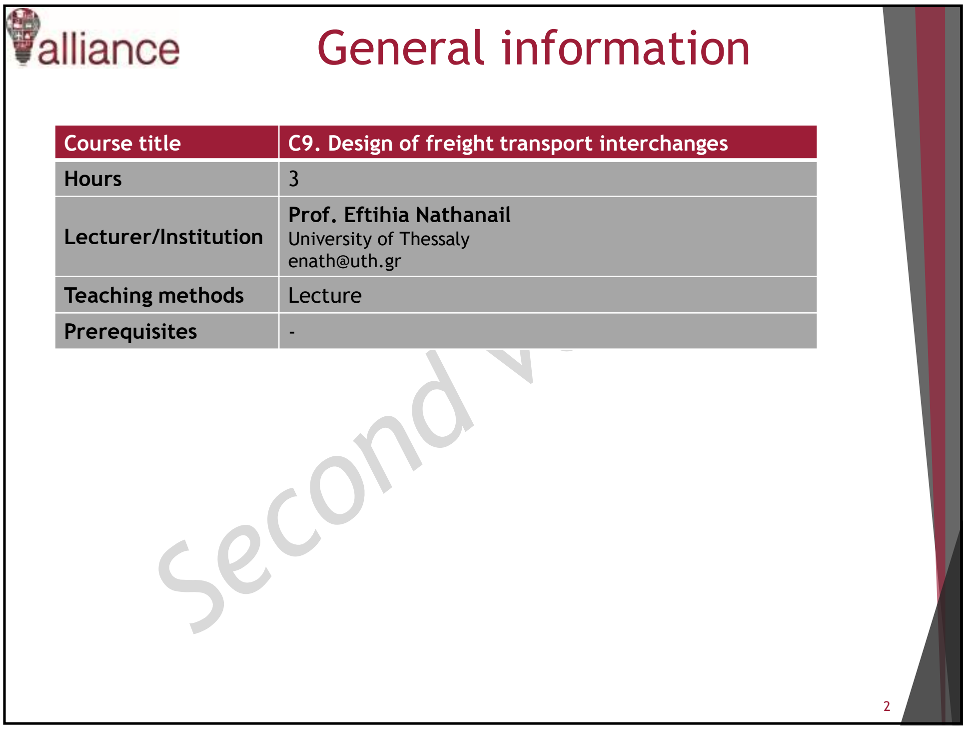
Design of freight transport interchanges

Assoc. Professor Eftihia Nathanail
University of Thessaly (UTh), Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



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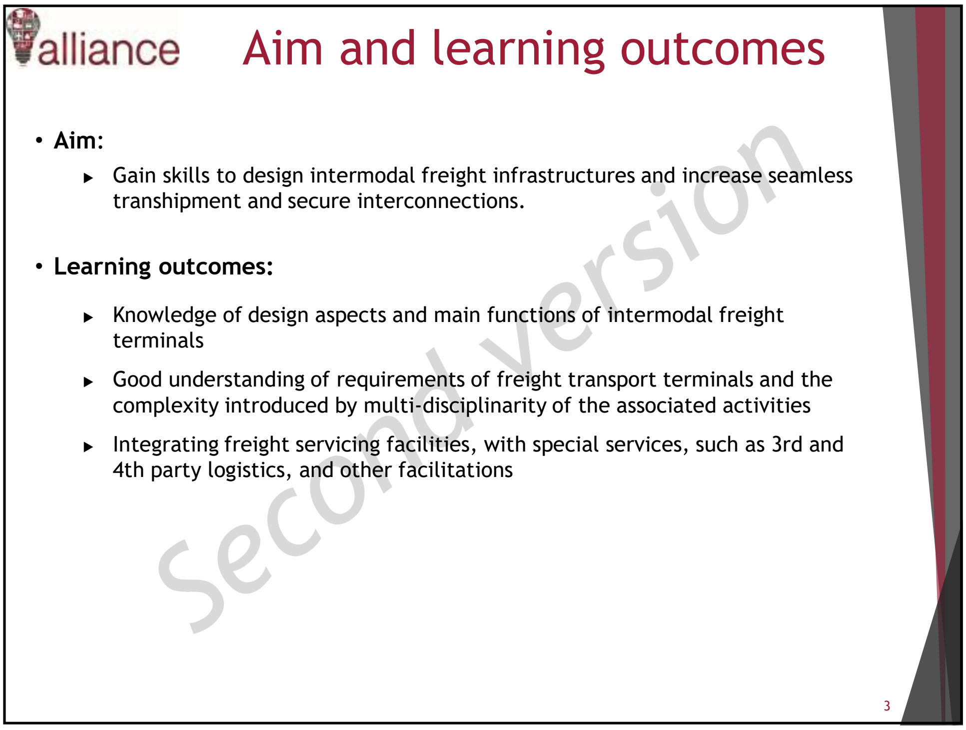
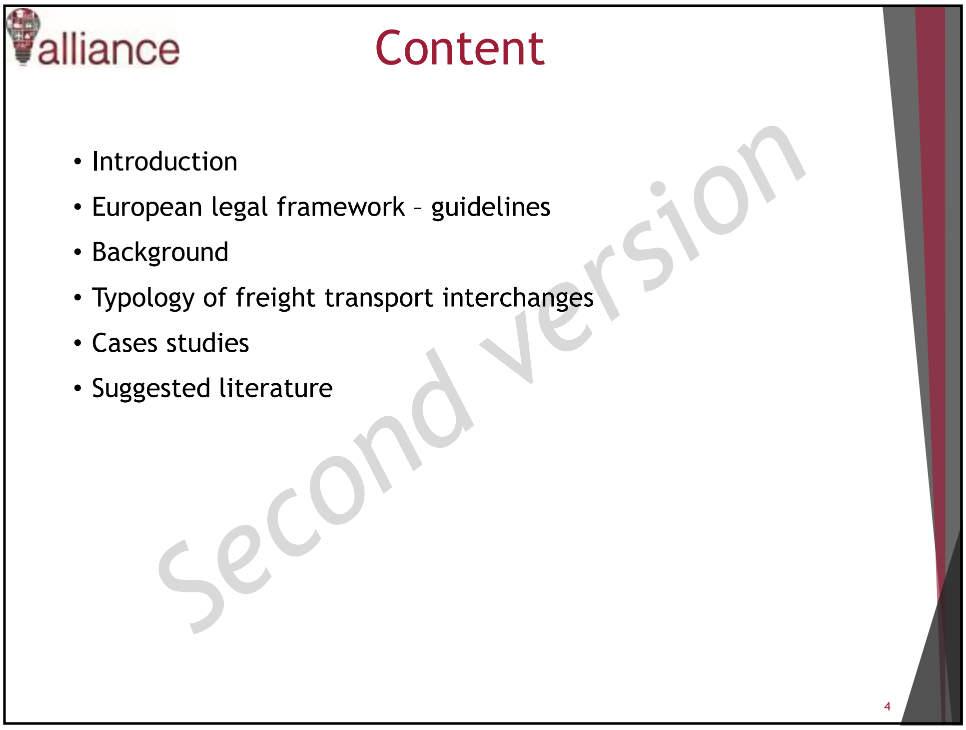
General information

Course title	C9. Design of freight transport interchanges
Hours	3
Lecturer/Institution	**Prof. Eftihia Nathanail** University of Thessaly enath@uth.gr
Teaching methods	Lecture
Prerequisites	-



Aim and learning outcomes

- **Aim:**
  - Gain skills to design intermodal freight infrastructures and increase seamless transhipment and secure interconnections.
- **Learning outcomes:**
  - Knowledge of design aspects and main functions of intermodal freight terminals
  - Good understanding of requirements of freight transport terminals and the complexity introduced by multi-disciplinarity of the associated activities
  - Integrating freight servicing facilities, with special services, such as 3rd and 4th party logistics, and other facilitations



Content

- Introduction
- European legal framework – guidelines
- Background
- Typology of freight transport interchanges
- Cases studies
- Suggested literature

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Introduction

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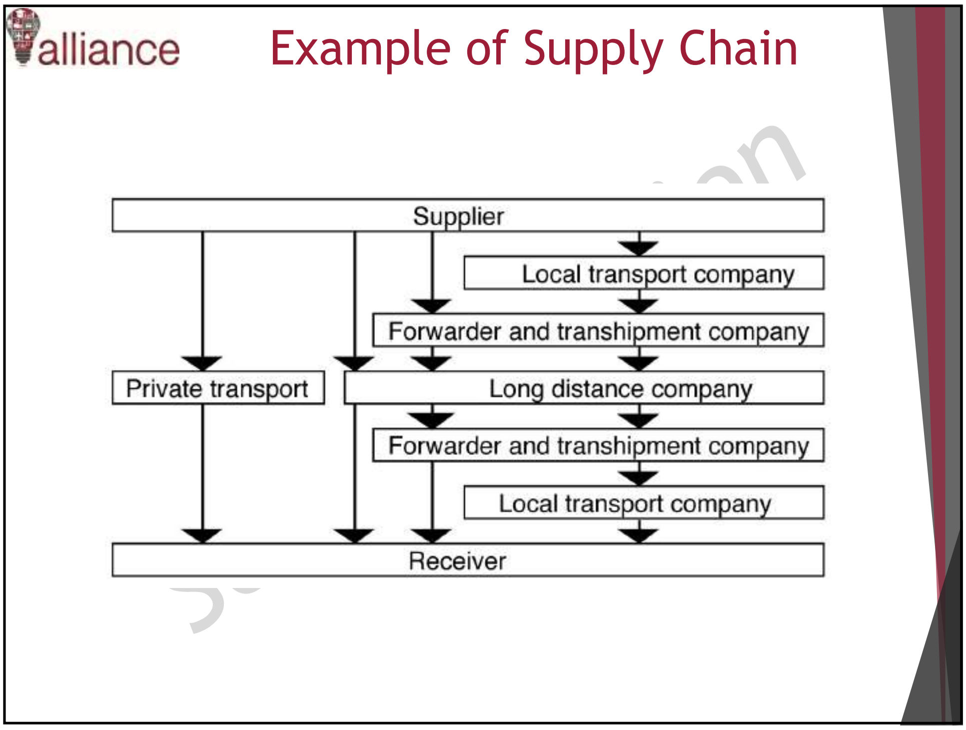
Supply Chain

Sequence of events and organization procedures under which goods are being transfered from an origin (supplier) to a destination (receiver)



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Example of Supply Chain

Supplier

Local transport company

Forwarder and transhipment company

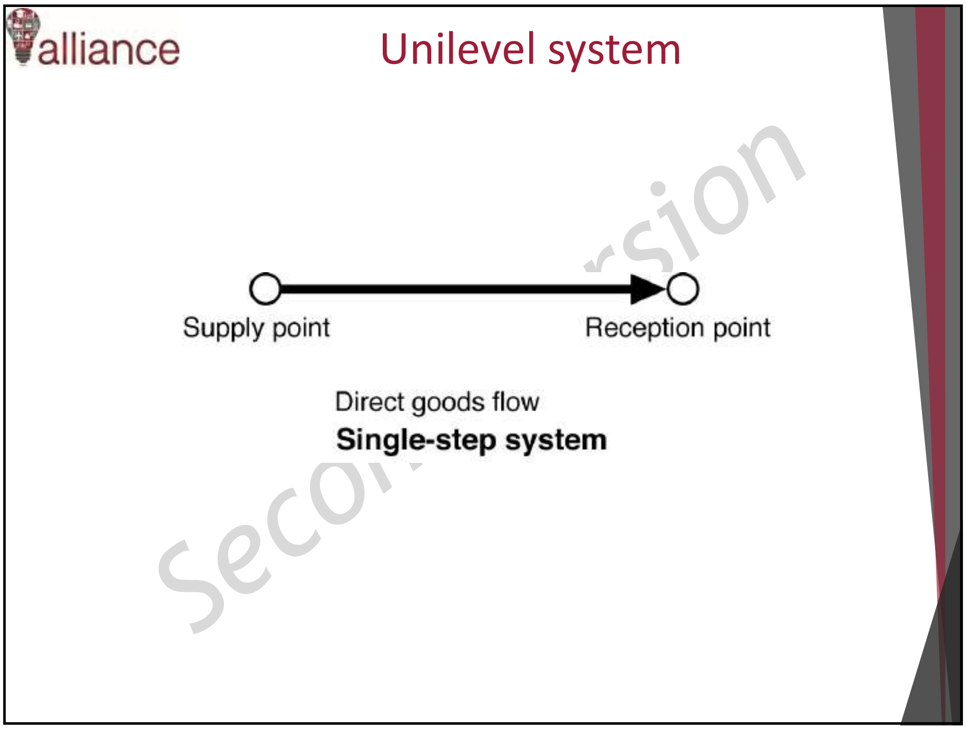
Private transport

Long distance company

Forwarder and transhipment company

Local transport company

Receiver



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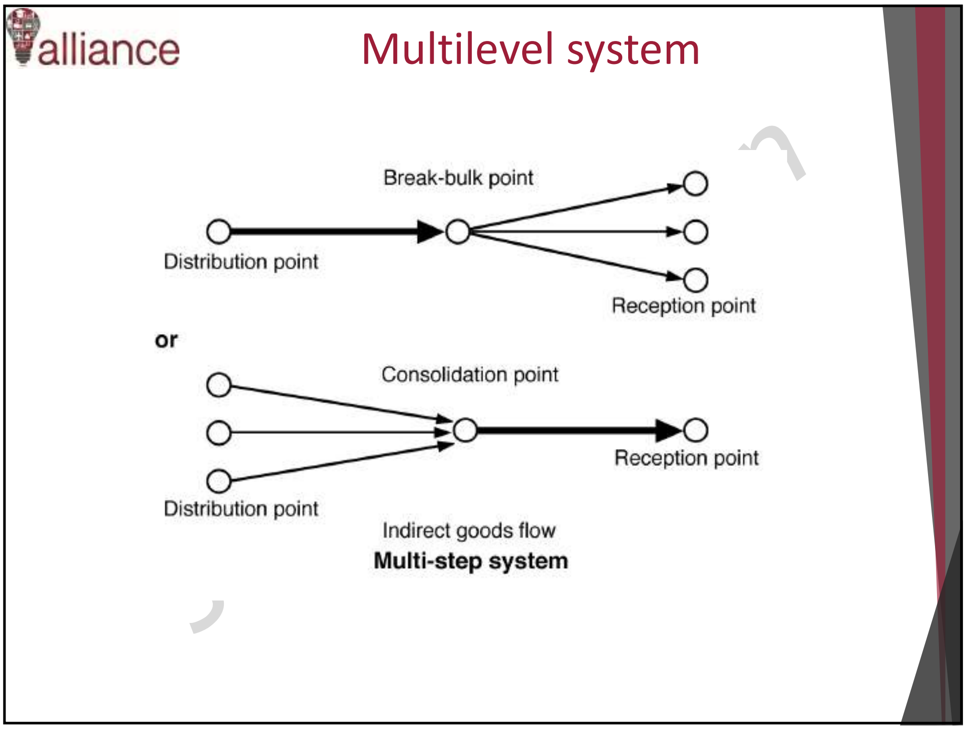
Unilevel system

Supply point

Reception point

Direct goods flow

Single-step system



Multilevel system

Break-bulk point

Distribution point

Reception point

or

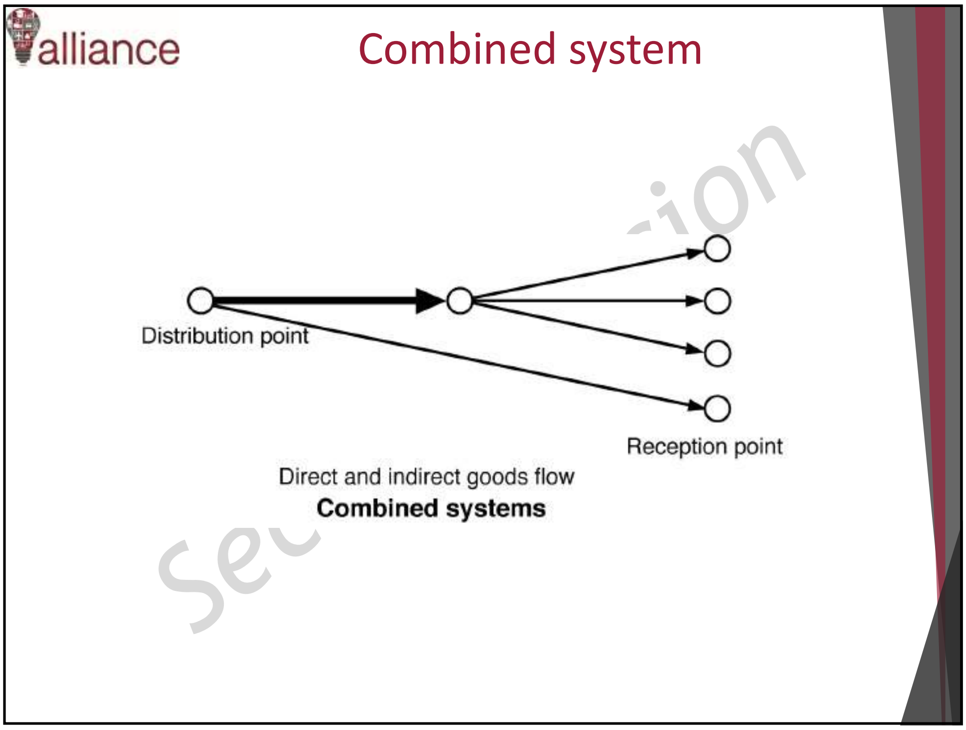
Consolidation point

Reception point

Distribution point

Indirect goods flow

Multi-step system



Combined system

Distribution point

Reception point

Direct and indirect goods flow

Combined systems

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Terminology

- According to European Community Directive 92/106/EEC **combined** transportation is
  - transportation of goods with various transportation modes
  - Bigger part of travel on rail or inland waterways or see or air
  - First and last parts on road
- **Multi-modal** transportation indicates usage of more than one modes for transportation
- **Intermodal** transport assumes transportation same transportation unit by transferring it among modes

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Freight Transport Interchanges

- *Freight transport interchanges are nodal points on the transportation network which contribute to the seamless transportation of goods, maximizing transportation adequacy, achieving customer satisfaction and ensuring system efficiency for door-to-door transportation, through the optimum combination of transportation modes in the most sustainable way.*
- *They are managed by public and/or private body(ies), and all activities including transport, handling and distribution of cargo are operated by several transport and logistics providers, established at the facilities.*

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European legal framework for industrial building

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Legislation Framework

REGULATION (EU) No 1315/2013 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on Union guidelines for the development of the trans-European transport network and repealing Decision No 661/2010/EU

Definitions

'freight terminal': *a structure equipped for transshipment between at least two transport modes or between two different rail systems, and for temporary storage of freight, such as ports, inland ports, airports and rail-road terminals;*

'logistic platform': *an area which is directly linked to the transport infrastructure of the trans-European transport network including at least one* ***freight terminal****, and which enables logistics activities to be carried out;*

'urban node': *an urban area where the transport infrastructure of the trans-European transport network, such as ports including passenger terminals, airports, railway stations,* ***logistic platforms*** *and* ***freight terminals*** *located in and around an urban area, is connected with other parts of that infrastructure and with the infrastructure for regional and local traffic;*

Legislation Framework

EU Regulation on Union guidelines for the development of the trans-European transport network and repealing

According to:

• **Section 11**- Railway Transport Infrastructure/ **Article 11**- Infrastructure components

• Railway transport infrastructure shall comprise, in particular:

▶ freight terminals and logistic platforms for the transshipment of goods within the rail mode and between rail and other transport modes;

▶ the connections of stations, freight terminals and logistic platforms to the other modes in the trans-European transport network;

• The technical equipment associated with railway lines may include electrification systems, equipment for the boarding and alighting of passengers and the loading and unloading of cargo in stations, logistic platforms and freight terminals. It may include any facility, such as automatic gauge-changing facilities for rail, necessary to ensure the safe, secure and efficient operation of vehicles, including their reduced impact on the environment and improved interoperability.

Legislation Framework

EU Regulation on Union guidelines for the development of the trans-European transport network and repealing

According to:

• **Section 11**- Railway Transport Infrastructure/ **Article 12**- Transport infrastructure requirements

▶ Freight terminals shall be connected with the road infrastructure or, where possible, the inland waterway infrastructure of the comprehensive network.

• **Section 2**- Inland waterways transport infrastructure/ **Article 14**- Infrastructure components

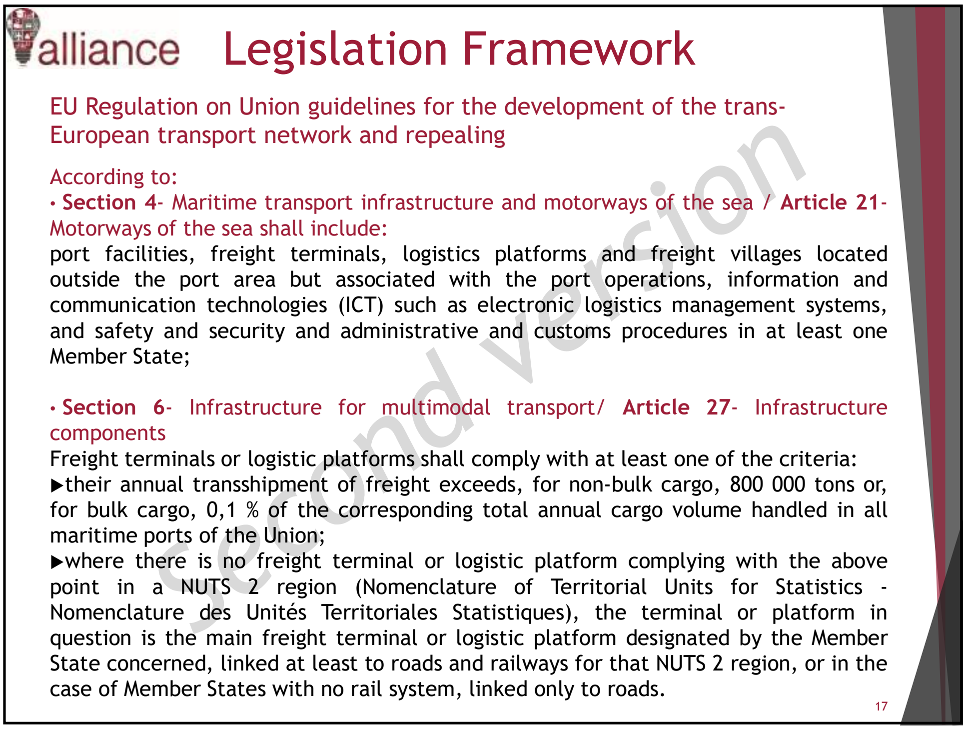
▶ Inland ports shall offer at least one freight terminal open to all operators in a non-discriminatory way and shall apply transparent charges.

• **Section 3**- Road transport infrastructure/ **Article 17**- Infrastructure components

Road transport infrastructure shall comprise, in particular:

▶ Freight terminals and logistic platforms;

▶ The connections of the freight terminals and logistic platforms to the other modes in the trans-European transport network;



Legislation Framework

EU Regulation on Union guidelines for the development of the trans-European transport network and repealing

According to:

- **Section 4**- Maritime transport infrastructure and motorways of the sea / **Article 21**- Motorways of the sea shall include:

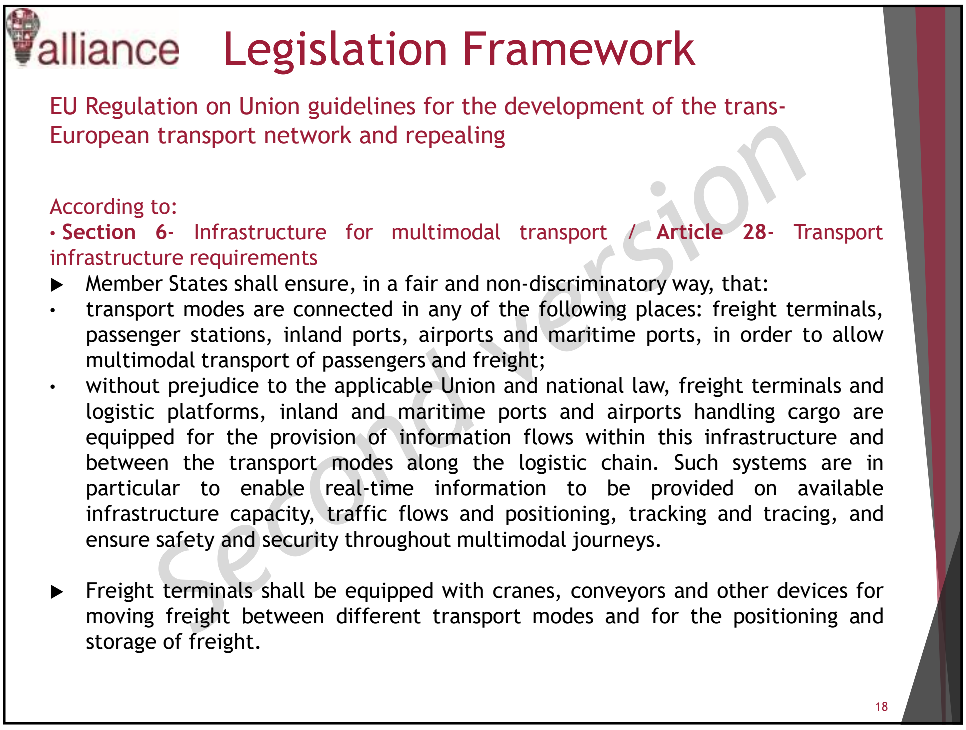
port facilities, freight terminals, logistics platforms and freight villages located outside the port area but associated with the port operations, information and communication technologies (ICT) such as electronic logistics management systems, and safety and security and administrative and customs procedures in at least one Member State;

- **Section 6**- Infrastructure for multimodal transport/ **Article 27**- Infrastructure components

Freight terminals or logistic platforms shall comply with at least one of the criteria:

▶their annual transshipment of freight exceeds, for non-bulk cargo, 800 000 tons or, for bulk cargo, 0,1 % of the corresponding total annual cargo volume handled in all maritime ports of the Union;

▶where there is no freight terminal or logistic platform complying with the above point in a NUTS 2 region (Nomenclature of Territorial Units for Statistics - Nomenclature des Unités Territoriales Statistiques), the terminal or platform in question is the main freight terminal or logistic platform designated by the Member State concerned, linked at least to roads and railways for that NUTS 2 region, or in the case of Member States with no rail system, linked only to roads.



Legislation Framework

EU Regulation on Union guidelines for the development of the trans-European transport network and repealing

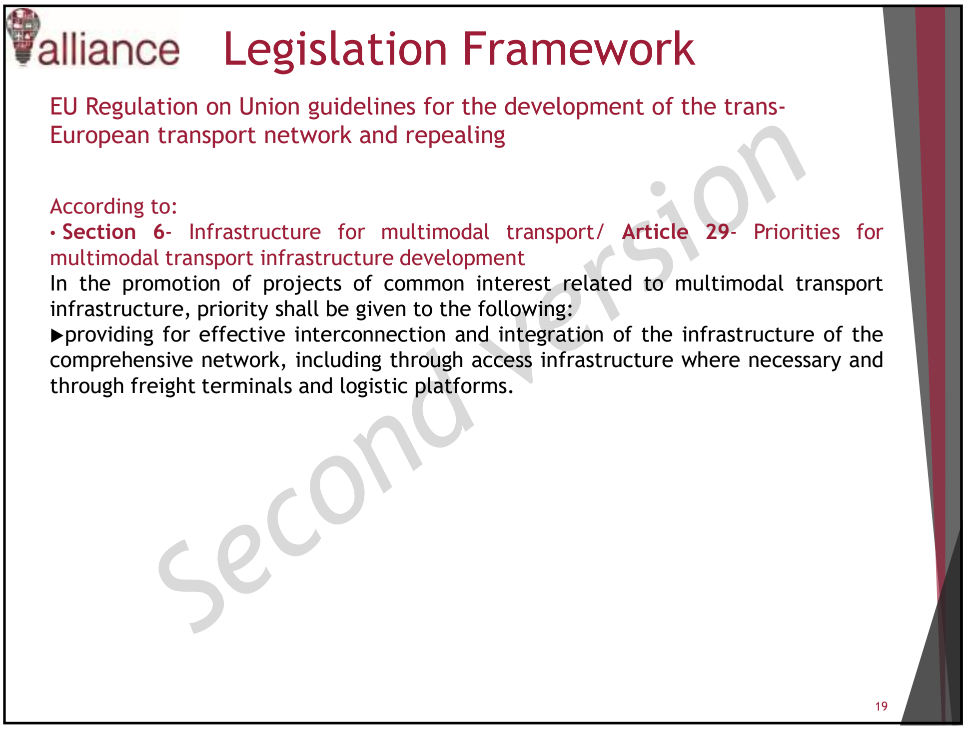
According to:

- **Section 6**- Infrastructure for multimodal transport / **Article 28**- Transport infrastructure requirements

▶ Member States shall ensure, in a fair and non-discriminatory way, that:

- transport modes are connected in any of the following places: freight terminals, passenger stations, inland ports, airports and maritime ports, in order to allow multimodal transport of passengers and freight;
- without prejudice to the applicable Union and national law, freight terminals and logistic platforms, inland and maritime ports and airports handling cargo are equipped for the provision of information flows within this infrastructure and between the transport modes along the logistic chain. Such systems are in particular to enable real-time information to be provided on available infrastructure capacity, traffic flows and positioning, tracking and tracing, and ensure safety and security throughout multimodal journeys.

▶ Freight terminals shall be equipped with cranes, conveyors and other devices for moving freight between different transport modes and for the positioning and storage of freight.



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Legislation Framework

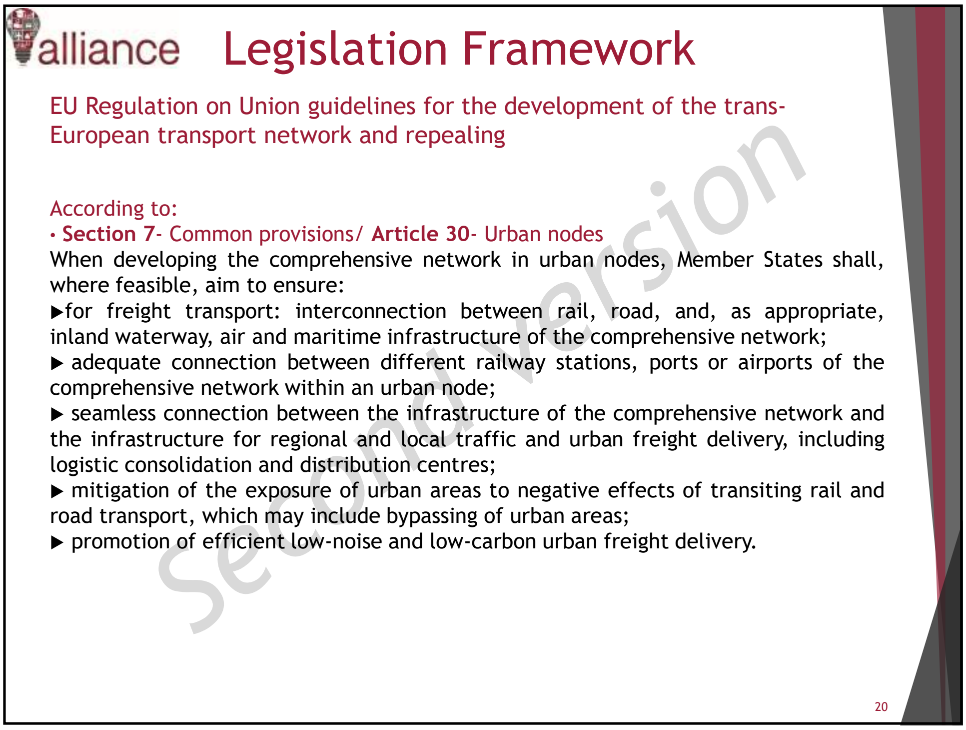
EU Regulation on Union guidelines for the development of the trans-European transport network and repealing

According to:

- **Section 6**- Infrastructure for multimodal transport/ **Article 29**- Priorities for multimodal transport infrastructure development

In the promotion of projects of common interest related to multimodal transport infrastructure, priority shall be given to the following:

▶providing for effective interconnection and integration of the infrastructure of the comprehensive network, including through access infrastructure where necessary and through freight terminals and logistic platforms.



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Legislation Framework

EU Regulation on Union guidelines for the development of the trans-European transport network and repealing

According to:

- **Section 7**- Common provisions/ **Article 30**- Urban nodes

When developing the comprehensive network in urban nodes, Member States shall, where feasible, aim to ensure:

▶for freight transport: interconnection between rail, road, and, as appropriate, inland waterway, air and maritime infrastructure of the comprehensive network;

▶ adequate connection between different railway stations, ports or airports of the comprehensive network within an urban node;

▶ seamless connection between the infrastructure of the comprehensive network and the infrastructure for regional and local traffic and urban freight delivery, including logistic consolidation and distribution centres;

▶ mitigation of the exposure of urban areas to negative effects of transiting rail and road transport, which may include bypassing of urban areas;

▶ promotion of efficient low-noise and low-carbon urban freight delivery.

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Background

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History

- Since 1980s efforts for individual or network of freight centers (FC)
- Operation based on private, public of public – private partnerships
- Based or not on strategic planning
- Serving private or public operations
- Supporting specific modal combinations
- Providing added value services and other servicing areas

Facilities

- 60 units in USA and 100 units in Europe:
  1. France (Plates formes logistiques / Centres logistiques de fret)
  2. Italy (Interporti)
  3. Germany (Güterverkehrszentren – GVZ)
  4. Spain (Centro de transport ή Plataforma logistica / Parco logistico)
  5. Great Britain (Freight villages)
  6. The Netherlands (Trade ports)
  7. Denmark (Transport centers)
  8. Austria (Cargo centers)
- Individual FC in Eastern Asia (China, Japan, Tailand, Filippines), Australia

Development

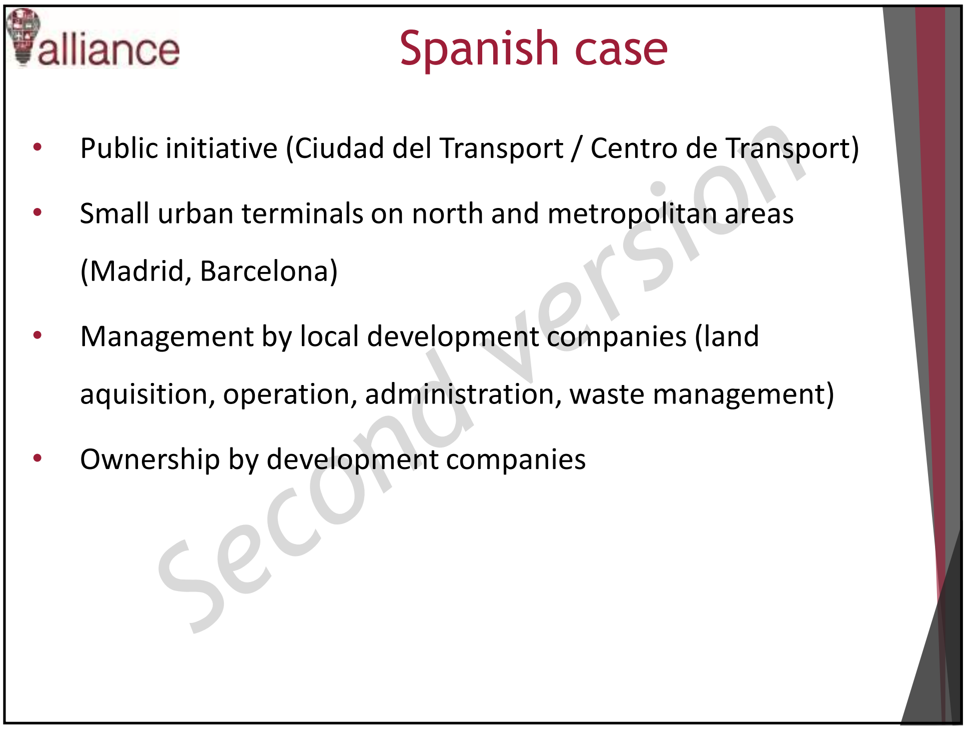
- Private initiative (USA, Germany, G. Britain, Italy)
- Governmental involvement (Spain, Australia)
- Most popular scheme: Public Private Partnerships – PPP
  - Private initiative
  - Supported by the state

French Case

- Development of Plates Formes Logistiques from Gares Routieres around Paris
- Objective: traffic problems alleviation, facilitation of urban distribution, replacement of big with smaller vehicles
- Initiative: SOGARIS, GARONOR – later PROLOGIS (development actors for limited time until administration passed onto public sector)
- Planning, organizing, operation by SOGARIS & PROLOGIS
- Funding from own sources, renting land and equipment

German Case

- Measure towards increasing traffic
- Provision of logistics services and added-value services
- Improving productivity
- Planning of GVZ by local and regional authorities
- Operating by associations and development companies
- Funding from own sources, national and European funds



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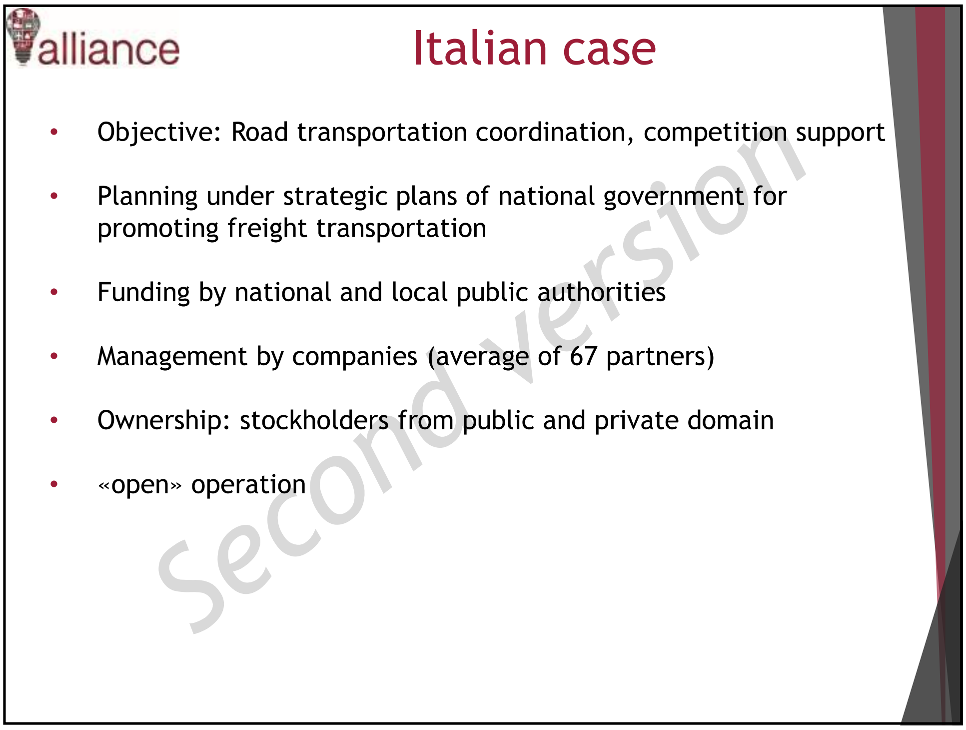
Spanish case

- Public initiative (Ciudad del Transport / Centro de Transport)
- Small urban terminals on north and metropolitan areas (Madrid, Barcelona)
- Management by local development companies (land aquisition, operation, administration, waste management)
- Ownership by development companies



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Italian case

- Objective: Road transportation coordination, competition support
- Planning under strategic plans of national government for promoting freight transportation
- Funding by national and local public authorities
- Management by companies (average of 67 partners)
- Ownership: stockholders from public and private domain
- «open» operation

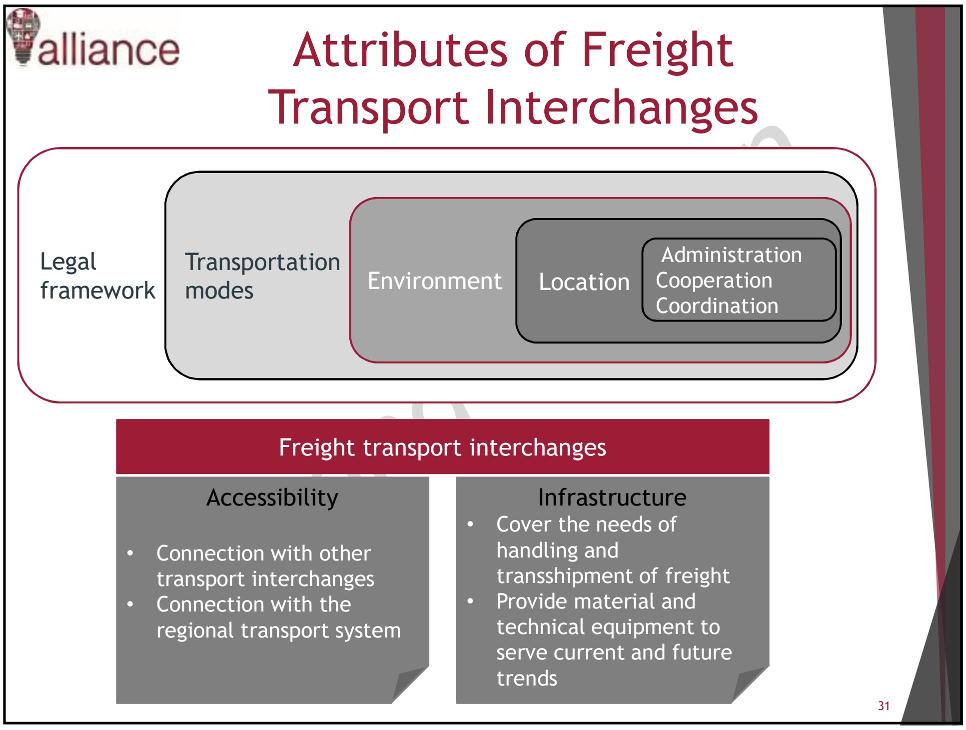
Europlatforms

- Provision of information
- Establishment and improvement of networking
- Promotion of intermodal supply chains
- Communication policy support
- Initiatives for innovative development

Requirements for Europlatforms' members

- «Open» centers
- Public facilities charged to private companies
- Common legal representation
- Support of intermodal transportation

Typology of Freight Transport Interchanges



Attributes of Freight Transport Interchanges

Legal framework

Transportation modes

Environment

Location

Administration
Cooperation
Coordination

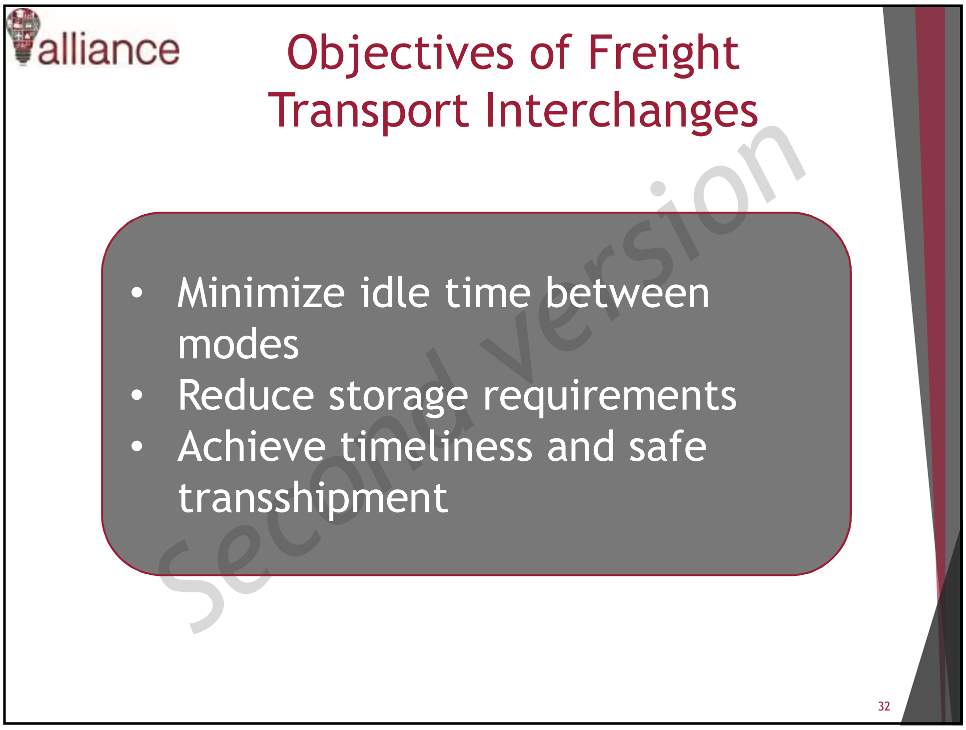
Freight transport interchanges

Accessibility

- Connection with other transport interchanges
- Connection with the regional transport system

Infrastructure

- Cover the needs of handling and transshipment of freight
- Provide material and technical equipment to serve current and future trends



Objectives of Freight Transport Interchanges

- Minimize idle time between modes
- Reduce storage requirements
- Achieve timeliness and safe transshipment

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Success parameters

- High specifications' transportation networks
- Completeness and density of transportation connections towards railway stations and ports
- High volumes of cargo (and unitized cargo - containerization)
- Well organized logistics chain
- Experience in co-financed projects

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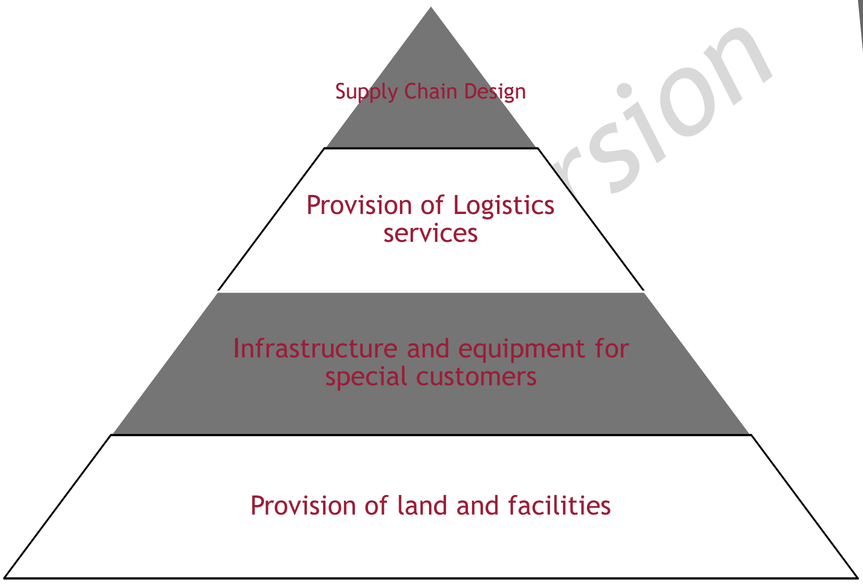
Pyramid of development


Supply Chain Design

Provision of Logistics services

Infrastructure and equipment for special customers

Provision of land and facilities

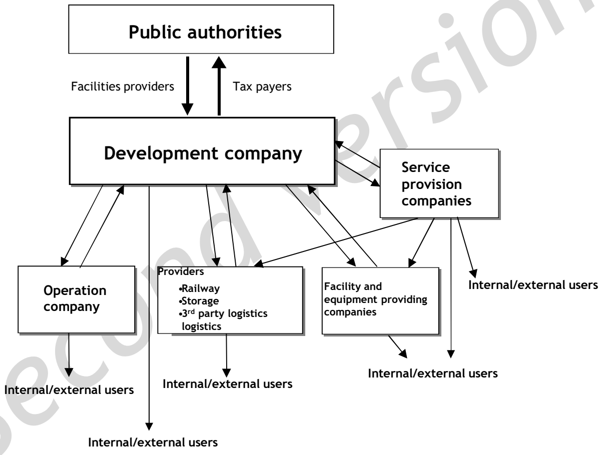
Stages of development

- Land aquisition
- Planning (facilities, equipment, services)
- Ownership
- Construction
- Operation - management

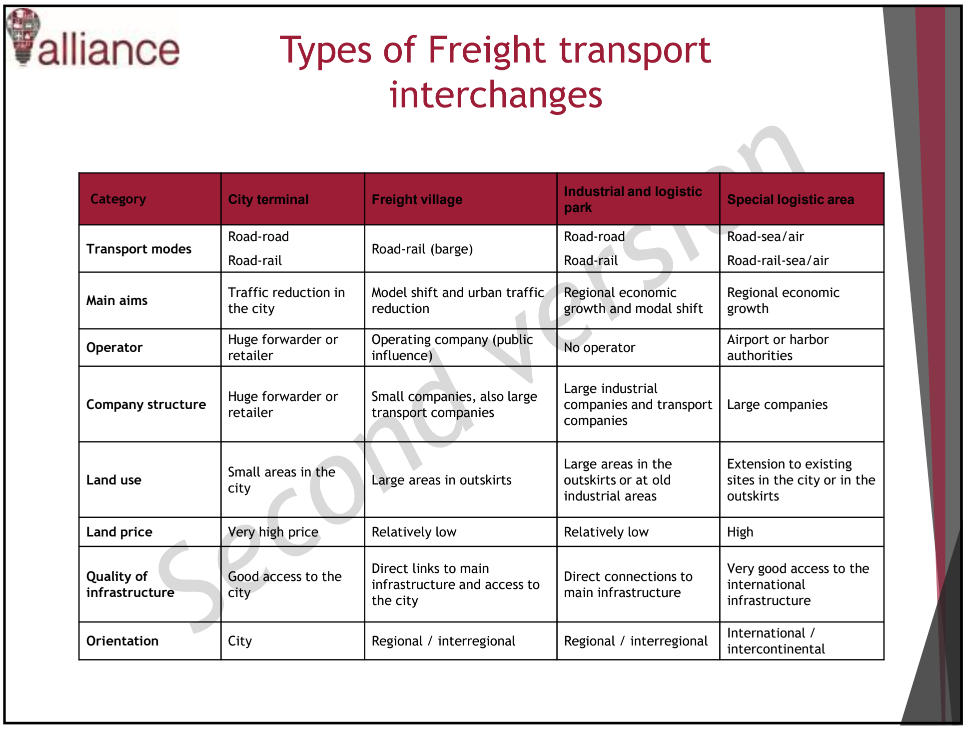
Size

- Small (up to 50000 sqm)
- Medium (50000 sqm – 500000 sqm)
- Large (over 500000 sqm)

Development model



Source: EDEK, 2002-2003



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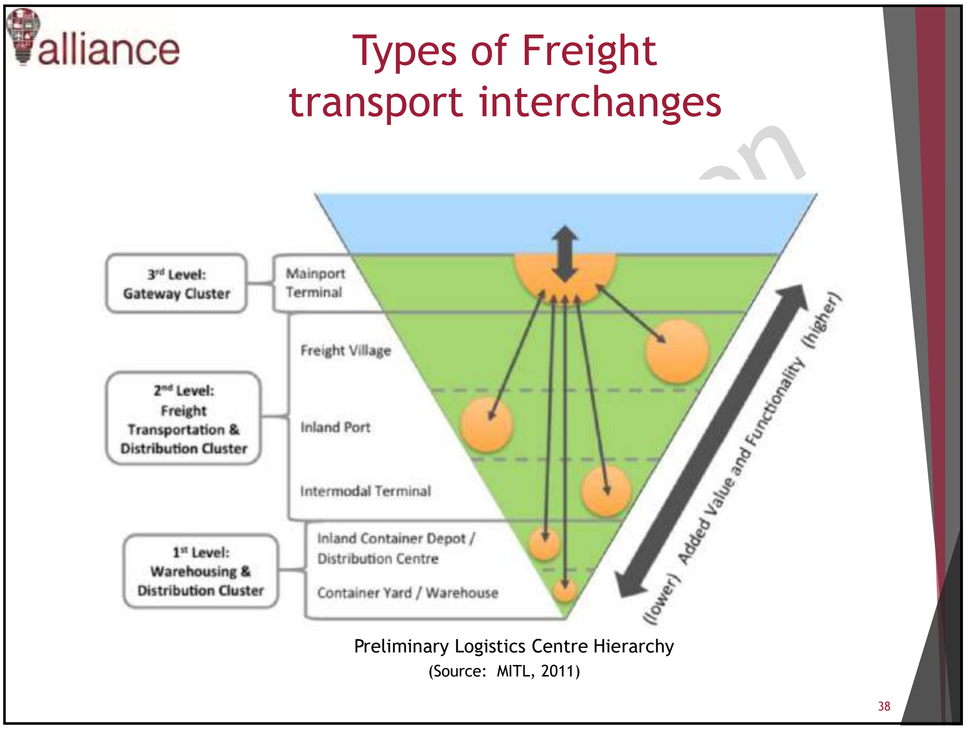
Types of Freight transport interchanges

Category	City terminal	Freight village	Industrial and logistic park	Special logistic area
Transport modes	Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air
Main aims	Traffic reduction in the city	Model shift and urban traffic reduction	Regional economic growth and modal shift	Regional economic growth
Operator	Huge forwarder or retailer	Operating company (public influence)	No operator	Airport or harbor authorities
Company structure	Huge forwarder or retailer	Small companies, also large transport companies	Large industrial companies and transport companies	Large companies
Land use	Small areas in the city	Large areas in outskirts	Large areas in the outskirts or at old industrial areas	Extension to existing sites in the city or in the outskirts
Land price	Very high price	Relatively low	Relatively low	High
Quality of infrastructure	Good access to the city	Direct links to main infrastructure and access to the city	Direct connections to main infrastructure	Very good access to the international infrastructure
Orientation	City	Regional / interregional	Regional / interregional	International / intercontinental



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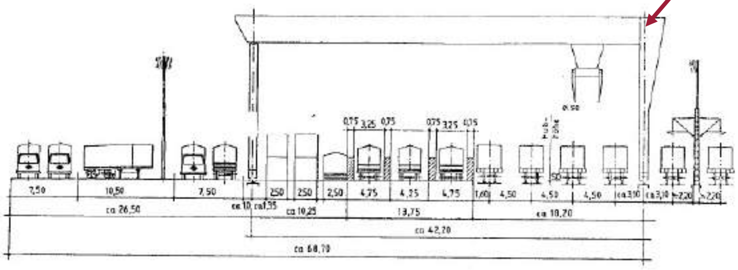
Types of Freight transport interchanges

Preliminary Logistics Centre Hierarchy
(Source: MITL, 2011)

Type

City Terminal	Freight Village	Industrial & logistic park	Special logistic area
Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air

Cargo Mover (Module Trains)
Vertical loading set up for intermodal transport



(Lechner, 2014)

City terminals

- City vicinity
- Traffic alleviation
- Facilitatte last mile distribution
- Influence business profiles in city
- High value land → restricted size
- Installation of companies

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Video

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Setting up (design) of a Urban Distribution Center (UDC) - Location

A logistics facility which enables centralized handling of received goods and deliveries in an urban area, relying on route and resource optimization

- ✓ Appropriate location
- ✓ Required spaces and equipment
- ✓ Internal services
- ✓ Satisfying complementary requirements
- ✓ Self-standing, self-supported

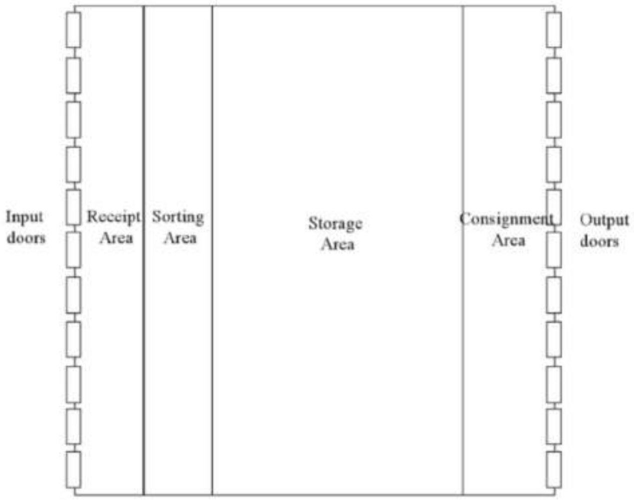
Urban
- Proximity to demand
- Small size

Suburban
- High demand
- Large size

Setting up (design) of a Urban Distribution Center (UDC) - Structure

- Supply chain
- Dimension of load units
  - \- Boxes
  - \- Pallets
  - \- Bulk
  - \- Containers
- Activities
- Accessibility to transportation network
- Service vehicles
- Handling equipment
- Storage area
- Building layout
- Stakeholders

Setting up (design) of a Urban Distribution Center (UDC) – Functional areas



Source: (Gattuso et al., 2015)

Case study - UDC

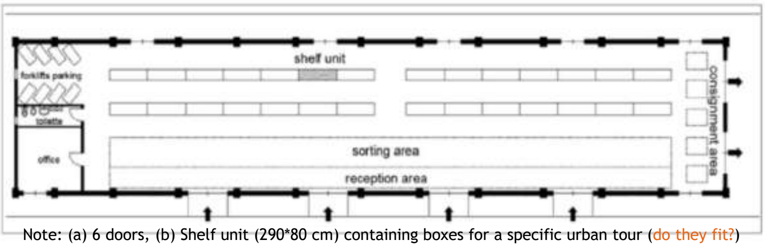
- Daily incoming flows: ?? pallets (120x80 and cargo height 120 cm)
    - *Number of daily trucks of ?? pallets capacity (for estimating traffic volume)*
    - *Load factor of inbound trucks: 85% (for estimating traffic volume)*
- Freight reception: in the afternoon
- Daily outgoing flows: 1670 boxes (60x80x60 cm) directed to urban center
- Urban distribution: in the morning
- Use of electrical vehicles of 10 boxes capacity
- Number of trips: ??
    - *?? Electrical vehicles (for estimating traffic)*

Data requirements/ assumptions

variable	description	μ	σ	distribution	parameters
Tu	Unloading time from long haul (min)	15	8.13	Gauss	μ, σ
Ts	Sorting time (min)	4.19	3.83	Exponential	θ=0.14
Th	Hanlding time (min)	3.67	0.7	Gauss	μ, σ
Tl	Loading time for urban distribution (min)	29	9	Gamma	k=0.363, λ=10.66

Estimated dimensions

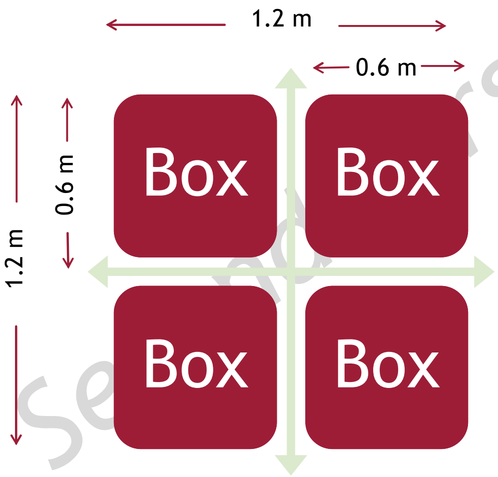
Area	Length (m)	Width (m)	Surface (sqm)	Capacity
receipt	43	1.5	64.5	
sorting	43	2.1	90.3	
storage	43	4.9	210.7	28 complete loads (tours)
consignment	4	10.4	41.6	5 complete loads (tours)
forklifts parking	5	4.3	21.5	8 forklifts
offices	4	5.9	23.6	

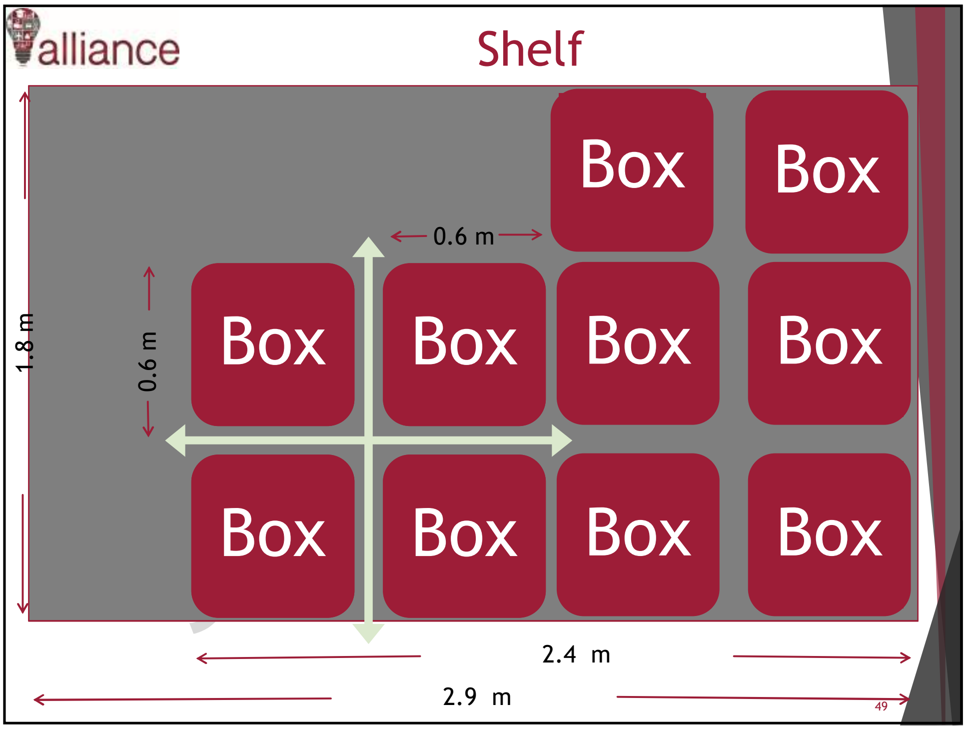


Note: (a) 6 doors, (b) Shelf unit (290*80 cm) containing boxes for a specific urban tour (do they fit?)

Source: (Gattuso et al., 2015)

Pallet





Shelf

Equipment

Front forklift

Stock picker forklift

Trans-pallet

Activity	Equipment	Quantity	Attributes
unloading	Front forklift	2	L=4.6m, W=1.7m, Hmax=6m Max payload=5000kg S=19km/hr
handling	Stock picker forklift	4	L=2.45m, W=0.98m, Hmax=10m Max payload=1200kg S=10km/hr
loading	Trans-pallet	2	L=1.6m, W=0.72m, Hmax=0.123m Max payload=1400kg S=5km/hr

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Assessment

activity	Involved equipment	μ (min)	σ (min)
Unloading time	truck	**14.82**	1.14
Sorting time	pallet	**4.04**	0.57
Handling time from sorting area to storage area	box	**16.08**	11.09
Storage time	box	1054.69	67.63
Handling time to setup outbound load	box	22.02	1.02
Occupation time of consignment buffers	load	**83.33**	57.15
Loading time	load	25.45	0.86
Tour time	EV	24.33	10.50
statistics	**Involved equipment**	**number**	
Number of tours per day	EV	…	
Number of boxes in storage area	box	…	

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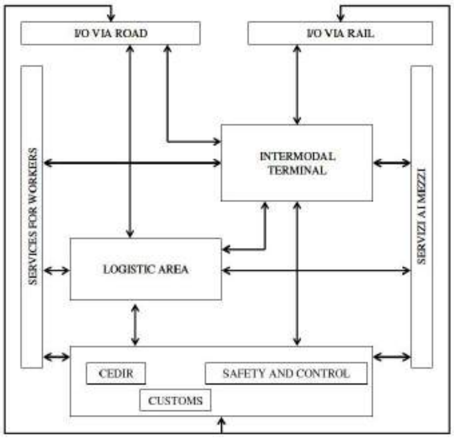
Type

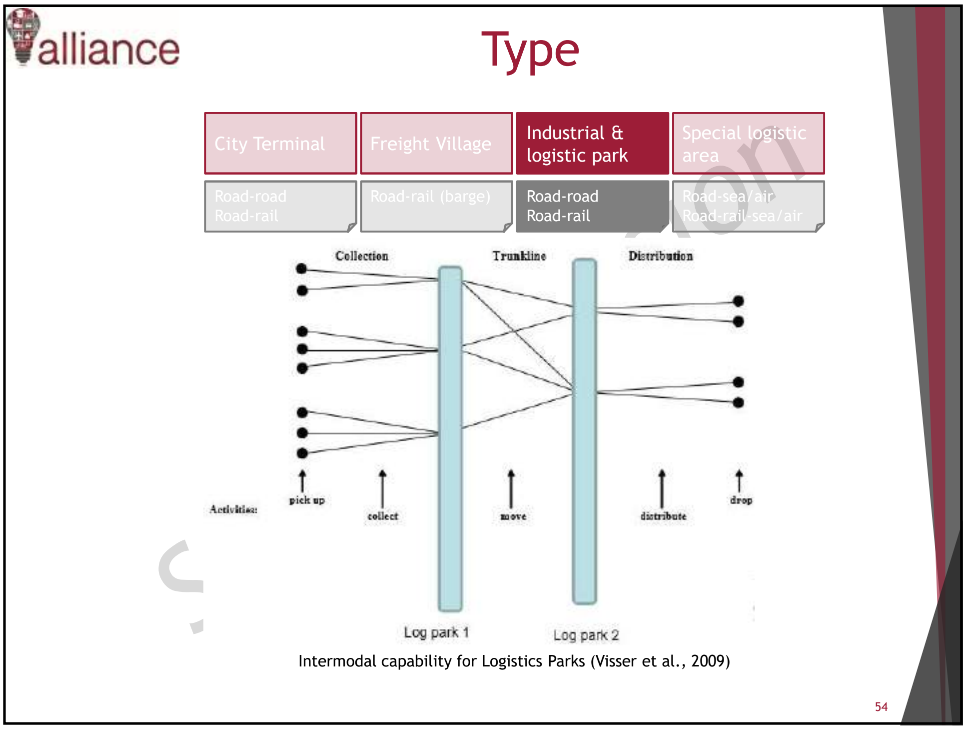
City Terminal	Freight Village	Industrial & logistic park	Special logistic area
Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air

- A freight village is the hub of a specific area where all the activities related to transport, logistics and goods distribution, both for national and international transit, are carried out, on a commercial basis.
  - at least two different transport modes
  - accommodation of other services
  - managed by various operators/providers
  - promotes cooperative activities to achieve synergies



(Cassone & Gattuso, 2010)

WILHELMSHAVEN freight village – North Germany
Source: jadeweserport.de



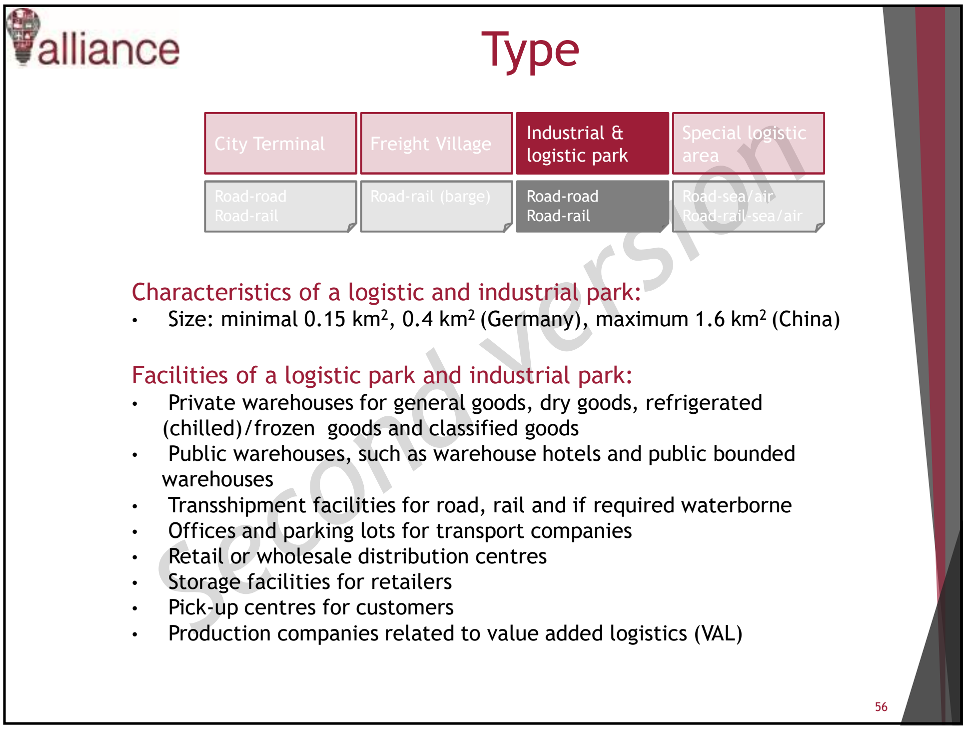
Type

City Terminal	Freight Village	Industrial & logistic park	Special logistic area
Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air

Intermodal capability for Logistics Parks (Visser et al., 2009)

Industrial parks

- Facilitators of industrial areas
- Large facilities far from urban areas
- Accommodate both production and transportation
- Contribute in traffic alleviation problems



Type

City Terminal	Freight Village	Industrial & logistic park	Special logistic area
Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air

Characteristics of a logistic and industrial park:

- Size: minimal 0.15 km^2, 0.4 km^2 (Germany), maximum 1.6 km^2 (China)

Facilities of a logistic park and industrial park:

- Private warehouses for general goods, dry goods, refrigerated (chilled)/frozen goods and classified goods
- Public warehouses, such as warehouse hotels and public bounded warehouses
- Transshipment facilities for road, rail and if required waterborne
- Offices and parking lots for transport companies
- Retail or wholesale distribution centres
- Storage facilities for retailers
- Pick-up centres for customers
- Production companies related to value added logistics (VAL)

Type

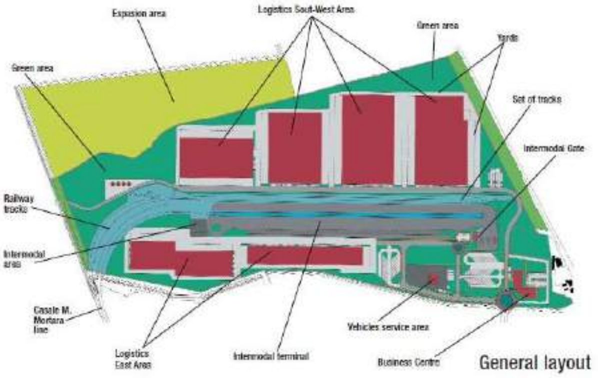
City Terminal	Freight Village	Industrial & logistic park	Special logistic area
Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air

Industrial parks require also supporting facilities:

- Collective and/or secured parking space
- Administration, bank, post, and customs clearance facilities, as well as training and research facilities
- Service stations for vehicle maintenance, washing and fuel, secured areas for parking and container depots
- Facilities for internal and external data communication and information
- Centralised waste disposal
- Security services
- Parking lots for private cars and public transport service
- Catering, hotel facilities etc.

Type

City Terminal	Freight Village	Industrial & logistic park	Special logistic area
Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air



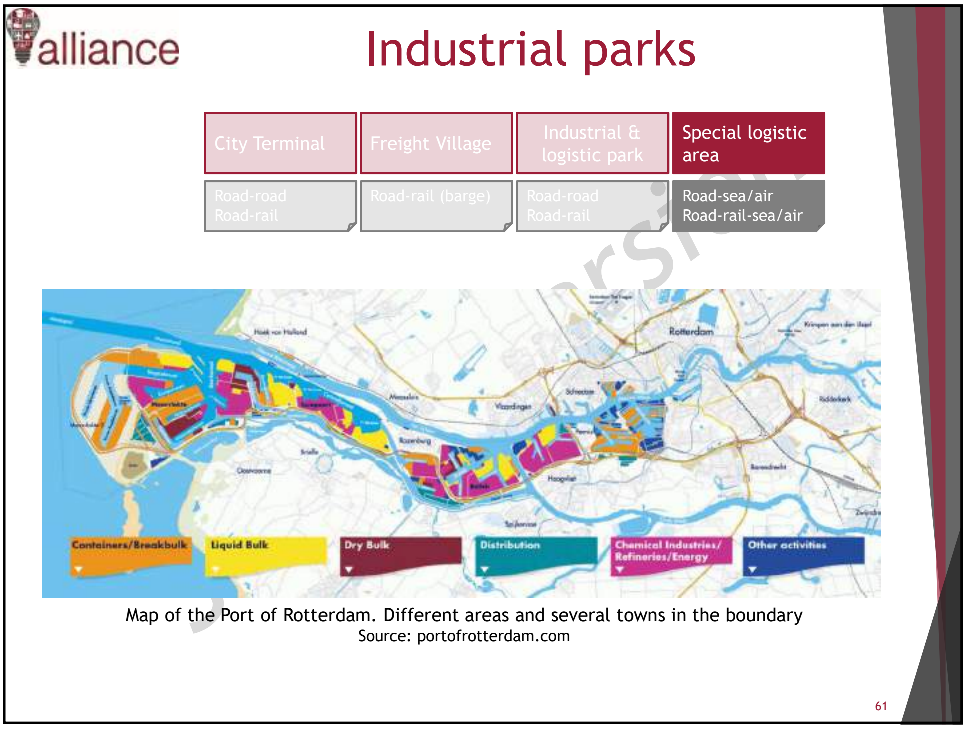
General layout of a Logistic Park (Visser et al., 2009)

Industrial parks

Type

City Terminal	Freight Village	Industrial & logistic park	Special logistic area
Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air

- Logistic Centers that operate in areas of other facilities related to freight.
- Apart from the basic services provided, these centers operate supportively, in cooperation with the freight interchange (port, airport, etc.) which are installed and 'belong‘ to.
  - ▶ Advantage: take advantage of the electromechanical equipment & logistics freight hubs
  - ▶ Disadvantage: often their services are determined based on the activities undertaken in the freight hubs



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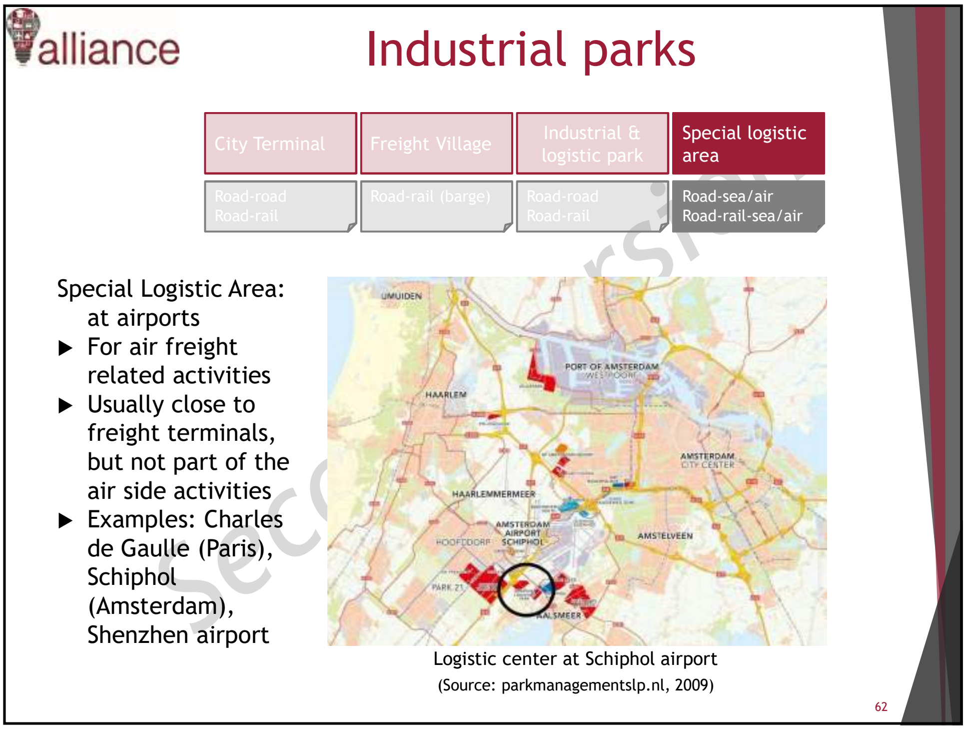
Industrial parks

City Terminal	Freight Village	Industrial & logistic park	Special logistic area
Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air

Map of the Port of Rotterdam. Different areas and several towns in the boundary
Source: portofrotterdam.com



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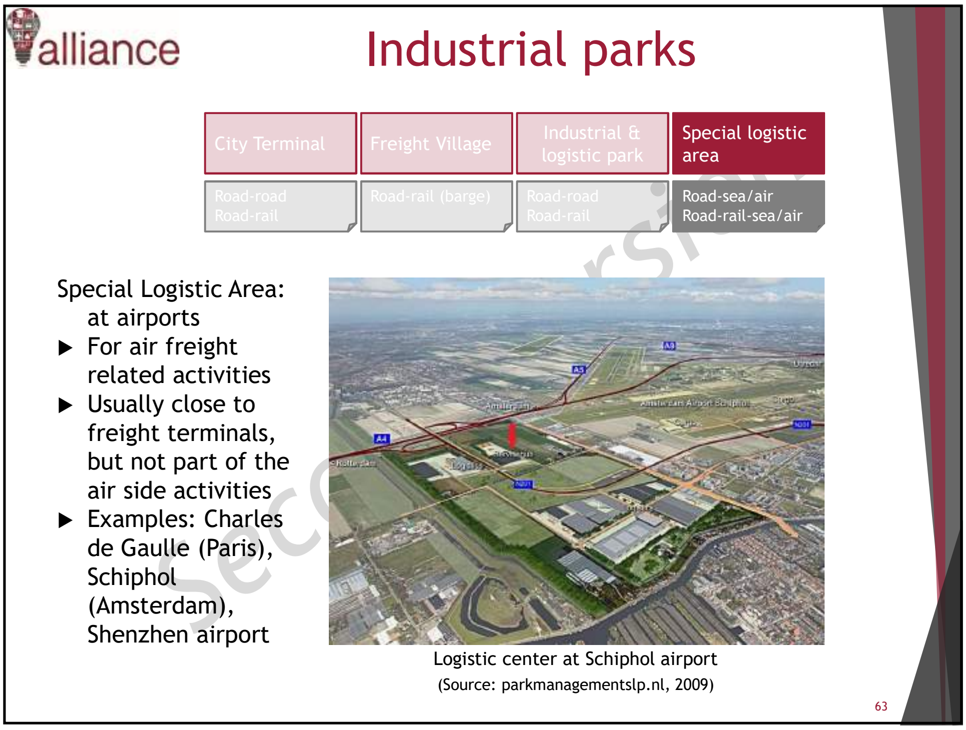
Industrial parks

City Terminal	Freight Village	Industrial & logistic park	Special logistic area
Road-road Road-rail	Road-rail (barge)	Road-road Road-rail	Road-sea/air Road-rail-sea/air

Special Logistic Area: at airports

- For air freight related activities
- Usually close to freight terminals, but not part of the air side activities
- Examples: Charles de Gaulle (Paris), Schiphol (Amsterdam), Shenzhen airport

Logistic center at Schiphol airport
(Source: parkmanagementslp.nl, 2009)



Industrial parks

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Logistic center at Schiphol airport

(Source: parkmanagementslp.nl, 2009)

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Industrial parks

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Case studies of special logistics areas

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Port of Rotterdam

Satellite photo of port

Port of Rotterdam

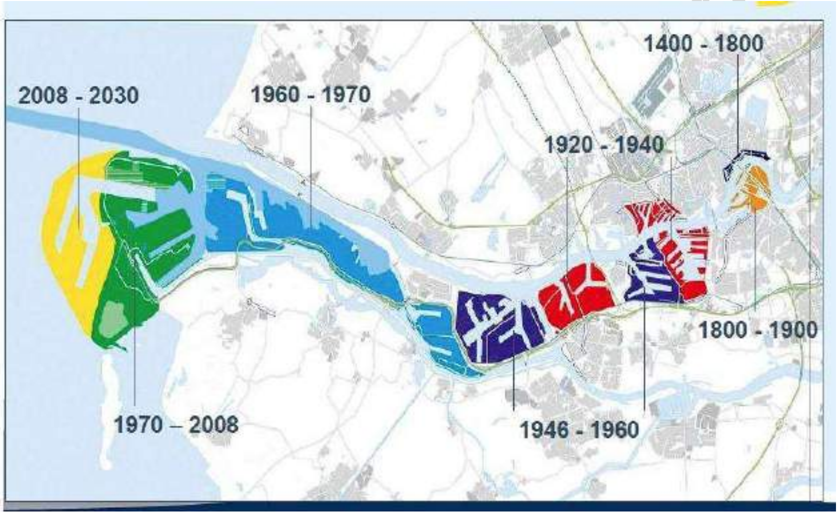
Aerial photo of port

Port of Rotterdam

Container station of port

Port of Rotterdam

Port's expansion



Source: oecd.org/netherlands/

Port of Rotterdam

- Basic elements
  - Created in the 14th century in Netherlands
  - The most important (tonnage) port of the world in the period 1962 to 2004 (now, after Shanghai, Singapore, Guangzhou, Qingdao, Port Hedland and Tianjin)
  - 11th largest port in the world (container traffic)
  - Area: 105 square kilometers
  - Deep, 24 m (1 of the 2 ports worldwide) and advanced equipment to serve both bulk cargoes and containers (autonomous robotic cranes, automated container placement stowage space - port community system)
  - Links to road (200 trucks per day) and rail (340 regular service on a weekly basis) and conductors

Source: portofrotterdam.com

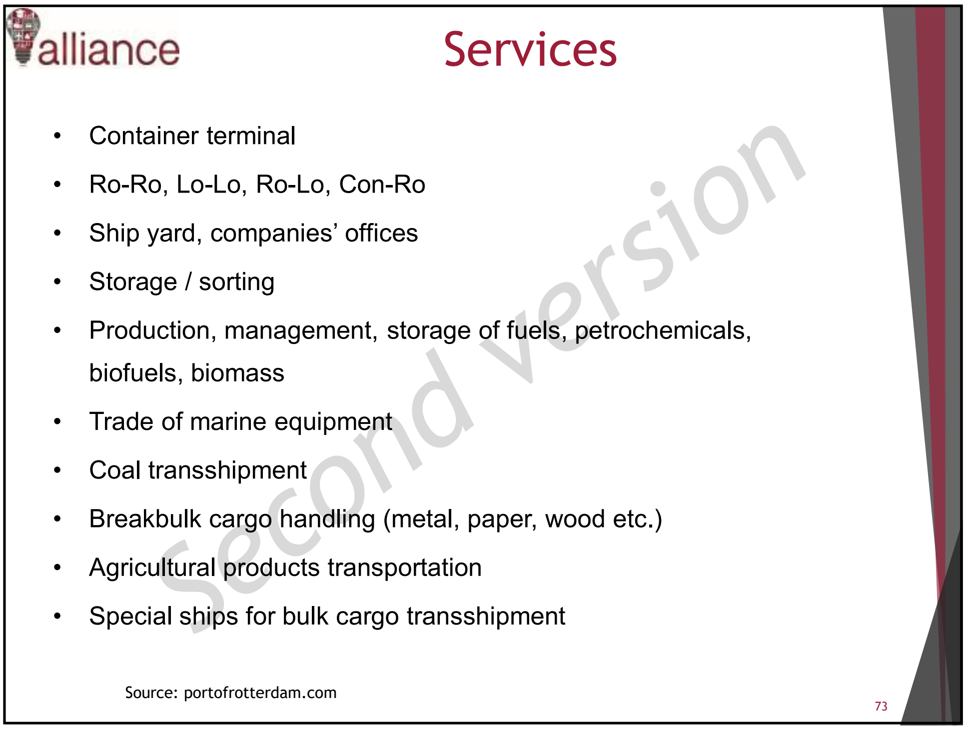
Port of Rotterdam

- Operational elements
  - 126 square kilometers for freight development activities (municipality's area is around 200 sq km)
  - Total length of the wider port area: 40 km
  - port agency jobs: 1200 (500 million € annual turnover)
  - Total number of jobs: 90000
  - Volume of goods and commodities (2014): 444,7 million tons
  - Number of vessels origin / destination Marine (super ocean) transport: 37000
  - Number of vessels origin / destination river transportation: 110000
  - operator: local and government authorities
  - Value of goods and services for the region: 11 billion €
  - 70% of the port owns to city and 30% to the country

Source: portofrotterdam.com

Port of Rotterdam

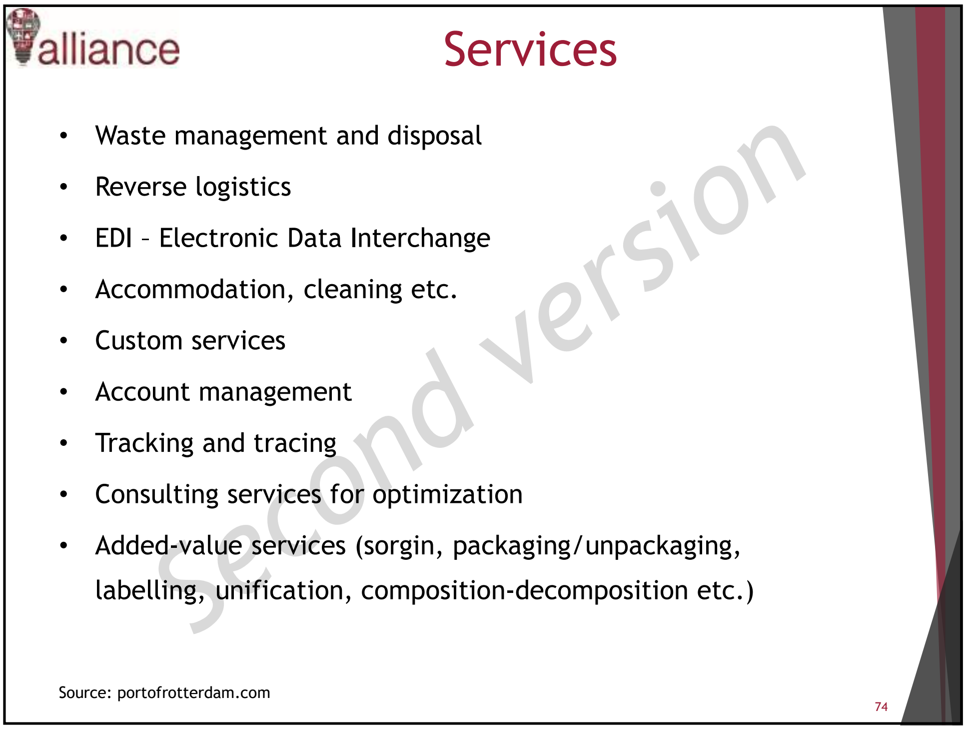
Port's operational development areas



Services

- Container terminal
- Ro-Ro, Lo-Lo, Ro-Lo, Con-Ro
- Ship yard, companies' offices
- Storage / sorting
- Production, management, storage of fuels, petrochemicals, biofuels, biomass
- Trade of marine equipment
- Coal transshipment
- Breakbulk cargo handling (metal, paper, wood etc.)
- Agricultural products transportation
- Special ships for bulk cargo transshipment

Source: portofrotterdam.com



Services

- Waste management and disposal
- Reverse logistics
- EDI – Electronic Data Interchange
- Accommodation, cleaning etc.
- Custom services
- Account management
- Tracking and tracing
- Consulting services for optimization
- Added-value services (sorgin, packaging/unpackaging, labelling, unification, composition-decomposition etc.)

Source: portofrotterdam.com

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Port of Rotterdam

- Video (Loading at Port of Rotterdam)

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Manchester Airport –
World Freight Terminal

Manchester Airport –

World Freight Terminal

Aerial photo of the terminal

Manchester Airport –

World Freight Terminal

Aerial photo of the terminal

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Manchester Airport –
World Freight Terminal

- Basic and operational elements
  - 'World Freight Terminal': the 'heart' of transport networks
  - In the wider area of Manchester city center (14 Km from the town)
  - Area (buildings and warehouses): 60 sq. kilometers
  - 3rd biggest airport of Great Britain (in freight load)
  - Total load served: 250000 tons (2015)
  - Property & management: local authorities (city council) together with MAG (Manchester Airports Group) - Shareholder of airline and other companies of the wider region
  - Three terminals (co-location of passenger and freight)
  - Connection by road and rail (train, tram) transport
  - Service: more than 100 airlines, 22 destinations

Source: manchesterairport.co.uk

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Manchester Airport –
World Freight Terminal

Airplane loading

Services

- Transportation, storage, tracking & tracing
- Connection with road – rail
- Bulk cargo, containers, special commodities
- Added-value services
- Waste management
- Emissions reduction policies
- Customs, security, sanitary services

Services

- ► Aircraft yard
- ► Small animals servicing
- ► Airport services
- ► Accommodation
- ► Information
- ► Private shipments
- ► Parking
- ► Shopping areas
- ► Private transportation

Airplane loading

- Video (Container air cargo loading)

Airplane loading

- Video (Container air cargo loading)

video loading

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Guidance to further knowledge acquisition

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Thank you for your attention!

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C10 – Smart Technologies for Efficient Transport Logistics

Olaf Poenicke

Fraunhofer Institute for Factory Operation and Automation IFF Magdeburg, Germany

Version 2017/07/11

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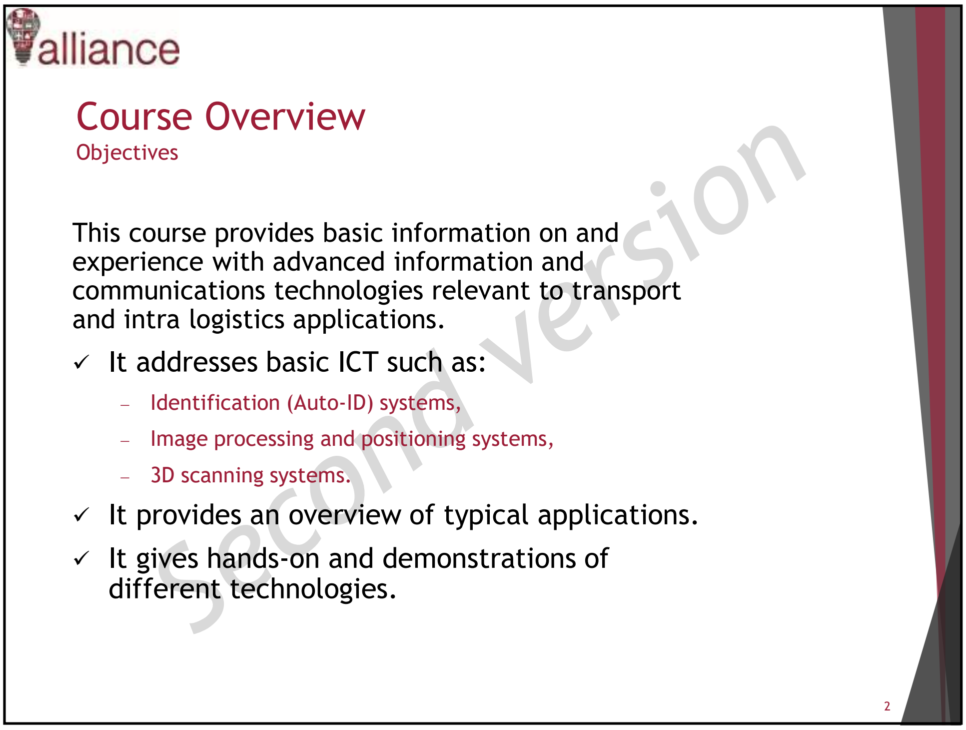

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Course Overview

Objectives

This course provides basic information on and experience with advanced information and communications technologies relevant to transport and intra logistics applications.

- ✓ It addresses basic ICT such as:
  - Identification (Auto-ID) systems,
  - Image processing and positioning systems,
  - 3D scanning systems.
- ✓ It provides an overview of typical applications.
- ✓ It gives hands-on and demonstrations of different technologies.

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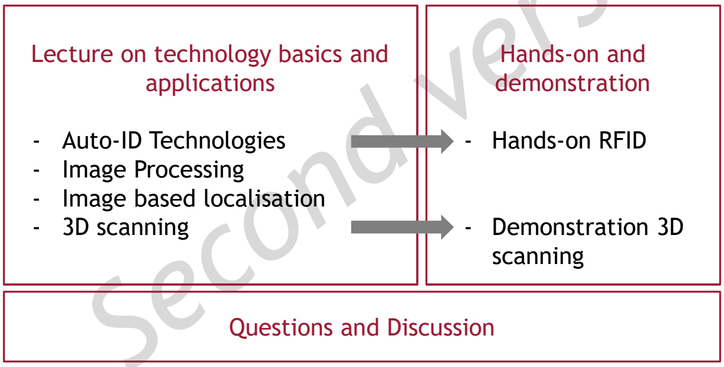
Course Overview

Structure

The course is divided into three modules:



Lecture on technology basics and applications

- Auto-ID Technologies
- Image Processing
- Image based localisation
- 3D scanning

Hands-on and demonstration

- Hands-on RFID
- Demonstration 3D scanning

Questions and Discussion

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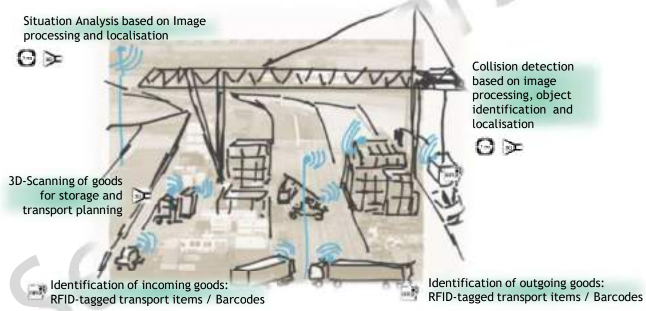
Course Overview

Application fields

The technologies discussed are relevant to the basic logistics processes in transport and intra logistics operation – e.g.:



The processing and management of the generated logistics data (information logistics) are described and discussed in Course C7.

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Course Overview

Abbreviations

Auto-ID	Automatic Identification
EPC	Electronic Product Code
EPCIS	Electronic Product Code Information Service
LF / HF / UHF	Low Frequency / High Fr. / Ultra High Fr.
MW	Microwave
OCR	Optical Character Recognition
RGB	Red Green Blue
RFID	Radio Frequency Identification
RTI	Returnable Transport Item
UII	Unique Item Identifier

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Auto-ID Technologies

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AUTO-ID Basics

Overview of Auto-ID Technologies

The term automatic identification and data capture or simply automatic identification (**Auto-ID**) refers to methods of identifying objects, capturing and collecting data on them and transmitting that data.

It is primarily used in:

- Retail → product marking
- Manufacturing and logistics → tracking and tracing throughout supply chains → **production - storage - dispatch - delivery**
- Security → access control systems
- Corporate data → industrial data acquisition

Within Logistics operations either the product itself or the transport unit (parcel / pallet / …) is identified by Auto-ID.

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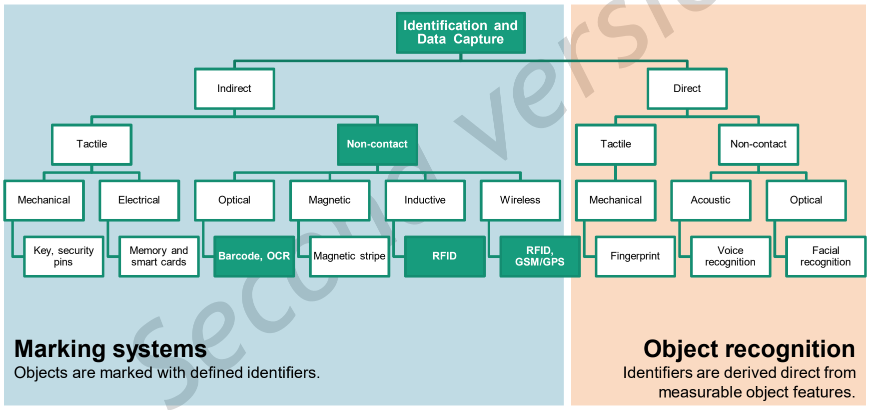
AUTO-ID Basics

Overview of Auto-ID Technologies



Identification and Data Capture

- Indirect
  - Tactile
    - Mechanical
      - Key, security pins
    - Electrical
      - Memory and smart cards
  - **Non-contact**
    - Optical
      - **Barcode, OCR**
    - Magnetic
      - Magnetic stripe
    - Inductive
      - **RFID**
    - Wireless
      - **RFID, GSM/GPS**
- Direct
  - Tactile
    - Mechanical
      - Fingerprint
  - Non-contact
    - Acoustic
      - Voice recognition
    - Optical
      - Facial recognition

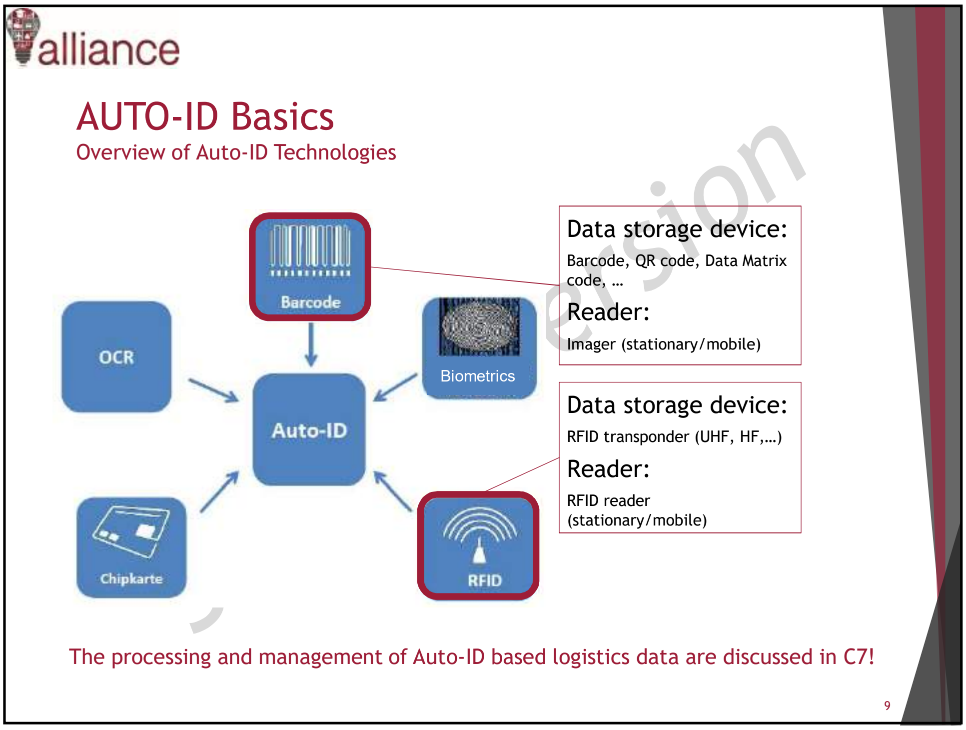
Marking systems

Objects are marked with defined identifiers.

Object recognition

Identifiers are derived direct from measurable object features.

The processing and management of Auto-ID based logistics data are discussed in C7!



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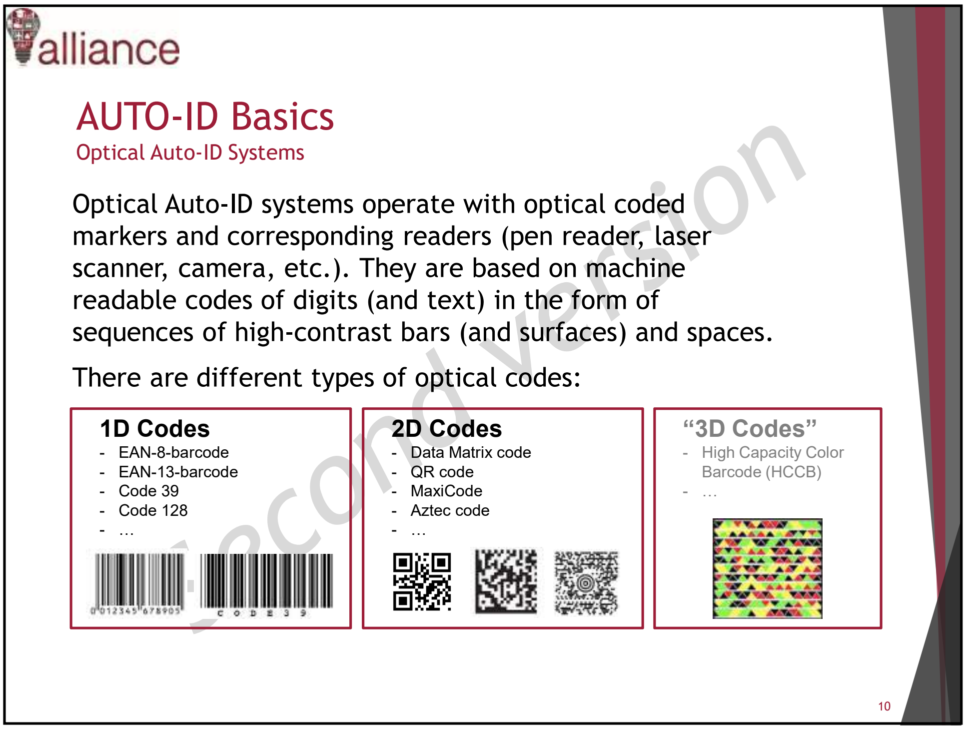
AUTO-ID Basics

Overview of Auto-ID Technologies

Data storage device:
Barcode, QR code, Data Matrix code, …
Reader:
Imager (stationary/mobile)

Data storage device:
RFID transponder (UHF, HF,…)
Reader:
RFID reader (stationary/mobile)

The processing and management of Auto-ID based logistics data are discussed in C7!



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AUTO-ID Basics

Optical Auto-ID Systems

Optical Auto-ID systems operate with optical coded markers and corresponding readers (pen reader, laser scanner, camera, etc.). They are based on machine readable codes of digits (and text) in the form of sequences of high-contrast bars (and surfaces) and spaces.

There are different types of optical codes:

1D Codes
- EAN-8-barcode
- EAN-13-barcode
- Code 39
- Code 128
- …

2D Codes
- Data Matrix code
- QR code
- MaxiCode
- Aztec code
- …

"3D Codes"
- High Capacity Color Barcode (HCCB)
- …

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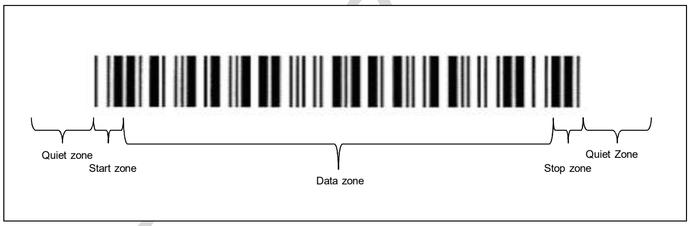
AUTO-ID Basics

Optical Auto-ID Systems

1D and 2D codes consist of black and white that give off different reflections when scanned by a reader, which reads the different arrangements of sections:

- Barcode → width of bars and spaces in a sequence
- 2D code → black and white surface at defined points



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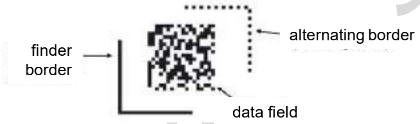
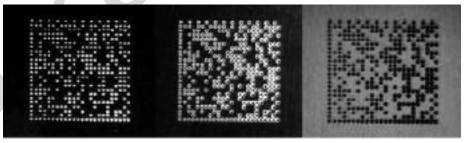
AUTO-ID Basics

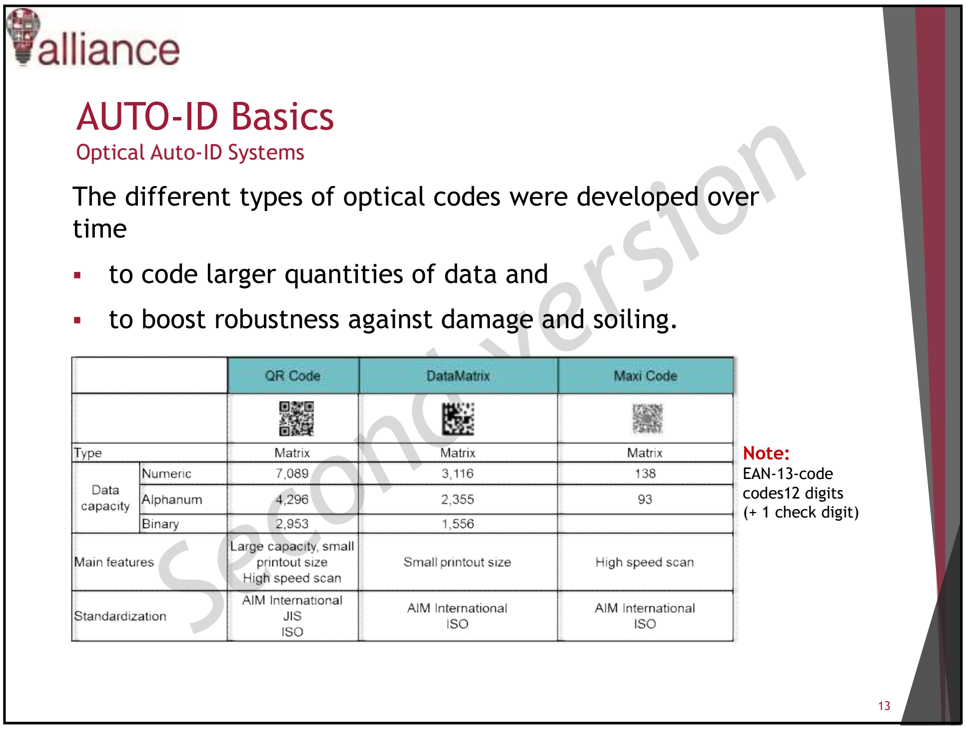
Optical Auto-ID Systems

Along with the individual subfields filled in, 2D codes always also have orientation marks used to align the code read by the reader.



Other industrial marking systems have been developed in addition to optical codes printed on paper. To an extent, the lighting has to be right when codes are being read.





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AUTO-ID Basics

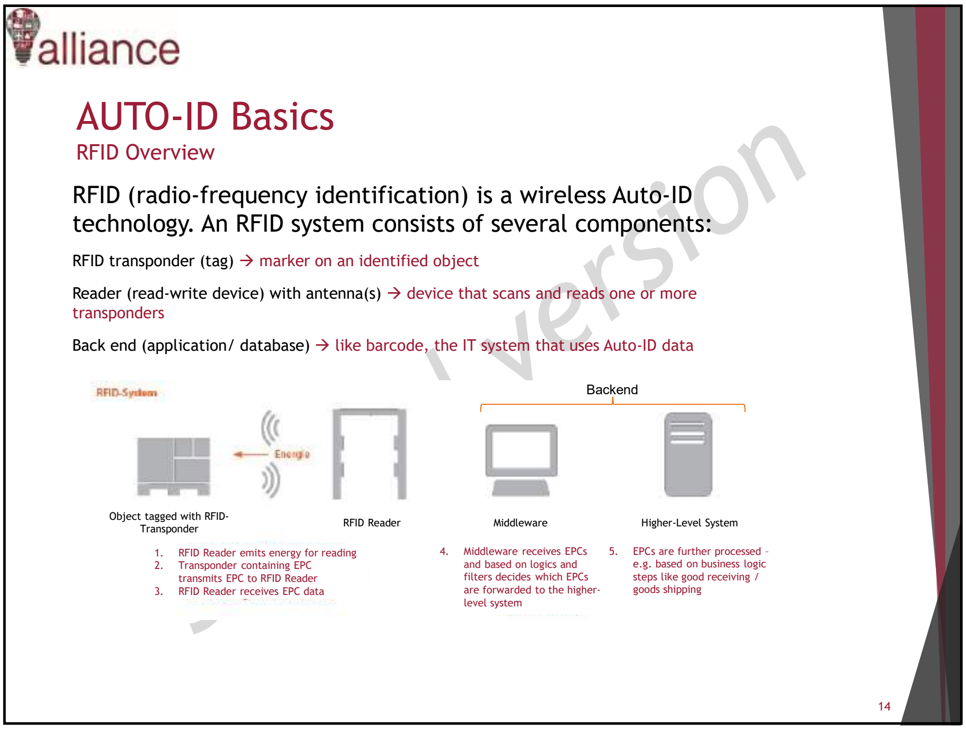
Optical Auto-ID Systems

The different types of optical codes were developed over time

- to code larger quantities of data and
- to boost robustness against damage and soiling.

		QR Code	DataMatrix	Maxi Code
Type		Matrix	Matrix	Matrix
Data capacity	Numeric	7,089	3,116	138
	Alphanum	4,296	2,355	93
	Binary	2,953	1,556	
Main features		Large capacity, small printout size High speed scan	Small printout size	High speed scan
Standardization		AIM International JIS ISO	AIM International ISO	AIM International ISO

Note:
EAN-13-code codes12 digits (+ 1 check digit)



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AUTO-ID Basics

RFID Overview

RFID (radio-frequency identification) is a wireless Auto-ID technology. An RFID system consists of several components:

RFID transponder (tag) → marker on an identified object

Reader (read-write device) with antenna(s) → device that scans and reads one or more transponders

Back end (application/ database) → like barcode, the IT system that uses Auto-ID data

1. RFID Reader emits energy for reading
2. Transponder containing EPC transmits EPC to RFID Reader
3. RFID Reader receives EPC data
4. Middleware receives EPCs and based on logics and filters decides which EPCs are forwarded to the higher-level system
5. EPCs are further processed - e.g. based on business logic steps like good receiving / goods shipping

AUTO-ID Basics

RFID Overview

Using RFID for wireless transmission of transponder data has advantages over other Auto-ID technologies:

- Data transmission does not require direct or visual contact
- Depending on the frequency range, greater read ranges of >10m are achievable (even >100m for active RFID systems)
- Apart from single reading, several RFID-tagged objects can be scanned (primarily in the UHF range) at the same time, too → bulk reading
- Apart from using it as identification technology, RFID can be combined with other sensor functions → data logger / condition monitoring

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AUTO-ID Basics

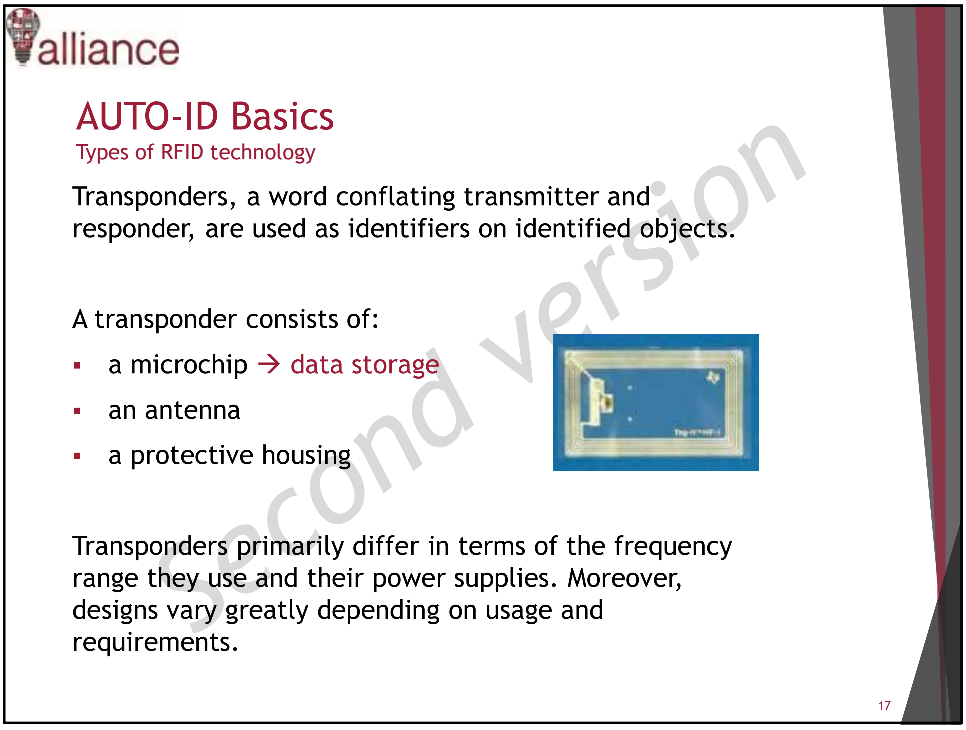
RFID Overview

Barcode and RFID Compared

Optical codes und RFID systems have different pros and cons.

These have to be considered in each use case and allowed for when selecting the suitable technology.

Characteristics	**Barcode**		**RFID**	
	1D-Code	2D-Code	active	passive
transmission	optical		electromagnetic	
data capacity	very low	low	high	
line of sight	required		not required	
shape and size	fixed		flexible	
critical environ-mental factors	dirt, humidity, high temperature		metal, liquids, very high temperature	
reading rates	low	medium	high	
data security	very low	low	very high	
information	static		dynamic (read + write)	
costs for identifier	very low		very high	high
costs for readers	comparable			
bulk reading	not possible		possible	
reading distance	low (few cm)		very high (>> 10m possible)	high (up to 10m)
security against counterfeiting	low		high	
level of industrial use	very high	medium	low	



AUTO-ID Basics

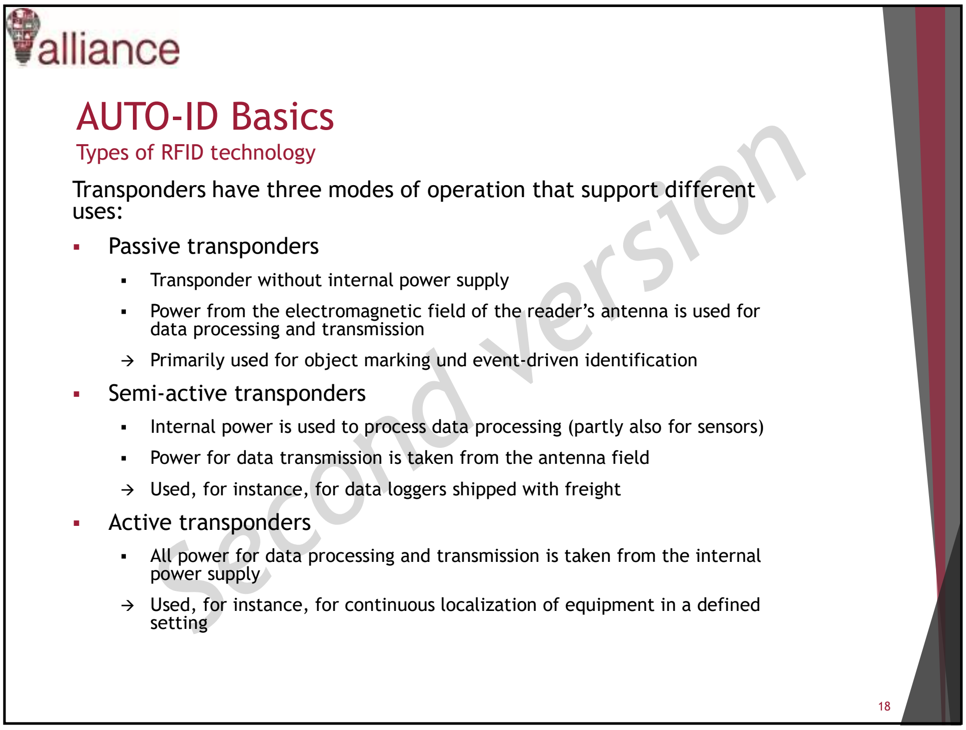
Types of RFID technology

Transponders, a word conflating transmitter and responder, are used as identifiers on identified objects.

A transponder consists of:

- a microchip → data storage
- an antenna
- a protective housing

Transponders primarily differ in terms of the frequency range they use and their power supplies. Moreover, designs vary greatly depending on usage and requirements.



AUTO-ID Basics

Types of RFID technology

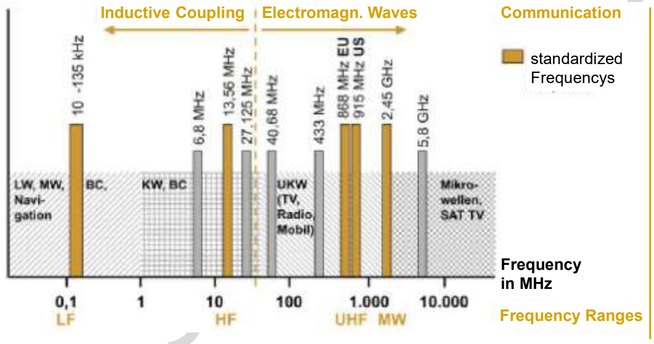
Transponders have three modes of operation that support different uses:

- Passive transponders
  - Transponder without internal power supply
  - Power from the electromagnetic field of the reader's antenna is used for data processing and transmission
  - → Primarily used for object marking und event-driven identification
- Semi-active transponders
  - Internal power is used to process data processing (partly also for sensors)
  - Power for data transmission is taken from the antenna field
  - → Used, for instance, for data loggers shipped with freight
- Active transponders
  - All power for data processing and transmission is taken from the internal power supply
  - → Used, for instance, for continuous localization of equipment in a defined setting

AUTO-ID Basics

Types of RFID technology

RFID technology differs in several radio frequency ranges which affect the possibility to read RFID transponders on and through different materials as also the achievable reading distance.



LF - distance < 1m
→ e.g. used for key systems

HF - distance up to 1,5m
→ e.g. used for document management (libraries)

UHF - distance up to >10m
→ usage esp. in production and logistics processes

MW - very quick data transmission
→ e.g. used for toll billing systems

AUTO-ID Basics

Types of RFID technology

UHF-RFID can be used pervasively in shipping, manufacturing and service.

Globally used frequency ranges have to be taken into account when using UHF-RFID.

→ ***Broadband transponders can be used universally.***

→ ***The frequency of 915 MHz has been assigned to RFID in Europe.***

<table>
<tr><td>Energy supply</td><td colspan="2">Aktiv</td><td colspan="2">Semiaktiv/ -passiv</td><td colspan="2">Passiv</td></tr>
<tr><td>Frequency band</td><td>LF
(kHz)</td><td colspan="2">HF
(MHz)</td><td colspan="2">UHF
(MHz)</td><td>SHF/MW
(GHz)</td></tr>
<tr><td>Reading distance</td><td colspan="2">Close-Coupling</td><td colspan="2">Remote-Coupling</td><td colspan="2">Long-Range</td></tr>
<tr><td>Data storage</td><td colspan="3">Data-on-Tag</td><td colspan="3">Data-on-Network</td></tr>
<tr><td>Memory size</td><td colspan="2">1bit</td><td colspan="2">Bis 96bit</td><td colspan="2">Über 96bit</td></tr>
</table>

Frequenz	***LF** (kHz)*	***HF** (MHz)*	***UHF** (MHz)*	***MW** (GHz)*
Europa	125	13,56	865-868	2,45
USA, Kanada	125	13,56	915	2,45
Australien	125	13,56	918-926	2,45
Südafrika	125	13,56	913-915	2,45
Japan	125	13,56	950-956	2,45
Korea	125	13,56	910-914	-
China	-	-	915	2,45

AUTO-ID Basics

Examples of RFID use

RFID is widely used in manufacturing and shipping. The applications listed below focus on passive UHF-RFID transponders.

Typical uses of UHF-RFID in manufacturing and shipping include:

- item identification
- container management / shipping equipment pooling
- production management using RFID-tagged parts
  → e.g. in the automotive supplier industry
- tagging of equipment parts or valuable modules with RFID for life cycle management and MRO operations
  → e.g. in the aviation industry

AUTO-ID Basics

Examples of RFID use

RFID is used extensively in retail to

- identify items (e.g. apparel industry)
- track items throughout the supply chain
- surveil items in shops (also UHF-RFID)
- Pool containers and other shipping equipment

Identification on item and shipping level in goods receiving / storage / dispatch.

RFID tags in garments from GERRY WEBER

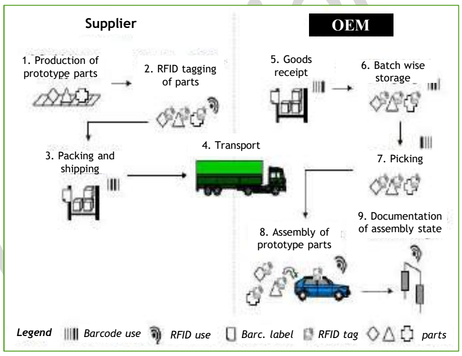
Scanning items tagged with RFID in so-called RFID Tunnel Gates

AUTO-ID Basics

Examples of RFID use

One example of use is prototyping in the automotive industry:

- Control of the complexity of varying parts
- Early incorporation of RFID in the design phase
- Parallel testing of durability and readability of RFID tags during trials



→ The goal is widespread use RFID in automotive mass production.

AUTO-ID Basics

Examples of RFID use

The tracking and tracing von RTIs is an important use in the shipping industry:

- Shipping equipment is tagged with
  - in retail (e.g. Düsseldorfer Paletten)
  - in automotive manufacturing
- Industry-specific data are used in part as identifiers RTIs (e.g. VDA standard)
- VDA is overseeing development of new generations of small containers (KLT) with integrated RFID
  - → Over 100 mill. KLTs are in circulation
  - → New generation of KLTs in 2017

AUTO-ID Basics

RFID Hardware Overview

Based on the application and the application's environment the selection of the best fitting RFID hardware is immanent!

- The RFID processes need to be defined and tested ▫ feasibility
- RFID transponders need to be selected (active / passive; smart label / hard tag / flag tag / …)
- The reader hardware needs to be selected (stationary / mobile; antenna characteristics and orientation)
- IT integration of RFID systems (interfaces)

AUTO-ID Basics

RFID IT Interface Overview

When integrating RFID systems, a distinction has to be made between mobile devices (handheld RFID reader) and stationary devices. In principle, RFID data are process on the following levels:

Mobile and stationary RFID readers with an embedded computing unit can have middleware direct in them as client applications.

AUTO-ID Basics

RFID Number Ranges / Standardization

When implementing RFID systems in companies, it is important to observe standards for number ranges and the identification of individual objects:

- Definition / registration of individual number ranges
  - Avoid assigning identification numbers more than once (especially between locations or companies) → unique item identifiers or UIIs
  - Enable filter functions for more efficient IT filtering of read events
- Observe industry standards for marking defined types of objects (e.g. VDA 5501 for containers in the automotive sector)
- Number ranges are standardized by ISO and GS1 – GS1 has additionally developed a standard for cross-company Auto-ID data sharing

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AUTO-ID Basics

RFID Number Ranges / Standardization

IDENTIFY
GS1 Identification Standards

Company	Product	Logistics and Shipment	Location	Asset	Services
• Global Location Number (GLN)	• Global Trade Item Number (GTIN) • Serialized Global Trade Item Number (SGTIN)	• Serial Shipping Container Code (SSCC) • Global Shipping Identification Number (GSIN) • Global Identification Number for Consignment (GINC)	• Global Location Number (GLN) • Serialized Global Location Number (SGLN)	• Global Individual Asset Identifier (GIAI) • Global Returnable Asset Identifier (GRAI)	• Global Service Relation Number (GSRN) • Global Document Type Identifier (GDTI) • Global Coupon Number (GCN)

CAPTURE
GS1 Automatic Identification and Data Capture Standards

Share
GS1 Automatic Data Sharing Standards

Master Data	Transactional Data	Visibility Event Data
• Global Data Synchonisation Network (GDSN)	• eCom (EDI): EANCOM, GS1 XML	• EPC Information Services (EPCIS)

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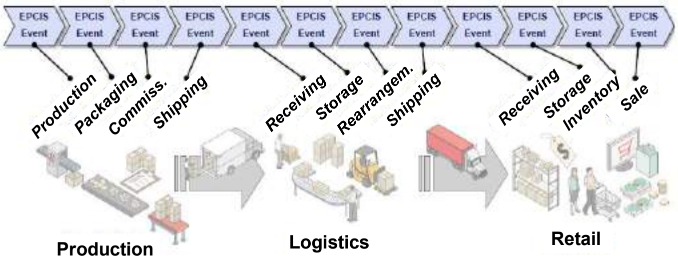
AUTO-ID Basics

RFID Number Ranges / Standardization

EPC Information Service EPCIS

- Makes it possible to track every movement and destination of objects marked with an EPC
- EPCIS is GS1’s standard that specifies interfaces that capture and query EPCIS events



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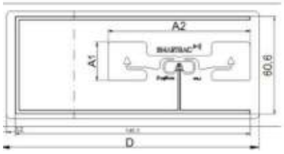
AUTO-ID Basics

Outlook

Trends in RFID technology development are already creating some new uses for RFID technology:

- Passive high-memory tags (advanced capabilities for data-on-tag-applications)
  - → use in aviation
  - → user memory of up to 24 kB

- Passive RFID tags with sensor functions
  - → e.g. tamper alarms
  - → e.g. moisture sensors



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AUTO-ID Basics

Outlook

Trends in RFID technology development are already creating some new uses for RFID technology:

- Standardization of electronic nameplates (DIN 66277)
  - → relevant for manufacturing plants
  - → use of RFID and 2D codes

- Harmonization of globally used frequency ranges and maximum reader output power
  - → tags can be more sensitive
  - → more power is available for bulk scanning

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For information - no slide within the course!

Hands-on RFID

For information - no slide within the course!

Hands-on RFID

Description

Within the Hands-on different kinds of RFID hardware will be shown and tried out by the audience:

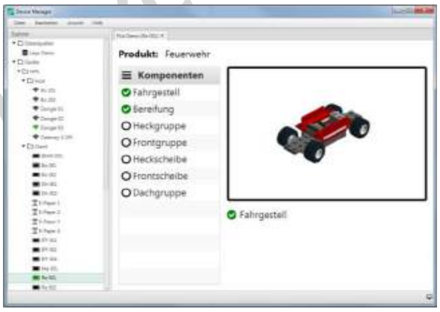
- RFID Handheld reader
  - → Reading of single RFID tags / bulk reading of multiple RFID tags
  - → Changing the ID of a RFID tag
  - → Varying the emitted reader power to try out different read ranges
- RFID transponders
  - → Different transponder designs for various applications
  - → Functional capability of RFID tags – e.g. on metal materials
- RFID Wristband reader
  - → Demo application with product assembly

For information - no slide within the course!

Hands-on RFID

Description

For the demo application of the RFID Wristband the audience will use the device to identify single pickings for a product assembly – the RFID reads are visualised in an IFF software application



Produkt: Feuerwehr

Komponenten

✓ Fahrgestell
✓ Bereifung
○ Heckgruppe
○ Frontgruppe
○ Heckscheibe
○ Frontscheibe
○ Dachgruppe

✓ Fahrgestell

Image Processing

Image Processing

Introduction

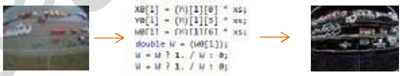
Image processing is the generation, transmission and analysis of images in order to extract information on concrete objects.

Generation

Transmission

Analysis

Image processing is the processing of images.



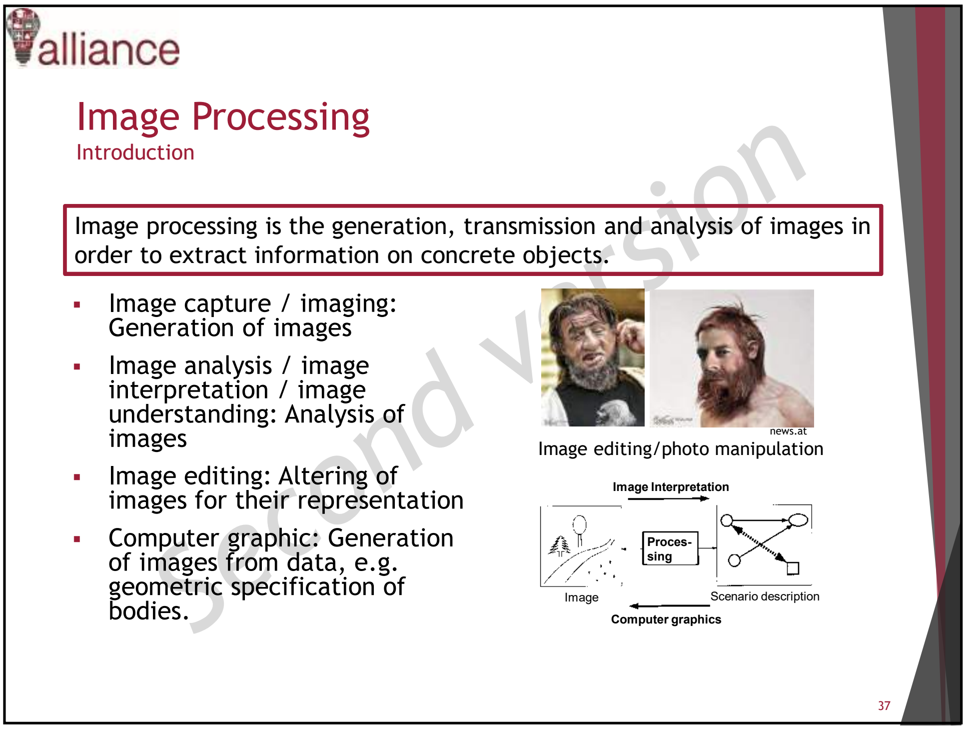


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Image Processing

Introduction

Image processing is the generation, transmission and analysis of images in order to extract information on concrete objects.

- Image capture / imaging: Generation of images
- Image analysis / image interpretation / image understanding: Analysis of images
- Image editing: Altering of images for their representation
- Computer graphic: Generation of images from data, e.g. geometric specification of bodies.

news.at

Image editing/photo manipulation

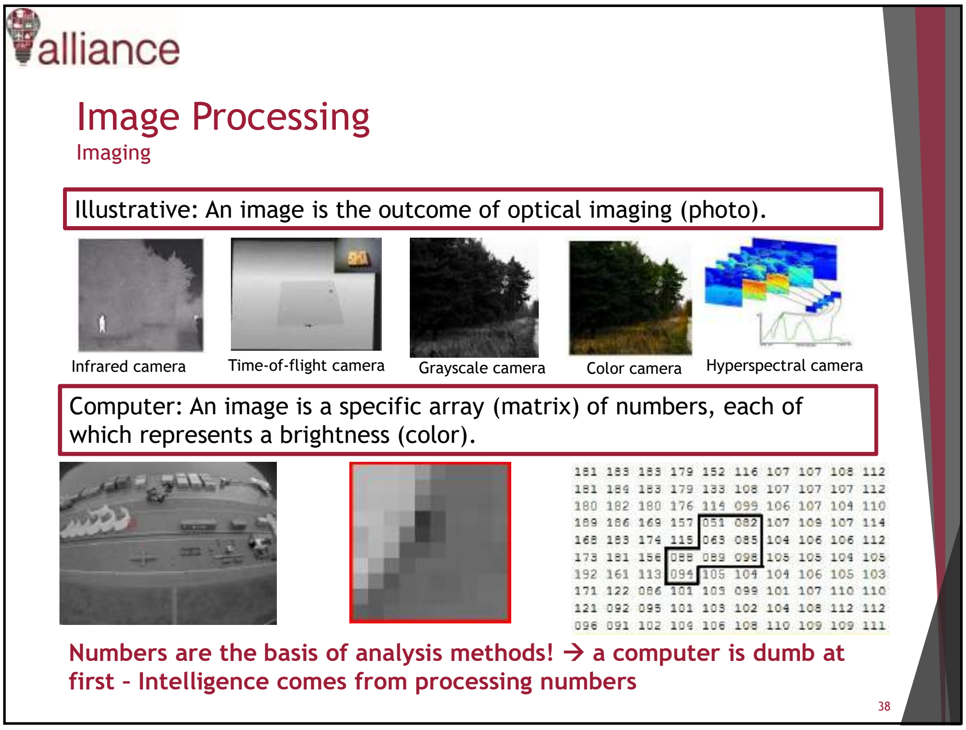

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Image Processing

Imaging

Illustrative: An image is the outcome of optical imaging (photo).

Infrared camera Time-of-flight camera Grayscale camera Color camera Hyperspectral camera

Computer: An image is a specific array (matrix) of numbers, each of which represents a brightness (color).

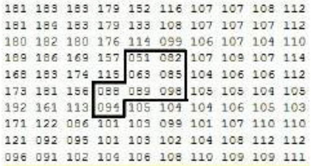
181	183	183	179	152	116	107	107	108	112
181	184	183	179	133	108	107	107	107	112
180	182	180	176	114	099	106	107	104	110
189	186	169	157	051	082	107	109	107	114
168	183	174	115	063	085	104	106	106	112
173	181	156	088	089	098	105	105	104	105
192	161	113	094	105	104	104	106	105	103
171	122	086	101	103	099	101	107	110	110
121	092	095	101	103	102	104	108	112	112
096	091	102	104	106	108	110	109	109	111

Numbers are the basis of analysis methods! → a computer is dumb at first - Intelligence comes from processing numbers

Image Processing

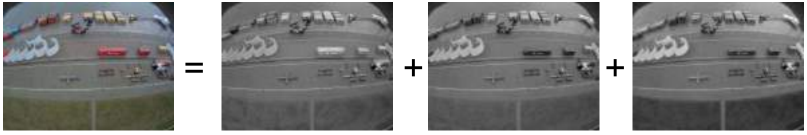
Image Channels

- Grayscale camera (infrared camera, time-of-flight camera) images have one image channel



181	183	183	179	152	116	107	107	108	112
181	184	183	179	133	108	107	107	107	112
180	182	180	176	114	099	106	107	104	110
189	186	169	157	051	082	107	109	107	114
168	183	174	115	063	085	104	106	106	112
173	181	156	088	089	098	105	105	104	105
192	161	113	094	105	104	104	106	105	103
171	122	086	101	103	099	101	107	110	110
121	092	095	101	103	102	104	108	112	112
096	091	102	104	106	108	110	109	109	111

- Color camera images have three image channels: R (red), G (green), B (blue). Every image channel is represented as a matrix in a computer (image stack).



- Hyperspectral camera images have100+ image channels (image cube).

Image Processing

Interference

Interference in images (non-cooperative imaging situations)

- Reflections
- Homogeneous illumination changes
- Inhomogeneous illumination changes
- Particle interference
- Visual obstructions
- Object deformation

Shadows

Reflections

Obstructions

Image Processing

Practical Relevance for Logistics Applications

Image Processing is a basic technical principle which is used in various Logistics Applications – such as:

- Identification of vehicles (OCR-based)
- Identification of products and other objects (Barcode, 2D-codes)
- Classification of vehicles and other objects
- Localization of vehicles and other objects
- Monitoring of spatial areas (e.g. occupation of storage areas)
- 3D imaging as emerging technology for logistics applications


OCR-based number plate recognition


Marker-based localization

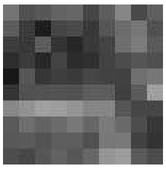

3D-imaging for dimensioning

Image Processing

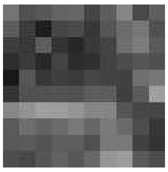
Quiz

When are two images identical?

1. When they have the same size (height and width)
2. When they have the same number of image channels.
3. When every image channel is represented by the same matrix, B1 - B2 = 0.


B_1

116	080	087	099	102	069	093	133	073	095
092	059	029	069	074	055	085	108	119	081
061	055	092	052	039	057	068	110	123	090
045	059	039	067	044	048	066	076	086	079
023	086	054	062	058	070	066	065	111	119
052	081	082	083	081	093	092	063	091	159
135	146	159	157	148	133	133	085	070	070
089	110	099	107	120	103	122	105	077	055
088	090	083	093	093	080	120	121	065	051
077	071	085	098	087	103	150	157	090	076


B_2

116	080	087	099	102	069	093	133	073	095
092	059	029	069	074	055	085	108	119	081
061	055	092	052	039	057	068	110	123	090
045	059	039	067	044	048	066	076	086	079
023	086	054	062	058	070	066	065	111	119
052	081	081	083	081	093	092	063	091	159
135	146	159	157	148	133	133	085	070	070
089	110	099	107	120	103	122	105	077	055
088	090	083	093	093	080	120	121	065	051
077	071	085	098	087	103	150	157	090	076

B_1 - B_2

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→ Differential imaging detects objects’ movements.

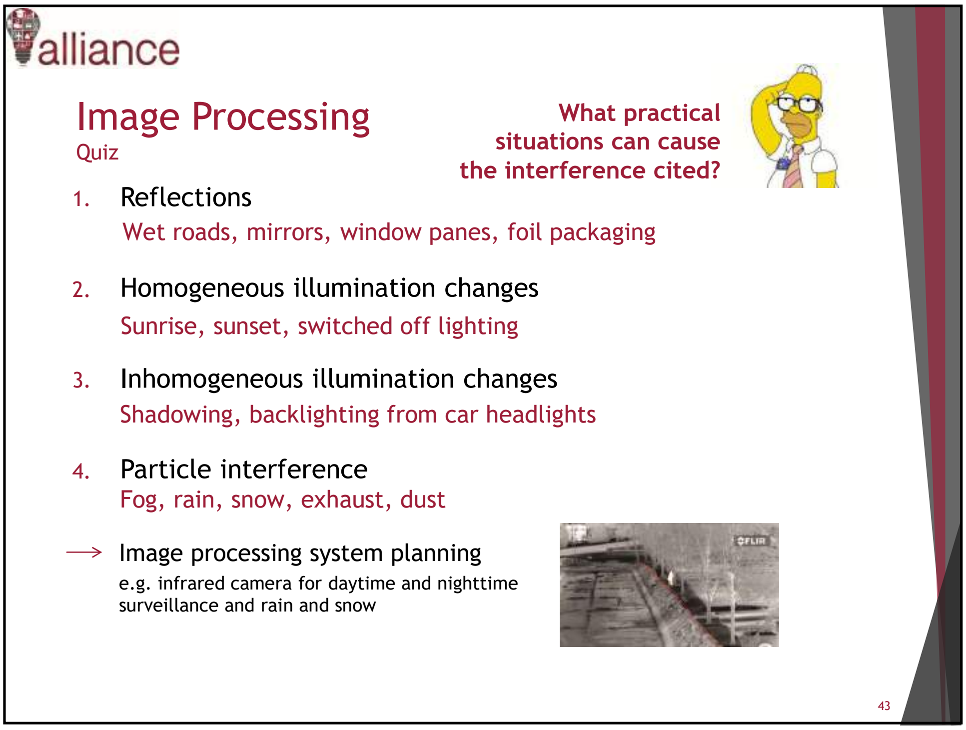

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Image Processing

Quiz

What practical situations can cause the interference cited?

1. Reflections
   Wet roads, mirrors, window panes, foil packaging
2. Homogeneous illumination changes
   Sunrise, sunset, switched off lighting
3. Inhomogeneous illumination changes
   Shadowing, backlighting from car headlights
4. Particle interference
   Fog, rain, snow, exhaust, dust

⟶ Image processing system planning
e.g. infrared camera for daytime and nighttime surveillance and rain and snow

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Image-Based Localization

Image-Based Localization

Introduction

- Logistical background
  - Chaotic warehousing: Shipping units are stored in the most convenient storage bin (no assigned locations)
  - Maintenance: Forklifts have to be serviced periodically (operating time)
  - → Focus on warehousing operations → storage / removal
- Technical and environmental conditions
  - Storage facilities are mostly indoors (weatherproof storage)
  - The absolute accuracy required is between 25cm to several meters
  - Metallic environment with moving metal bodies such as forklifts, cranes or coils
  - Device frequently cannot be mounted on forklifts because they are rental vehicles
- Image-based solution: Vehicle Positioning System
  - Passive planar image markers atop vehicles
  - Cameras on the ceiling

Image-Based Localization

Introduction

Camera on vehicle	Camera to vehicle
Advantages – Cost efficient if only a few vehicles are located in a particular area – Only a small amount of data has to be sent through the network	Advantages – No electronic devices on vehicles – Cost efficient if many vehicles are located in a particular area – Combinable with other image processing systems (documentation, visualization, object detection)
Disadvantages – Electronic devices on vehicle – Not combinable with other image processing systems (documentation, visualization, object detection)	Disadvantages – Not cost efficient if only a few vehicles are located in a particular area – A large amount of data has to be sent through the network

After weighing all of the pros and cons, the decision was made to implement a **camera-to-vehicle** system.

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Image-Based Localization

System Overview

Main components

- Cameras
- Passive planar image markers
- Software analysis module
- Processing units (hardware)

Cameras

- Various camera types can be uses
- Security cameras are currently being used (data volume, quality and costs)
- Aimed at the area used by vehicles

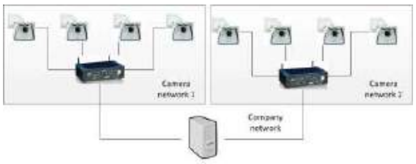

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Image-Based Localization

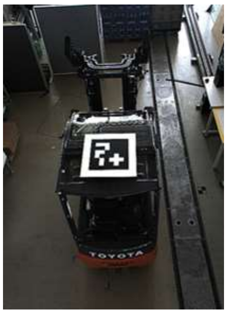
System Overview

Passive planar image markers

- Square in shape
- Simple black and white markers
- Metal plates, aluminum composite panels or plastic panels with printed or glued on code
- Mounted atop vehicles

Marker code

- Uniquely identifies a vehicle
- Marker code must be rotationally asymmetric
- Different sizes: 3 x 3, 4 x 4, 5 x 5, etc.



3 x 3 markers

5 x 5 markers

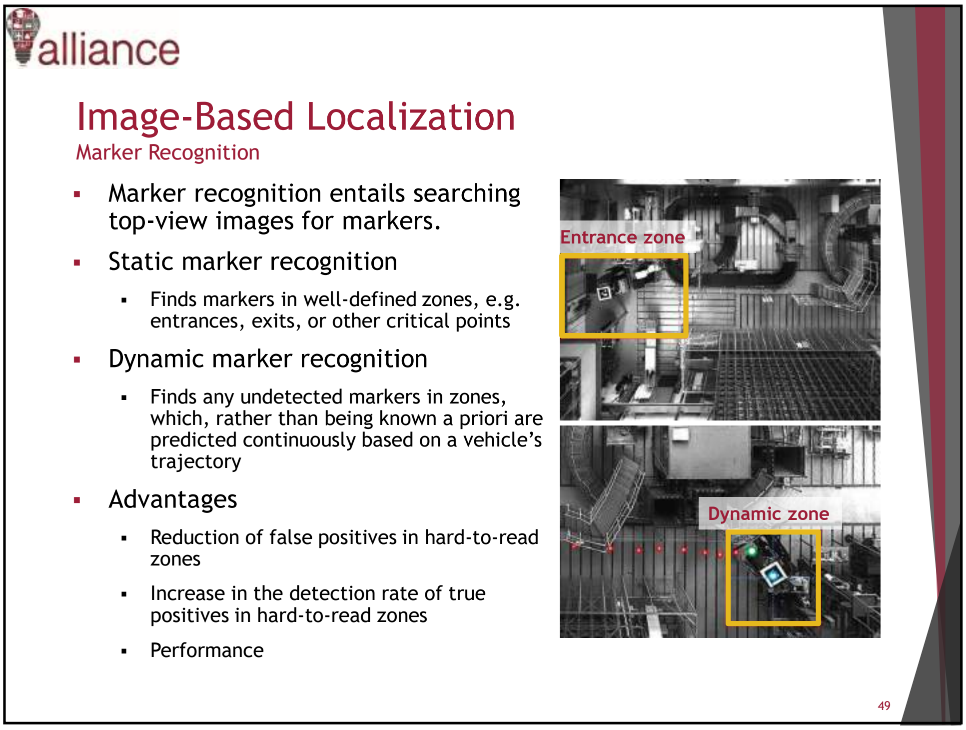


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Image-Based Localization

Marker Recognition

- Marker recognition entails searching top-view images for markers.
- Static marker recognition
  - Finds markers in well-defined zones, e.g. entrances, exits, or other critical points
- Dynamic marker recognition
  - Finds any undetected markers in zones, which, rather than being known a priori are predicted continuously based on a vehicle's trajectory
- Advantages
  - Reduction of false positives in hard-to-read zones
  - Increase in the detection rate of true positives in hard-to-read zones
  - Performance

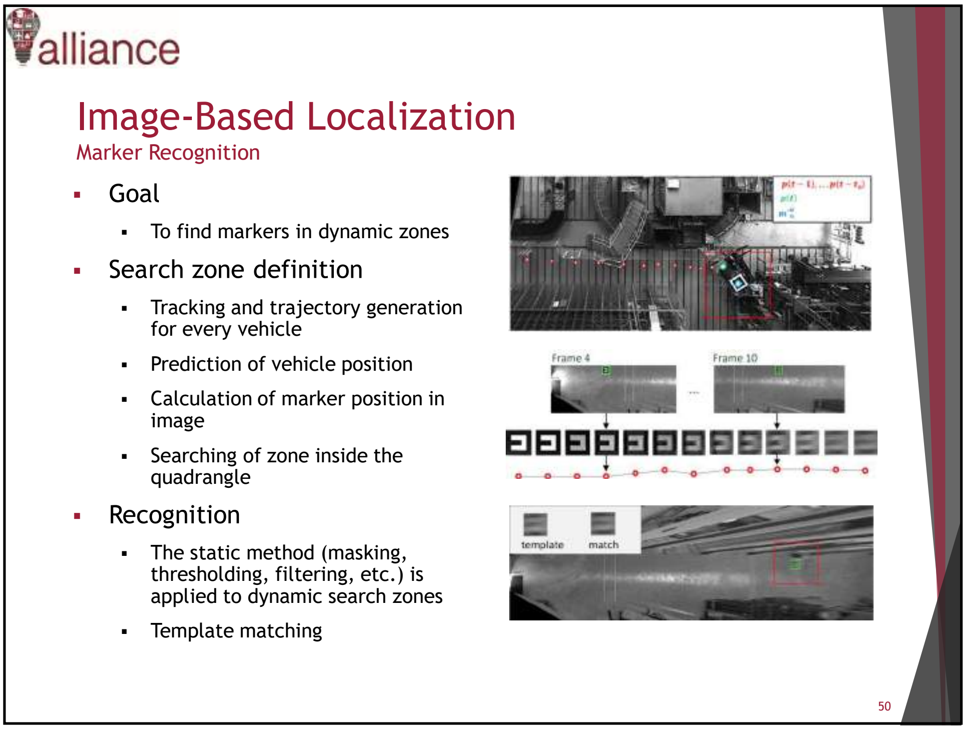

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Image-Based Localization

Marker Recognition

- Goal
  - To find markers in dynamic zones
- Search zone definition
  - Tracking and trajectory generation for every vehicle
  - Prediction of vehicle position
  - Calculation of marker position in image
  - Searching of zone inside the quadrangle
- Recognition
  - The static method (masking, thresholding, filtering, etc.) is applied to dynamic search zones
  - Template matching

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Image-Based Localization

Implemented System

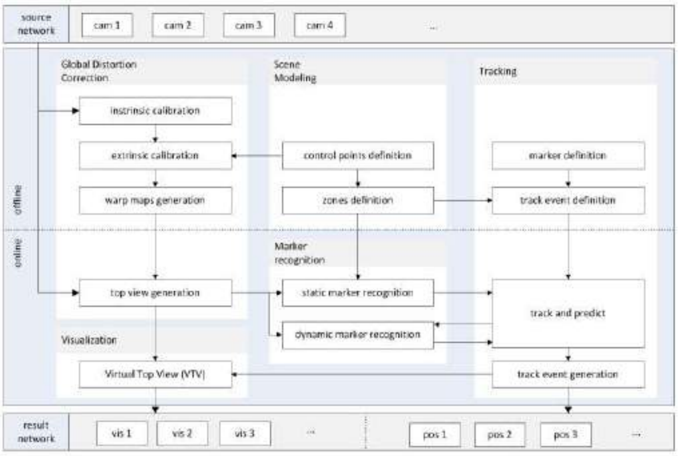

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Image-Based Localization

Implemented System

A short film of an actual logistics application of the marker based localization will be shown.

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3D Scanning

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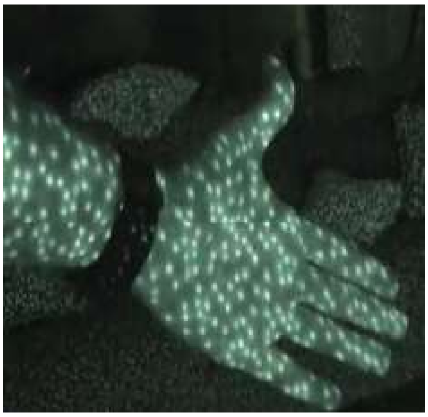
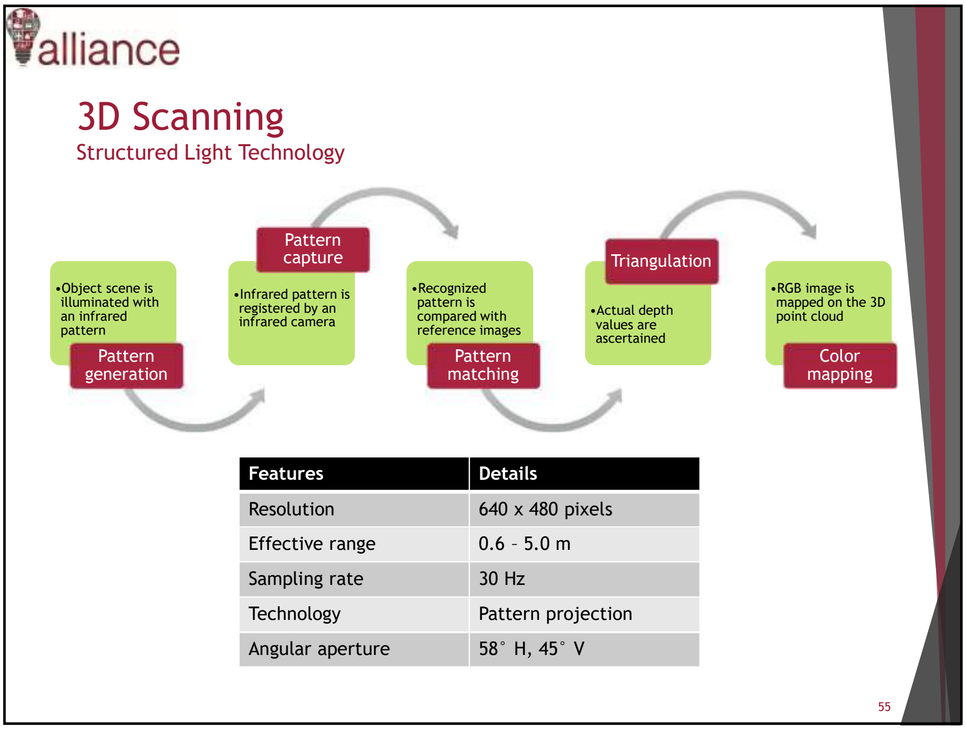
3D Scanning

Structured Light Technology



The Underlying Principle
3D Deep Scanning:
Structured Light

- A projector and a camera are needed to generate 3D surface structures. The projector generates a point matrix in a defined space. The camera analyzes the projected point matrix, calculating the coordinates in the space.
- The camera takes color 2D pictures. Generated structures can also be filled with texture.



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3D Scanning

Structured Light Technology

Pattern generation
- Object scene is illuminated with an infrared pattern

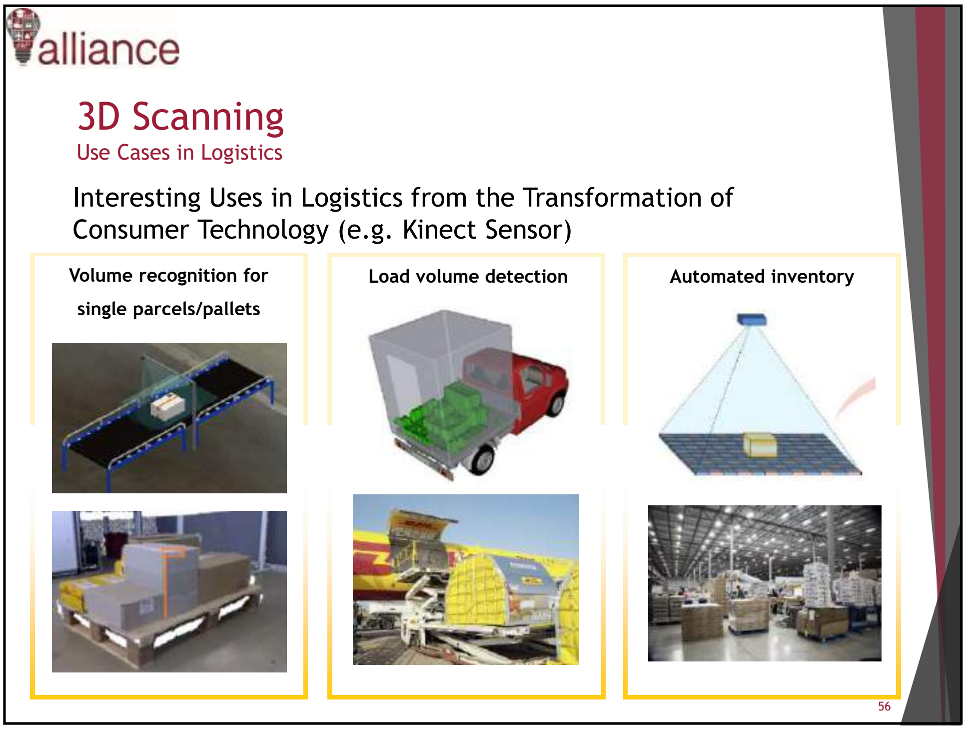
Pattern capture
- Infrared pattern is registered by an infrared camera

Pattern matching
- Recognized pattern is compared with reference images

Triangulation
- Actual depth values are ascertained

Color mapping
- RGB image is mapped on the 3D point cloud

Features	Details
Resolution	640 x 480 pixels
Effective range	0.6 – 5.0 m
Sampling rate	30 Hz
Technology	Pattern projection
Angular aperture	58° H, 45° V



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3D Scanning

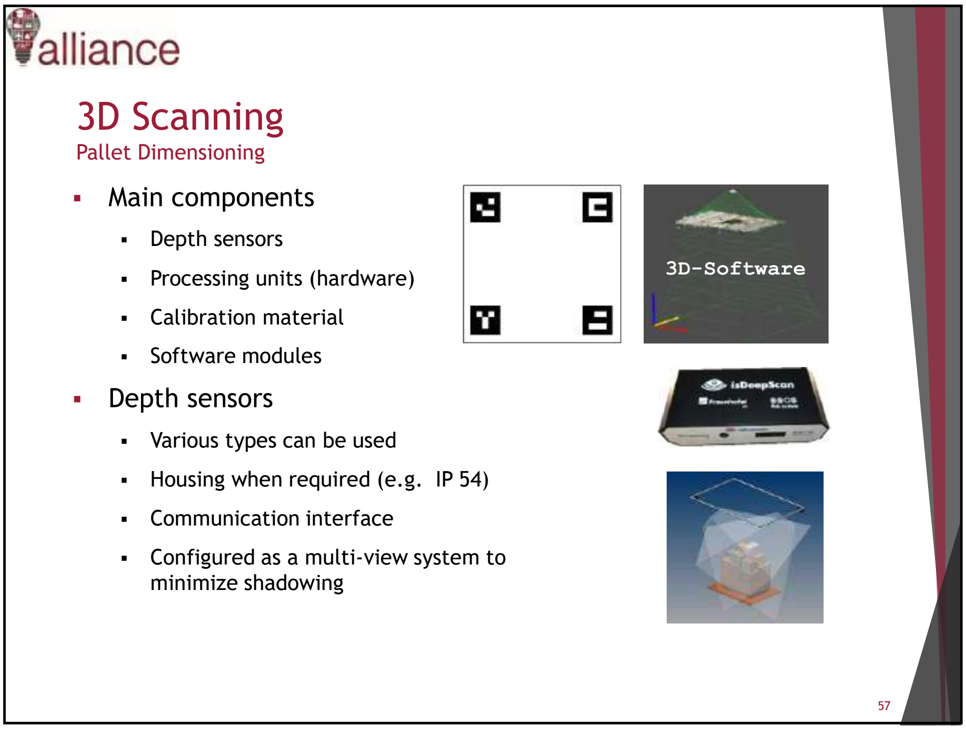
Use Cases in Logistics

Interesting Uses in Logistics from the Transformation of Consumer Technology (e.g. Kinect Sensor)

Volume recognition for single parcels/pallets

Load volume detection

Automated inventory



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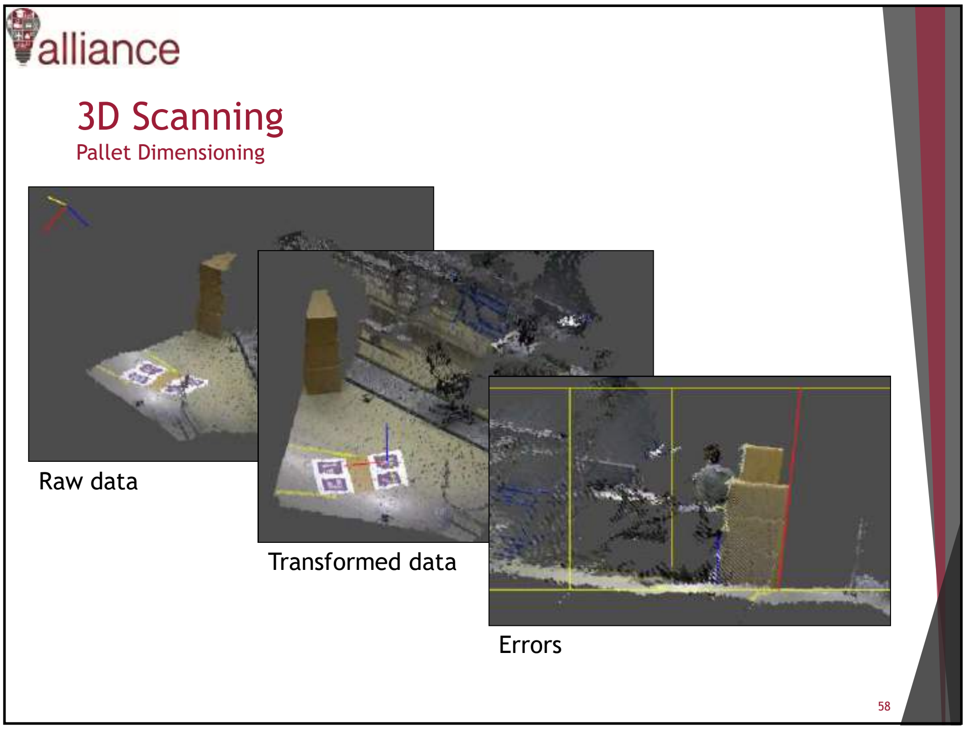
3D Scanning

Pallet Dimensioning

- Main components
  - Depth sensors
  - Processing units (hardware)
  - Calibration material
  - Software modules
- Depth sensors
  - Various types can be used
  - Housing when required (e.g. IP 54)
  - Communication interface
  - Configured as a multi-view system to minimize shadowing



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3D Scanning

Pallet Dimensioning

Raw data

Transformed data

Errors

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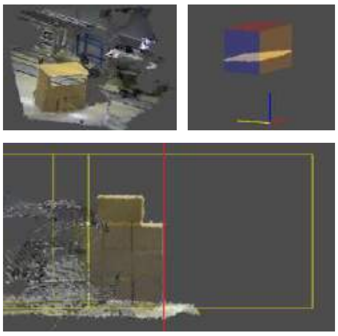
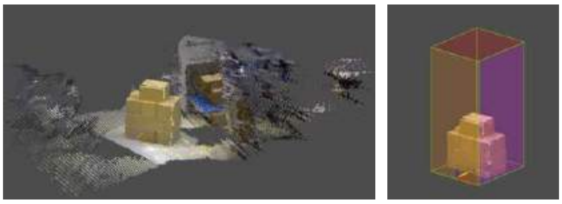
3D Scanning

Pallet Dimensioning

- Fine calibration
  - Placement of a plate in the sensor's near field
  - Segmentation
  - Optimization of transformation (Levenberg-Marquardt)
- Effective range
  - Setting of the sensor's specific effective range
  - Dynamic adjustment during sensing (x and y coordinates)





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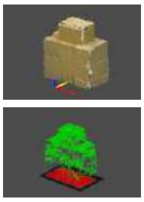
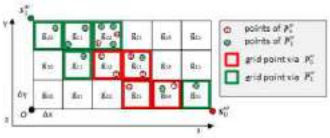
3D Scanning

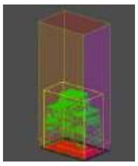
Pallet Dimensioning

- Calculating an elevation model from a point cloud
  - Assignment of points to a grid
  - Ascertainment of the elevation value of each grid point from the assigned points
  - Adjustment of the elevation values of the grid elements by a spatial median filter (optionally by computing the convex hull)





- Deriving shipment data from the elevation model
  - Length, width and height
  - Volume
  - Depth histogram



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For information - no slide within the course!

Demonstration 3D scanning

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For information - no slide within the course!

Demonstration 3D scanning

Description

The principle of the 3D scanning will be demonstrated with depth imaging sensor:

- Live stream with depth values
- Single shot of a depth image enhanced with RGB information
- Visualisation of 3D images in a 3D viewer

A 3D image of the course group will be made and provided for the participants.

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Suggested literature in red

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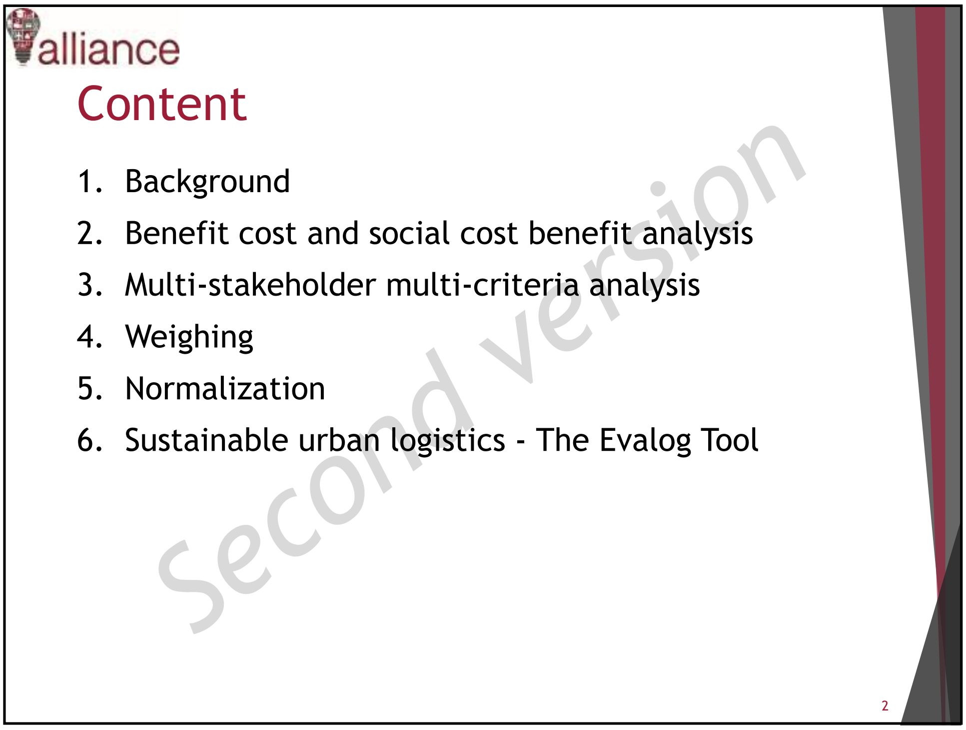
Decision making methodologies

University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



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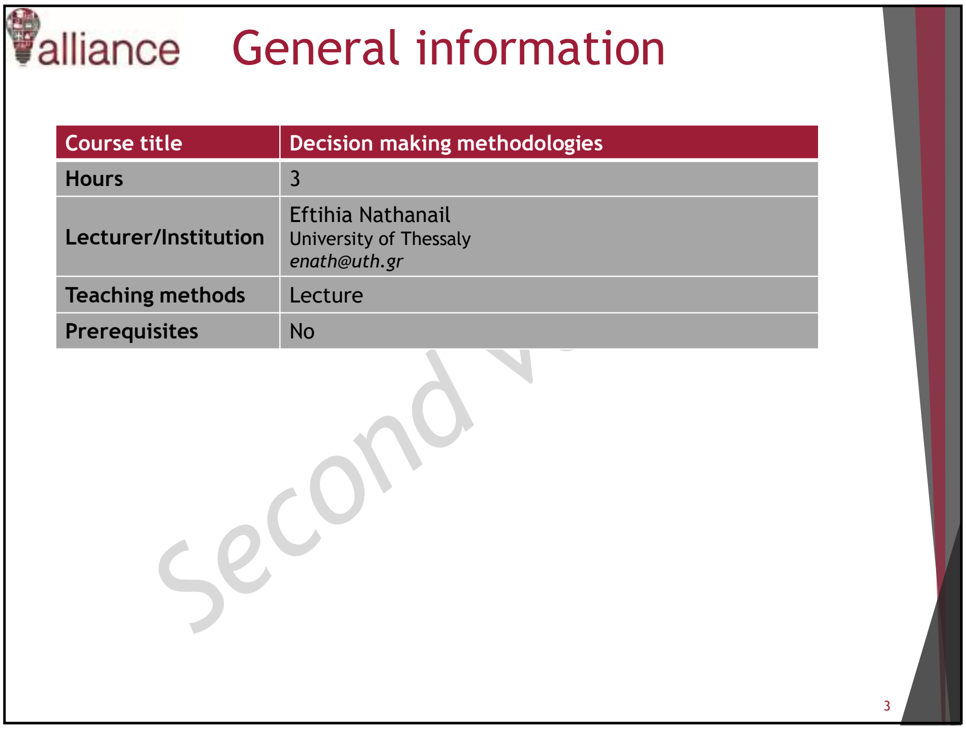
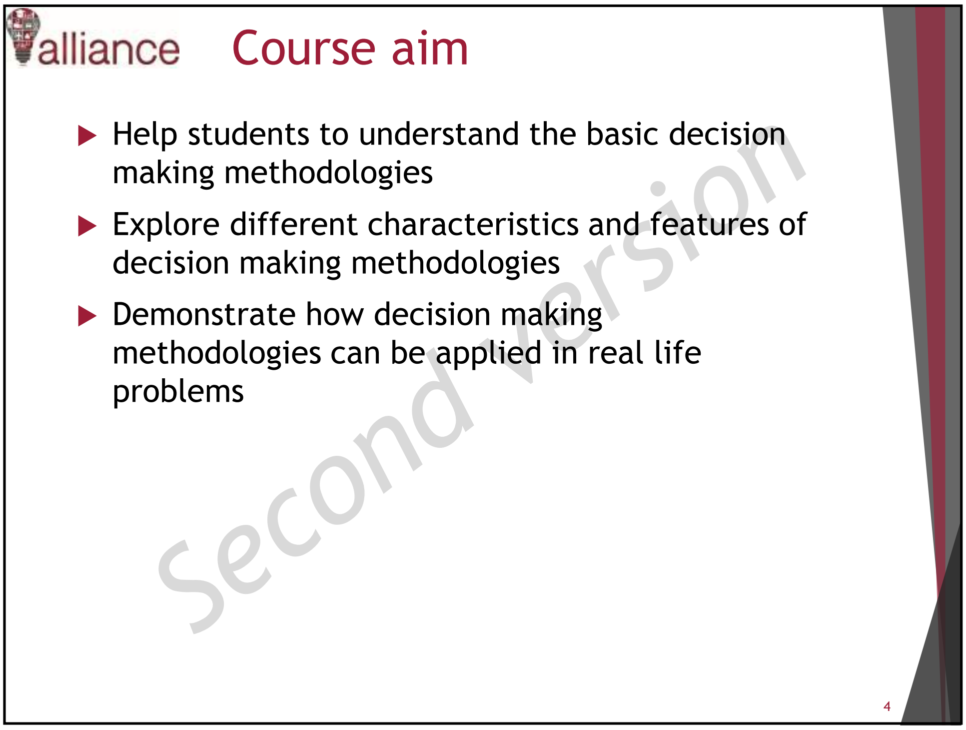
Content

1. Background
2. Benefit cost and social cost benefit analysis
3. Multi-stakeholder multi-criteria analysis
4. Weighing
5. Normalization
6. Sustainable urban logistics - The Evalog Tool



General information

Course title	Decision making methodologies
Hours	3
Lecturer/Institution	Eftihia Nathanail University of Thessaly *enath@uth.gr*
Teaching methods	Lecture
Prerequisites	No



Course aim

- Help students to understand the basic decision making methodologies
- Explore different characteristics and features of decision making methodologies
- Demonstrate how decision making methodologies can be applied in real life problems

Outcomes

- Apply basic steps of decision making
- Understand key methods for supporting logistics decision making
- Set goals, objectives and organize alternatives
- Understand most important decision making methods and problem building given alternatives and different stakeholders
- Evaluate alternatives with different units by considering normalization techniques
- Perform analysis, synthesis, and address problem issues and develop critical thinking skills to treat tradeoffs between alternatives
- Manage data and build decision support models in spreadsheets

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1. Background

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What is decision making?

- Uses explicit but no necessarily completely formalized models
- Helps obtain elements of responses to the questions posed by a stakeholder
- Clarifies the decision
- Recommends
- Favors a behavior
- Establishes solutions which are then submitted to the judgment of a decision maker

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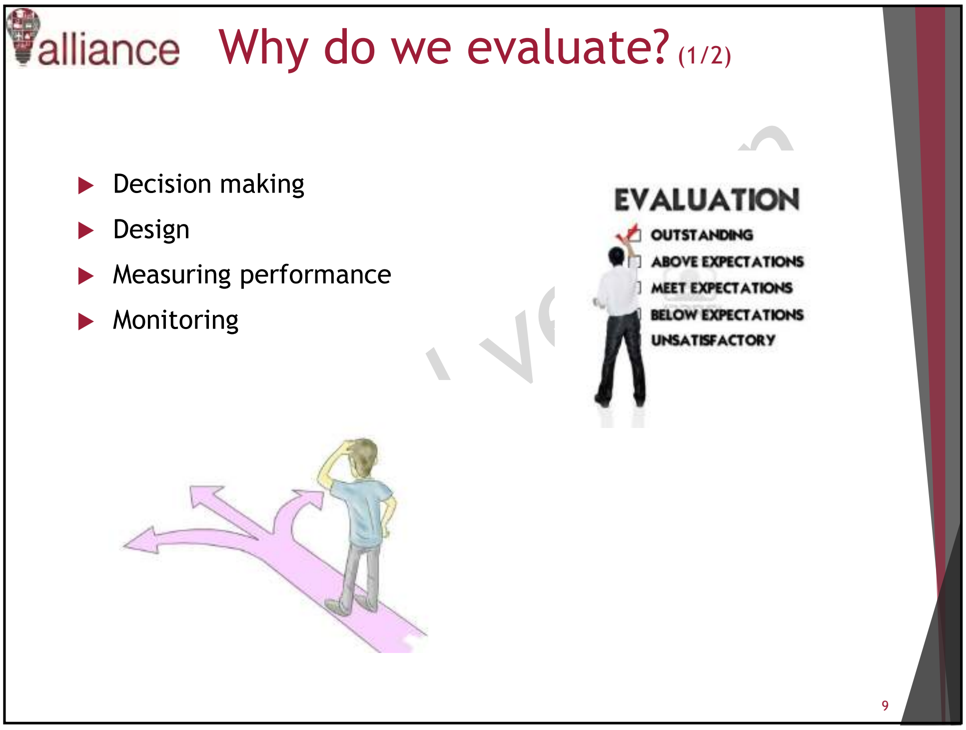
What is evaluation?

“Set of activities to conveniently arrange the information needed for a choice in order that the various participants in the choice process are enabled to make this choice as balanced as possible”

Reference: Nijkamp et al. 1990



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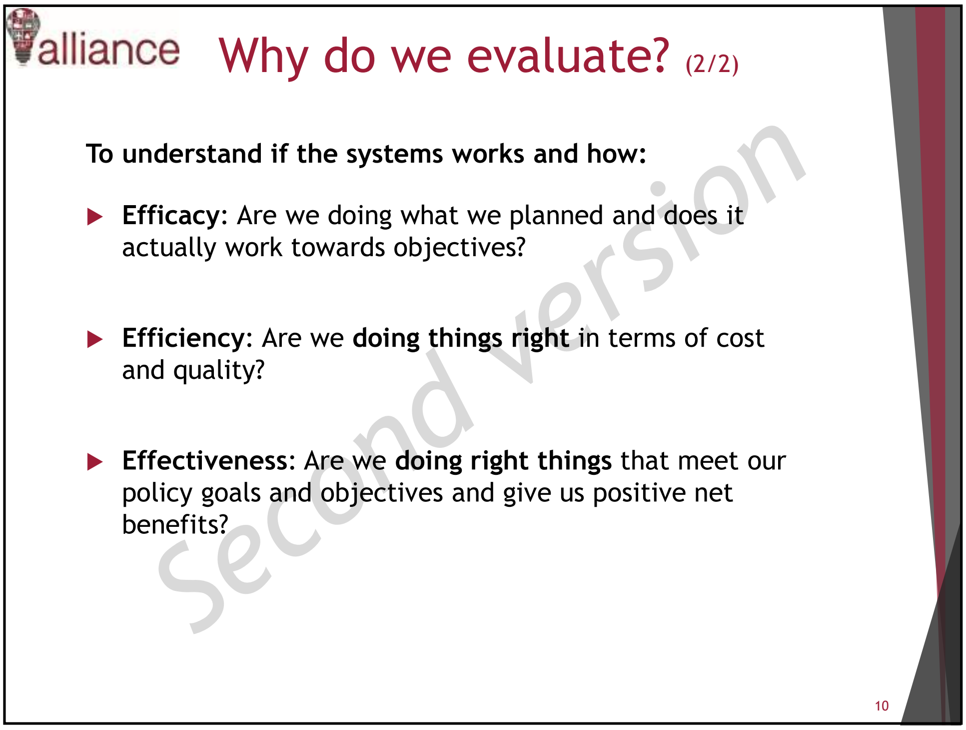
Why do we evaluate? (1/2)

- Decision making
- Design
- Measuring performance
- Monitoring



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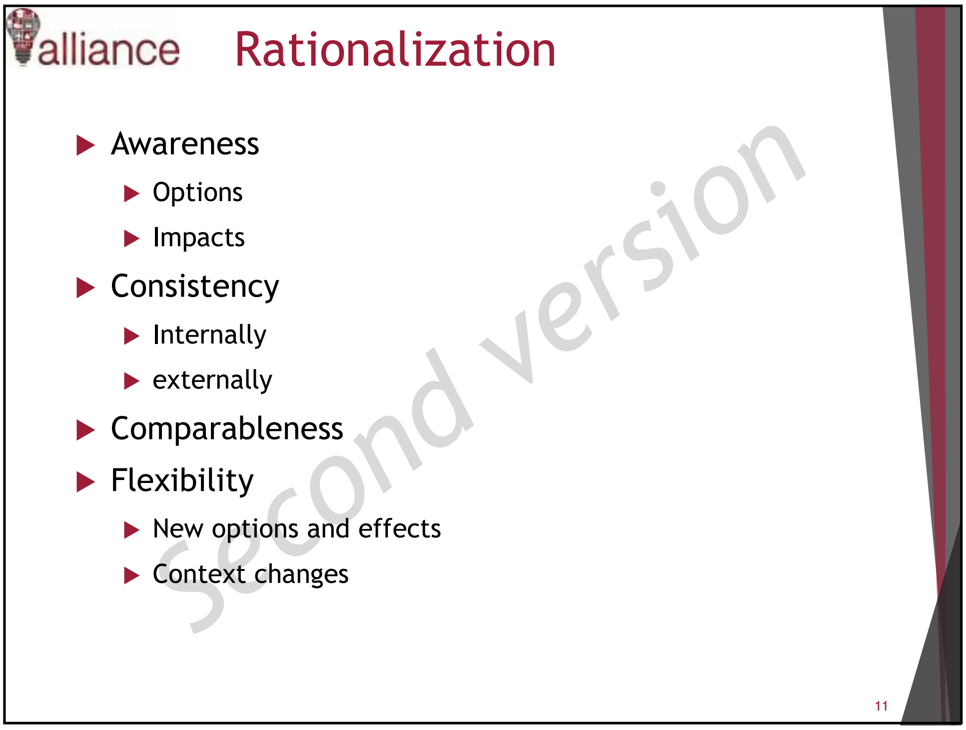
Why do we evaluate? (2/2)

To understand if the systems works and how:

- **Efficacy**: Are we doing what we planned and does it actually work towards objectives?
- **Efficiency:** Are we **doing things right** in terms of cost and quality?
- **Effectiveness:** Are we **doing right things** that meet our policy goals and objectives and give us positive net benefits?



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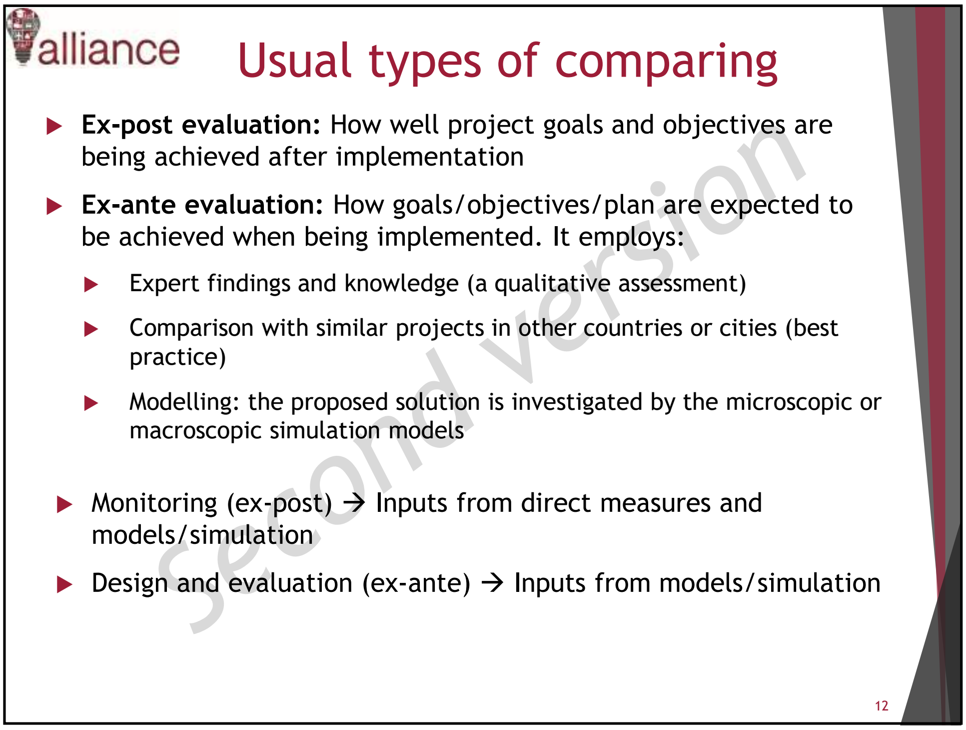
Rationalization

- Awareness
  - Options
  - Impacts
- Consistency
  - Internally
  - externally
- Comparableness
- Flexibility
  - New options and effects
  - Context changes



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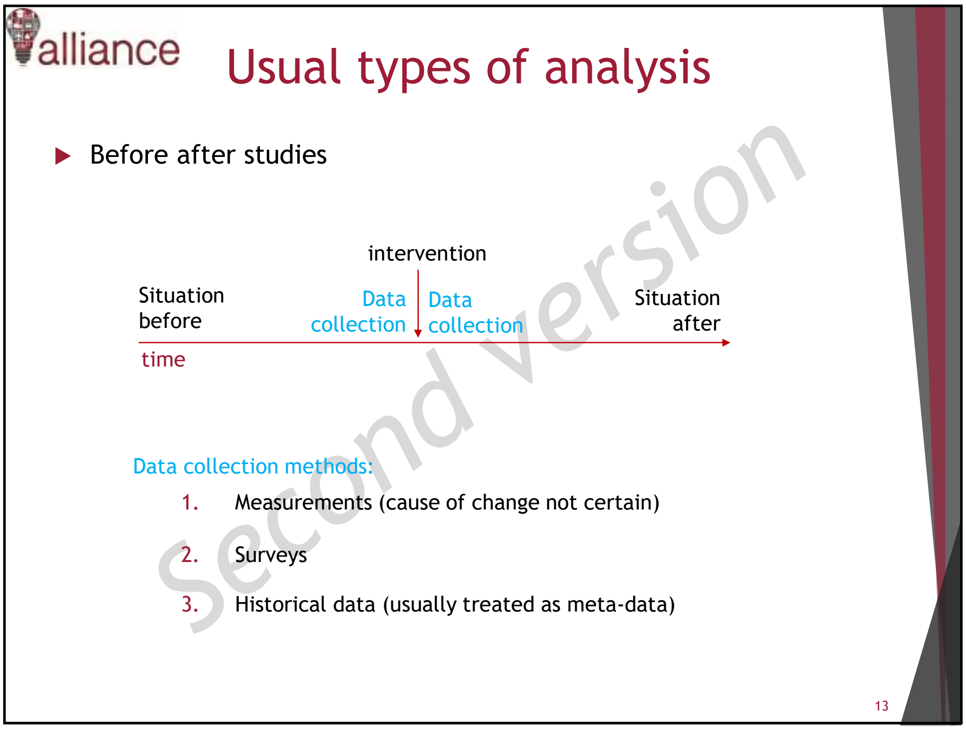
Usual types of comparing

- **Ex-post evaluation:** How well project goals and objectives are being achieved after implementation
- **Ex-ante evaluation:** How goals/objectives/plan are expected to be achieved when being implemented. It employs:
  - Expert findings and knowledge (a qualitative assessment)
  - Comparison with similar projects in other countries or cities (best practice)
  - Modelling: the proposed solution is investigated by the microscopic or macroscopic simulation models
- Monitoring (ex-post) → Inputs from direct measures and models/simulation
- Design and evaluation (ex-ante) → Inputs from models/simulation

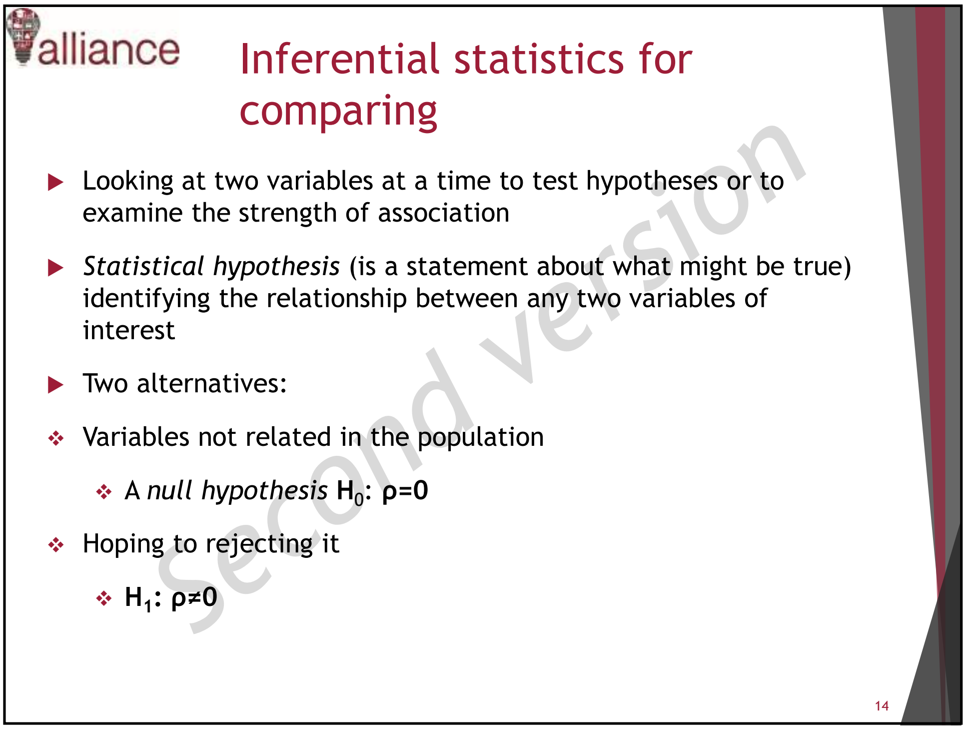


Usual types of analysis

- Before after studies

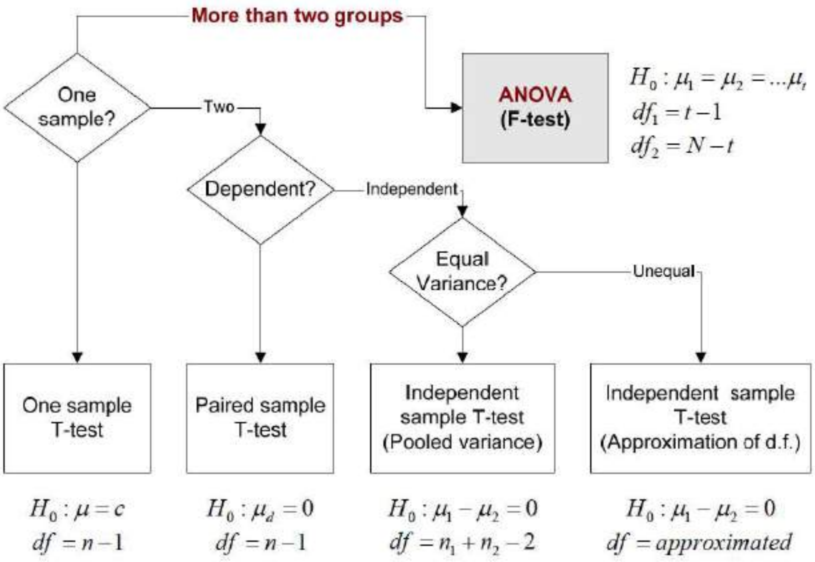
Data collection methods:

1. Measurements (cause of change not certain)
2. Surveys
3. Historical data (usually treated as meta-data)



Inferential statistics for comparing

- Looking at two variables at a time to test hypotheses or to examine the strength of association
- *Statistical hypothesis* (is a statement about what might be true) identifying the relationship between any two variables of interest
- Two alternatives:
- Variables not related in the population
  - A *null hypothesis* H_0: **ρ=0**
- Hoping to rejecting it
  - **H_1: ρ≠0**



More than two groups

One sample?

Two

Dependent?

Independent

Equal Variance?

Unequal

ANOVA (F-test)

$H_0 : \mu_1 = \mu_2 = ...\mu_t$
$df_1 = t-1$
$df_2 = N-t$

One sample T-test

$H_0 : \mu = c$
$df = n-1$

Paired sample T-test

$H_0 : \mu_d = 0$
$df = n-1$

Independent sample T-test (Pooled variance)

$H_0 : \mu_1 - \mu_2 = 0$
$df = n_1 + n_2 - 2$

Independent sample T-test (Approximation of d.f.)

$H_0 : \mu_1 - \mu_2 = 0$
$df = approximated$

Reference: Hun Myoung, 2009

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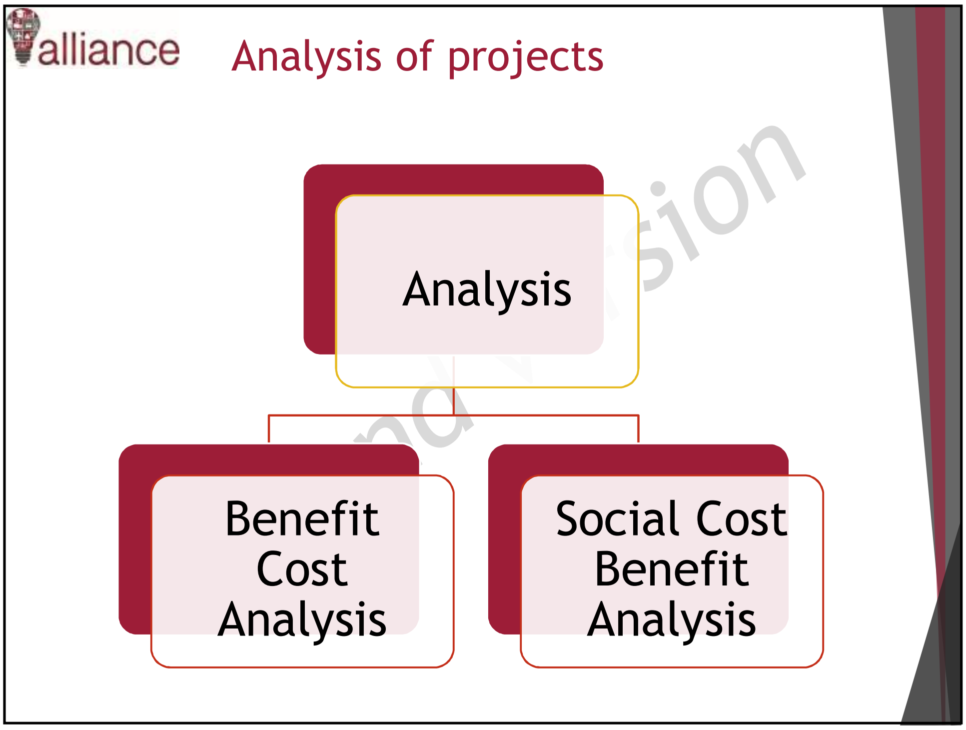
2. Benefit cost and social cost benefit analysis



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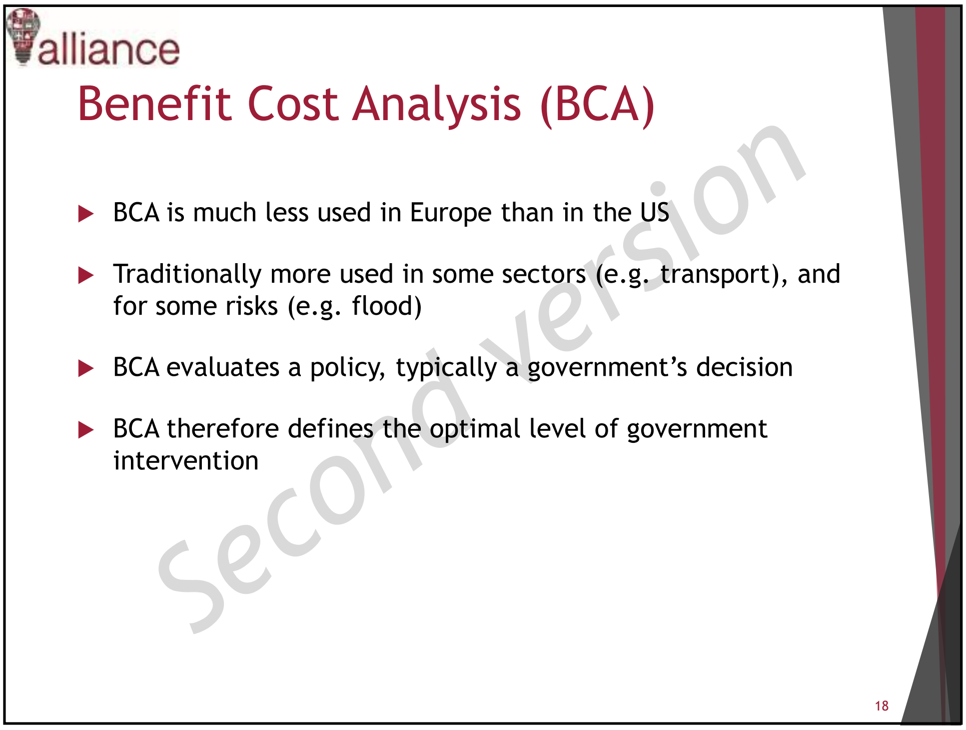
Analysis of projects

Analysis

Benefit Cost Analysis

Social Cost Benefit Analysis



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Benefit Cost Analysis (BCA)

- BCA is much less used in Europe than in the US
- Traditionally more used in some sectors (e.g. transport), and for some risks (e.g. flood)
- BCA evaluates a policy, typically a government's decision
- BCA therefore defines the optimal level of government intervention

Net Present Value

$$B_0 - C_0 + \frac{B_1-C_1}{(1+r)}+\frac{B_2-C_2}{(1+r)^2}+\ldots+\frac{B_t-C_t}{(1+r)^t} + \cdots + \frac{B_n-C_n}{(1+r)^n} =$$

$$=\sum_{t=o}^{n} \frac{B_t-C_t}{(1+r)^t}$$

where:

- B_t = benefits in year t
- C_t = costs in year t
- r = interest rate
- n = target year

Internal Rate of Return (IRR)

$$B_0 - C_0 + \frac{B_1-C_1}{(1+IR\ \ )}+\frac{B_2-C_2}{(1+IRR)^2}+\ldots+\frac{B_t-C_t}{(1+IR\ \ )^t} + \cdots + \frac{B_n-C_n}{(1+IR\ \ )^n} = 0$$

where:

- B_t = benefits in year t
- C_t = costs in year t
- IRR = interest rate that sets equation to zero
- n = target year

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Benefit Cost Ratio

$$\frac{\sum\left(\frac{B_i}{(1+r)^i}\right)}{\sum\left(\frac{C_i}{(1+r)^i}\right)} \quad \text{for i = 0 to n}$$

where:

- B_t = benefits in year t
- C_t = costs in year t
- r = interest rate
- n = target year

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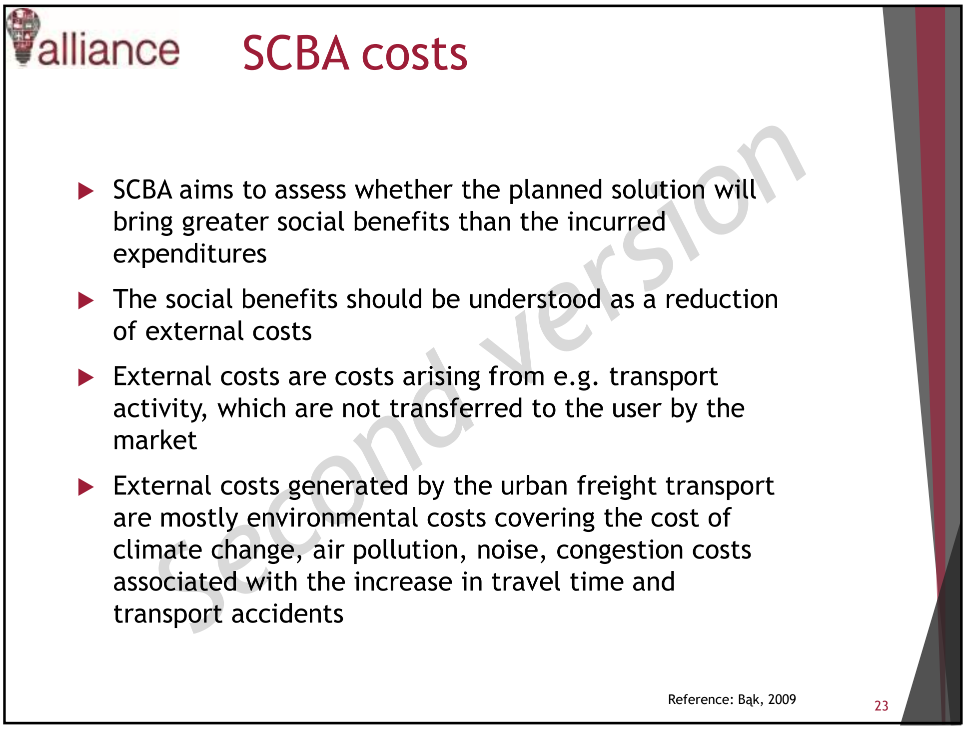
Social Cost Benefit Analysis purpose

- To assess the planned and/or implemented solution(s) expressed in the amount of expenses/costs that affect the gain of resulting social benefits.
  - Costs and benefits can be defined in different ways, and are divided into different types based on criteria
  - Internal and external (to the target group or area)
  - Tangible and intangible (and therefore directly or indirectly measurable)
  - Direct and indirect (depending on whether these are direct or indirect effects of the program)
  - Efficient and redistributive (depending on whether they increase net benefit, or just change the distribution of benefits)

Reference: Dunn, 2002



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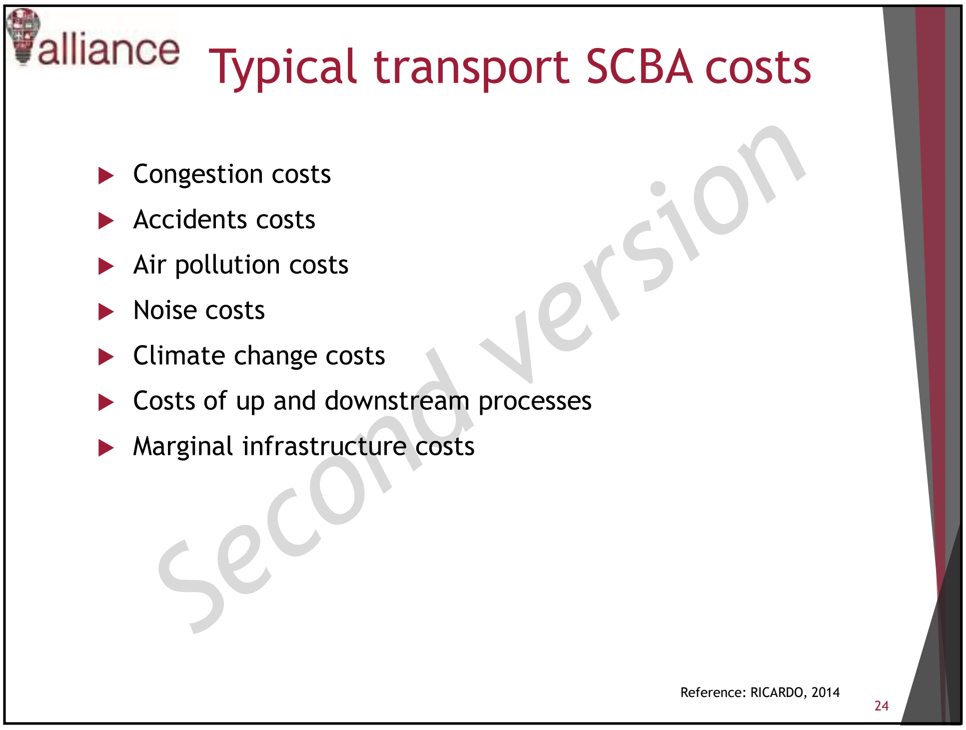
SCBA costs

- SCBA aims to assess whether the planned solution will bring greater social benefits than the incurred expenditures
- The social benefits should be understood as a reduction of external costs
- External costs are costs arising from e.g. transport activity, which are not transferred to the user by the market
- External costs generated by the urban freight transport are mostly environmental costs covering the cost of climate change, air pollution, noise, congestion costs associated with the increase in travel time and transport accidents

Reference: Bąk, 2009



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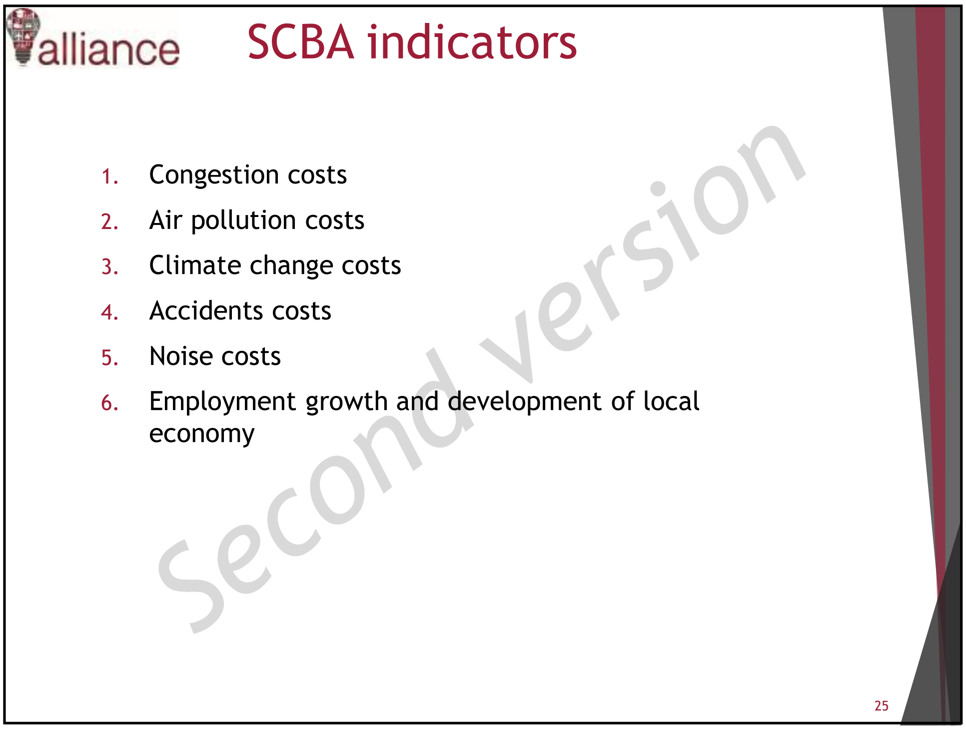
Typical transport SCBA costs

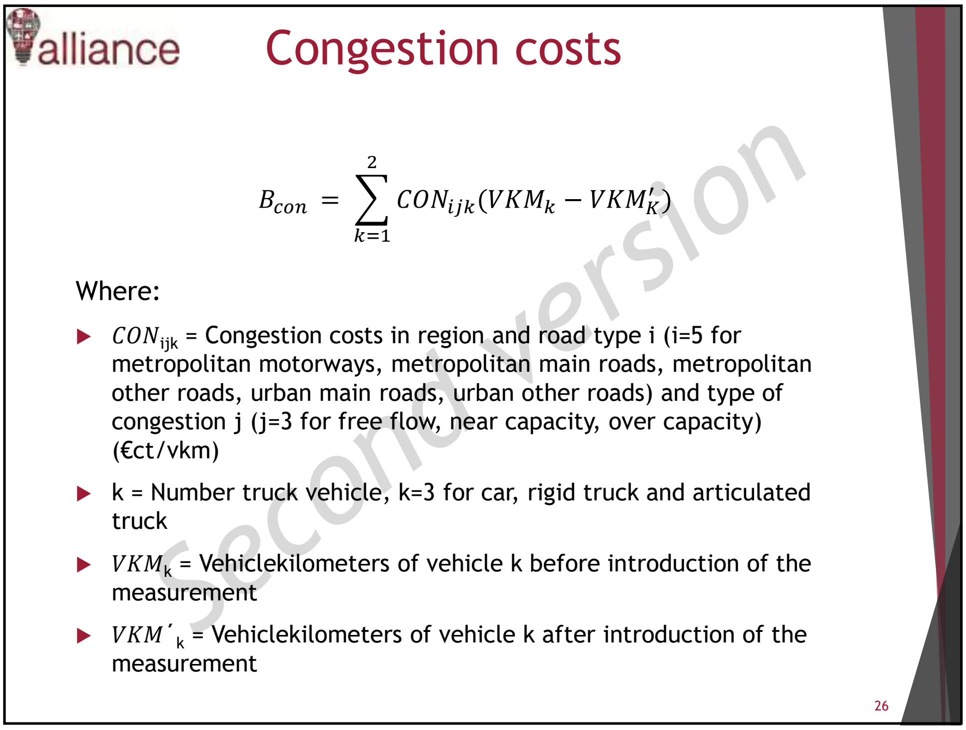
- Congestion costs
- Accidents costs
- Air pollution costs
- Noise costs
- Climate change costs
- Costs of up and downstream processes
- Marginal infrastructure costs

Reference: RICARDO, 2014



SCBA indicators

1. Congestion costs
2. Air pollution costs
3. Climate change costs
4. Accidents costs
5. Noise costs
6. Employment growth and development of local economy

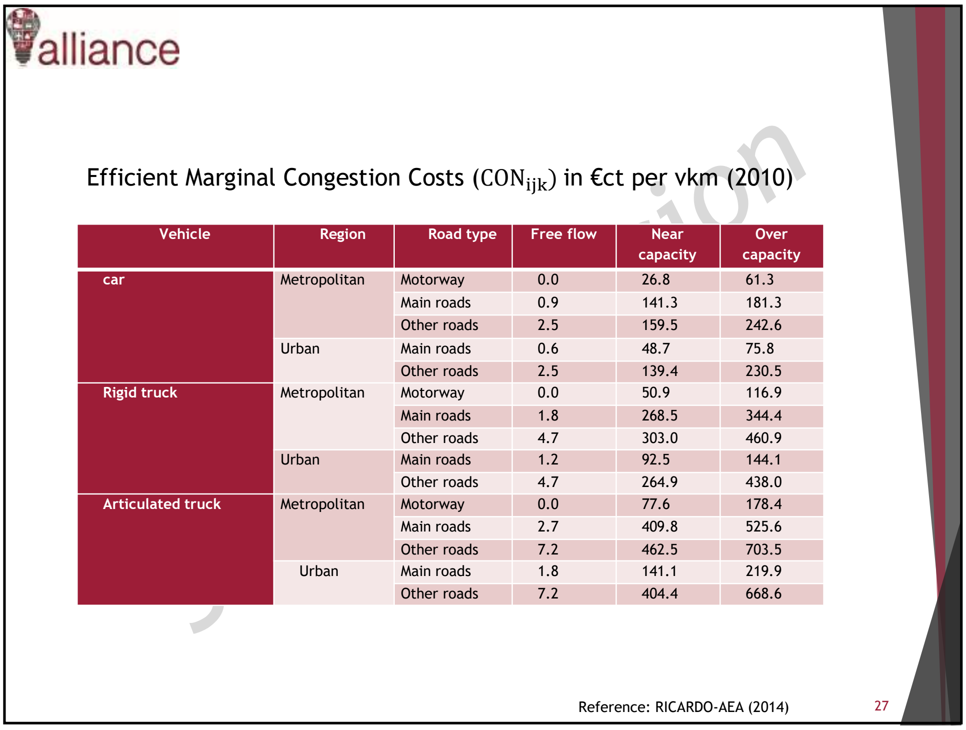


Congestion costs

$$B_{con} = \sum_{k=1}^{2} CON_{ijk}(VKM_k - VKM'_K)$$

Where:

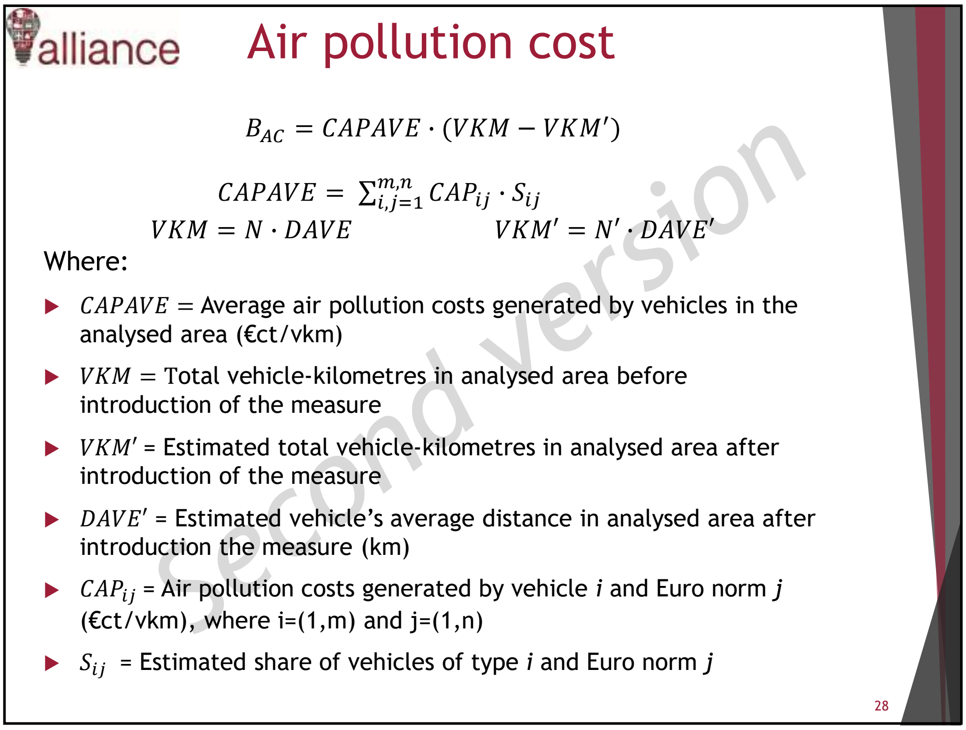
- CON_{ijk} = Congestion costs in region and road type i (i=5 for metropolitan motorways, metropolitan main roads, metropolitan other roads, urban main roads, urban other roads) and type of congestion j (j=3 for free flow, near capacity, over capacity) (€ct/vkm)
- k = Number truck vehicle, k=3 for car, rigid truck and articulated truck
- VKM_k = Vehiclekilometers of vehicle k before introduction of the measurement
- VKM'_k = Vehiclekilometers of vehicle k after introduction of the measurement



Efficient Marginal Congestion Costs (CON_{ijk}) in €ct per vkm (2010)

Vehicle	Region	Road type	Free flow	Near capacity	Over capacity
car	Metropolitan	Motorway	0.0	26.8	61.3
		Main roads	0.9	141.3	181.3
		Other roads	2.5	159.5	242.6
	Urban	Main roads	0.6	48.7	75.8
		Other roads	2.5	139.4	230.5
Rigid truck	Metropolitan	Motorway	0.0	50.9	116.9
		Main roads	1.8	268.5	344.4
		Other roads	4.7	303.0	460.9
	Urban	Main roads	1.2	92.5	144.1
		Other roads	4.7	264.9	438.0
Articulated truck	Metropolitan	Motorway	0.0	77.6	178.4
		Main roads	2.7	409.8	525.6
		Other roads	7.2	462.5	703.5
	Urban	Main roads	1.8	141.1	219.9
		Other roads	7.2	404.4	668.6

Reference: RICARDO-AEA (2014)



Air pollution cost

$$B_{AC} = CAPAVE \cdot (VKM - VKM')$$

$$CAPAVE = \sum_{i,j=1}^{m,n} CAP_{ij} \cdot S_{ij}$$

$$VKM = N \cdot DAVE \qquad VKM' = N' \cdot DAVE'$$

Where:

- $CAPAVE$ = Average air pollution costs generated by vehicles in the analysed area (€ct/vkm)
- VKM = Total vehicle-kilometres in analysed area before introduction of the measure
- VKM' = Estimated total vehicle-kilometres in analysed area after introduction of the measure
- $DAVE'$ = Estimated vehicle's average distance in analysed area after introduction the measure (km)
- CAP_{ij} = Air pollution costs generated by vehicle *i* and Euro norm *j* (€ct/vkm), where i=(1,m) and j=(1,n)
- S_{ij} = Estimated share of vehicles of type *i* and Euro norm *j*

Marginal external air pollution costs (CAP_{ij}) for cars in €ct/vkm (2010) in urban area

Engine	EURO-Class		Engine	EURO-Class	
Car diesel			Car petrol		
<1.4l	Euro 2	3.6	<1.4l	Euro 0	3.5
	Euro 3	2.5		Euro 1	1
	Euro 4	1.7		Euro 2	0.7
	Euro 5	0.9		Euro 3	0.4
	Euro 6	0.7		Euro 4	0.4
1.4-2.0l	Euro 0	9.9		Euro 5	0.4
	Euro 1	3.6		Euro 6	0.4
	Euro 2	3.2	1.4-2.0l	Euro 0	3.6
	Euro 3	2.6		Euro 1	1.1
	Euro 4	1.8		Euro 2	0.7
	Euro 5	0.9		Euro 3	0.4
	Euro 6	0.7		Euro 4	0.4
>2.0l	Euro 0	10.3		Euro 5	0.4
	Euro 1	3.7		Euro 6	0.4
	Euro 2	3.3	>2.0l	Euro 0	3.8
	Euro 3	2.6		Euro 1	1
	Euro 4	1.8		Euro 2	0.6
	Euro 5	0.9		Euro 3	0.4
	Euro 6	0.7		Euro 4	0.4
				Euro 5	0.4
				Euro 6	0.4

Marginal external air pollution costs (CAP_{ij}) for rigid heavy vehicles in €ct/vkm (2010) in urban area

EURO-Class (j)	Load capacity (i)							
	<=7.5 t	7.5 - 12 t	12 - 14 t	14 - 20 t	20 - 26 t	26 - 28 t	28 - 32 t	>32 t
EURO 0	15.4	20.5	22.5	29.0	31.8	33.4	38.2	39.2
EURO I	8.5	13.0	14.4	18.3	23.8	25.0	28.5	29.8
EURO II	6.9	10.5	11.6	14.5	18.9	19.9	22.8	23.7
EURO III	6.1	9.1	10.1	13.0	16.3	16.9	19.1	19.9
EURO IV	3.8	5.4	6.0	7.3	9.1	9.4	10.7	10.9
EURO V	3.7	5.2	5.5	7.4	8.3	8.4	8.5	8.5
EURO VI	1.7	1.8	1.8	2.1	2.1	2.1	2.1	2.1

Reference: RICARDO-AEA (2014)

Climate change costs

$$B_{CC} = CCCAVE \cdot (VKM - VKM')$$

$$CCCAVE = \sum_{i.j=1}^{m.n} CCC_{ij} \cdot S_{ij}$$

- CCCAVE = Average climate change costs generated by vehicles in analysed area (€ct/vkm)
- CCC_{ij} =Climate change costs generated by vehicle i and Euro norm j (€ct/vkm), for i=(1,m), j=(1,n)
- S_{ij} = Estimated share of vehicles of type *i* and Euro norm *j*
- VKM = Total vehiclekilometers in analysed area before introduction of the measure
- VKM' = Estimated total vehiclekilometers in analysed area after introduction of the measure

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Marginal climate change costs (CCC_{ij}) for cars in urban area €ct/vkm (2010)

Size	EURO-Class		Size	EURO-Class	
Passenger Car - Diesel			Passenger Car - Petrol		
<1,4L	EURO-2	1.7	<1,4L	EURO-0	2.8
	EURO-3	1.6		EURO-1	2.8
	EURO-4	1.6		EURO-2	2.5
	EURO-5	1.6		EURO-3	2.4
1,4-2L	EURO-0	2.4		EURO-4	2.4
	EURO-1	2.2		EURO-5	2.4
	EURO-2	2.2	1,4-2L	EURO-0	3.4
	EURO-3	2.1		EURO-1	3.1
	EURO-4	2.1		EURO-2	3.0
	EURO-5	2.1		EURO-3	2.9
>2L	EURO-0	3.3		EURO-4	2.9
	EURO-1	3.0		EURO-5	2.9
	EURO-2	3.0	>2L	EURO-1	3.9
	EURO-3	2.9		EURO-2	3.9
	EURO-4	2.9		EURO-3	3.5
	EURO-5	2.9		EURO-4	3.5
				EURO-5	3.5

Reference: RICARDO-AEA (2014)

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Road accidents

- Costs associated with the rescue and rehabilitation of victims of road accidents and the cost of special services (police, ambulance, fire brigade etc.).
- Damage to property
  - E.g.: production losses not covered by the insurance (as the result of the death or disability of the people involved in the accident),
  - Losses resulting from expenditures e.g. on education and so-called the cost of compensation, as the value of pain, grief and suffering caused by the accident.

Road safety studies

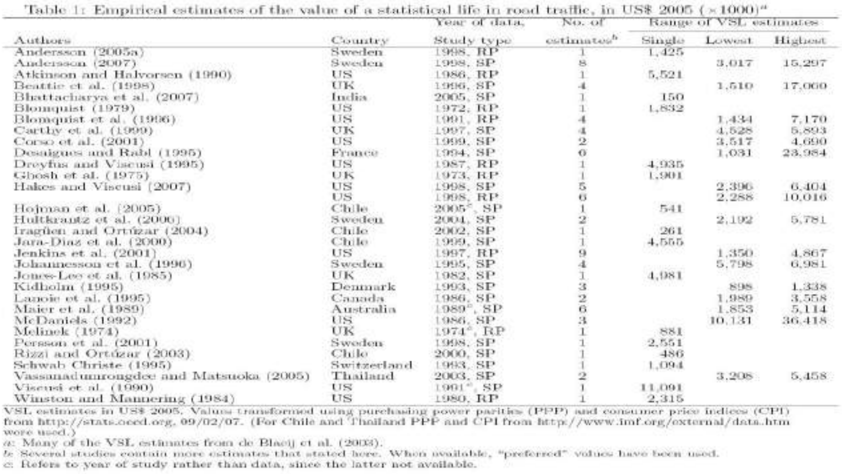


Table 1: Empirical estimates of the value of a statistical life in road traffic, in US$ 2005 (×1000)^a

Authors	Country	Year of data, Study type	No. of estimates^b	Range of VSL estimates		
				Single	Lowest	Highest
Andersson (2005a)	Sweden	1998, RP	1	1,425		
Andersson (2007)	Sweden	1998, SP	8		3,017	15,297
Atkinson and Halvorsen (1990)	US	1986, RP	1	5,521		
Beattie et al. (1998)	UK	1996, SP	4		1,510	17,060
Bhattacharya et al. (2007)	India	2005, SP	1	150		
Blomquist (1979)	US	1972, RP	1	1,832		
Blomquist et al. (1996)	US	1991, RP	4		1,434	7,170
Carthy et al. (1999)	UK	1997, SP	4		4,528	5,893
Corso et al. (2001)	US	1999, SP	2		3,517	4,690
Desaigues and Rabl (1995)	France	1994, SP	6		1,031	23,984
Dreyfus and Viscusi (1995)	US	1987, RP	1	4,935		
Ghosh et al. (1975)	UK	1973, RP	1	1,901		
Hakes and Viscusi (2007)	US	1998, SP	5		2,396	6,404
	US	1998, RP	6		2,288	10,016
Hojman et al. (2005)	Chile	2005^c, SP	1	541		
Hultkrantz et al. (2006)	Sweden	2004, SP	2		2,192	5,781
Iragüen and Ortúzar (2004)	Chile	2002, SP	1	261		
Jara-Diaz et al. (2000)	Chile	1999, SP	1	4,555		
Jenkins et al. (2001)	US	1997, RP	9		1,350	4,867
Johannesson et al. (1996)	Sweden	1995, SP	4		5,798	6,981
Jones-Lee et al. (1985)	UK	1982, SP	1	4,981		
Kidholm (1995)	Denmark	1993, SP	3		898	1,338
Lanoie et al. (1995)	Canada	1986, SP	2		1,989	3,558
Maier et al. (1989)	Australia	1989^c, SP	6		1,853	5,114
McDaniels (1992)	US	1986, SP	3		10,131	36,418
Melinek (1974)	UK	1974^c, RP	1	881		
Persson et al. (2001)	Sweden	1998, SP	1	2,551		
Rizzi and Ortúzar (2003)	Chile	2000, SP	1	486		
Schwab Christe (1995)	Switzerland	1993, SP	1	1,094		
Vassanadumrongdee and Matsuoka (2005)	Thailand	2003, SP	2		3,208	5,458
Viscusi et al. (1990)	US	1991^c, SP	1	11,091		
Winston and Mannering (1984)	US	1980, RP	1	2,315		

VSL estimates in US$ 2005. Values transformed using purchasing power parities (PPP) and consumer price indices (CPI) from http://stats.oecd.org, 09/02/07. (For Chile and Thailand PPP and CPI from http://www.imf.org/external/data.htm were used.)

a: Many of the VSL estimates from de Blaeij et al. (2003).

b: Several studies contain more estimates that stated here. When available, "preferred" values have been used.

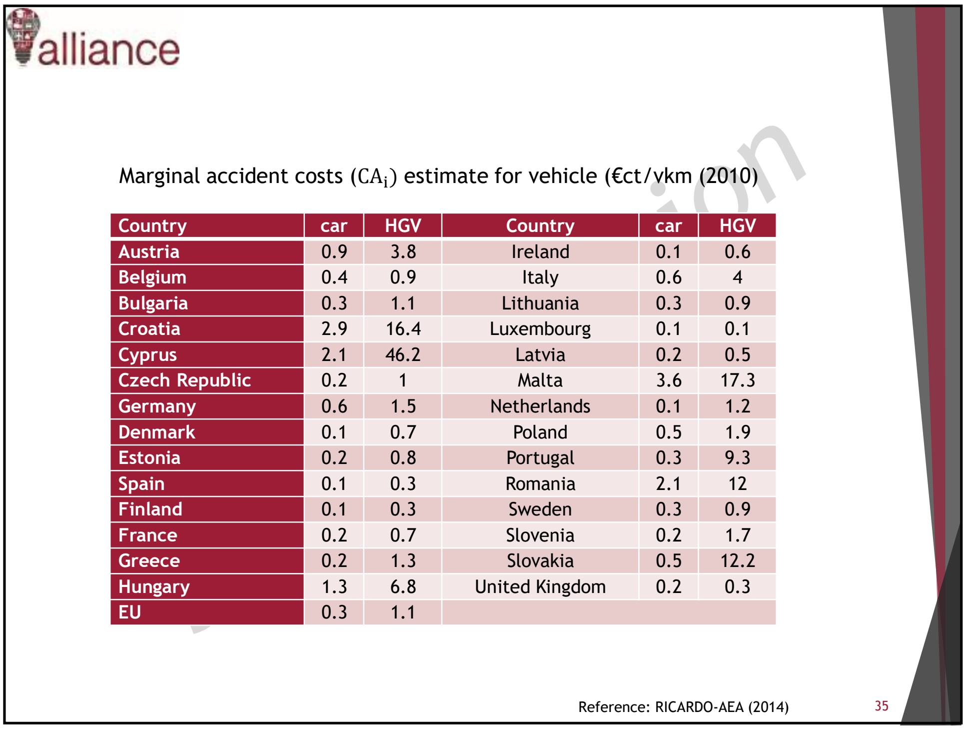
c: Refers to year of study rather than data, since the latter not available.

Source: Andersson and Treich, 2011

Accidents costs

$$B_A = CA_i \cdot (VKM - VKM')$$

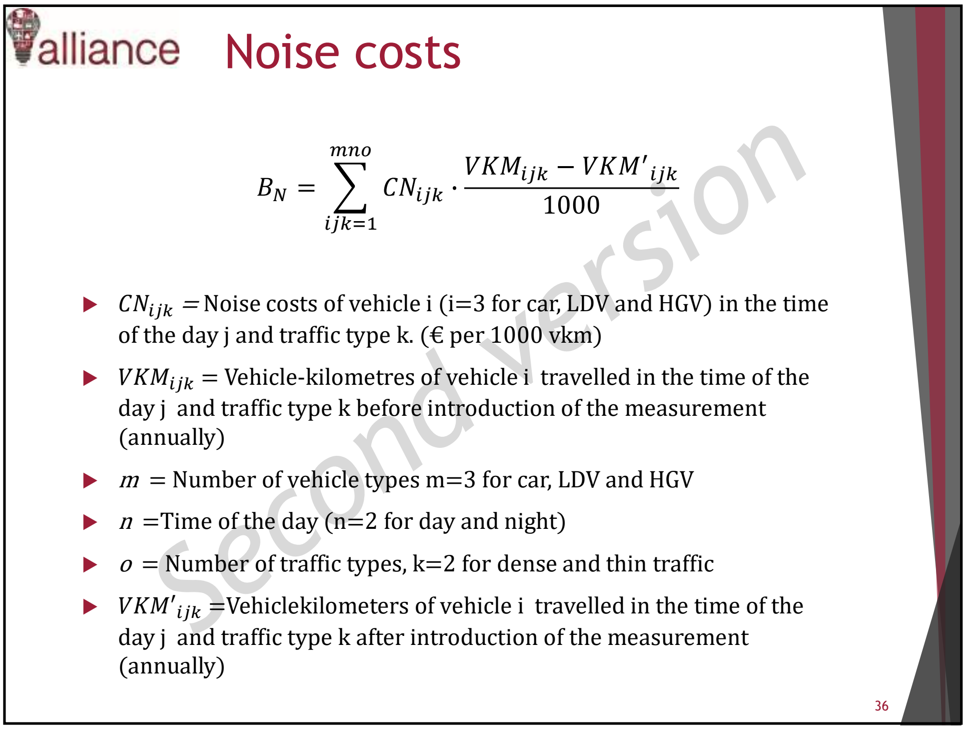
- CA_i = Marginal accident cost in country *i* (€ct/vkm)
- VKM = Total vehicle-kilometres in analysed area before introduction of the measure
- VKM' = Estimated total vehicle-kilometres in analysed area after introduction of the measure



Marginal accident costs ($\mathrm{CA_i}$) estimate for vehicle (€ct/vkm (2010)

Country	car	HGV	Country	car	HGV
Austria	0.9	3.8	Ireland	0.1	0.6
Belgium	0.4	0.9	Italy	0.6	4
Bulgaria	0.3	1.1	Lithuania	0.3	0.9
Croatia	2.9	16.4	Luxembourg	0.1	0.1
Cyprus	2.1	46.2	Latvia	0.2	0.5
Czech Republic	0.2	1	Malta	3.6	17.3
Germany	0.6	1.5	Netherlands	0.1	1.2
Denmark	0.1	0.7	Poland	0.5	1.9
Estonia	0.2	0.8	Portugal	0.3	9.3
Spain	0.1	0.3	Romania	2.1	12
Finland	0.1	0.3	Sweden	0.3	0.9
France	0.2	0.7	Slovenia	0.2	1.7
Greece	0.2	1.3	Slovakia	0.5	12.2
Hungary	1.3	6.8	United Kingdom	0.2	0.3
EU	0.3	1.1			

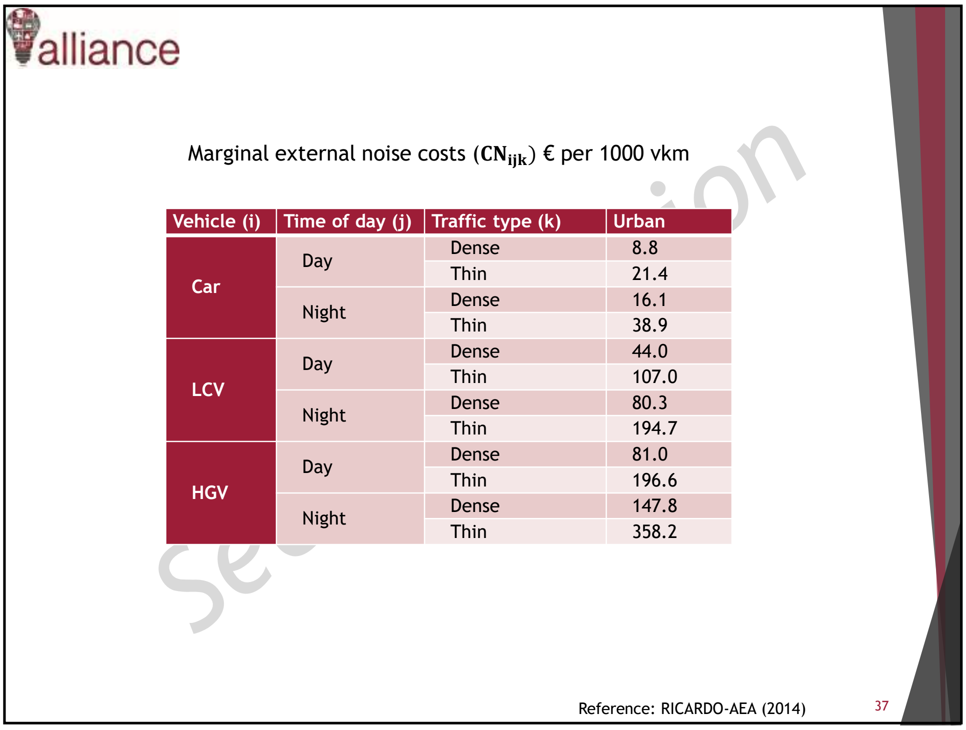
Reference: RICARDO-AEA (2014)



Noise costs

$$B_N = \sum_{ijk=1}^{mno} CN_{ijk} \cdot \frac{VKM_{ijk} - VKM'_{ijk}}{1000}$$

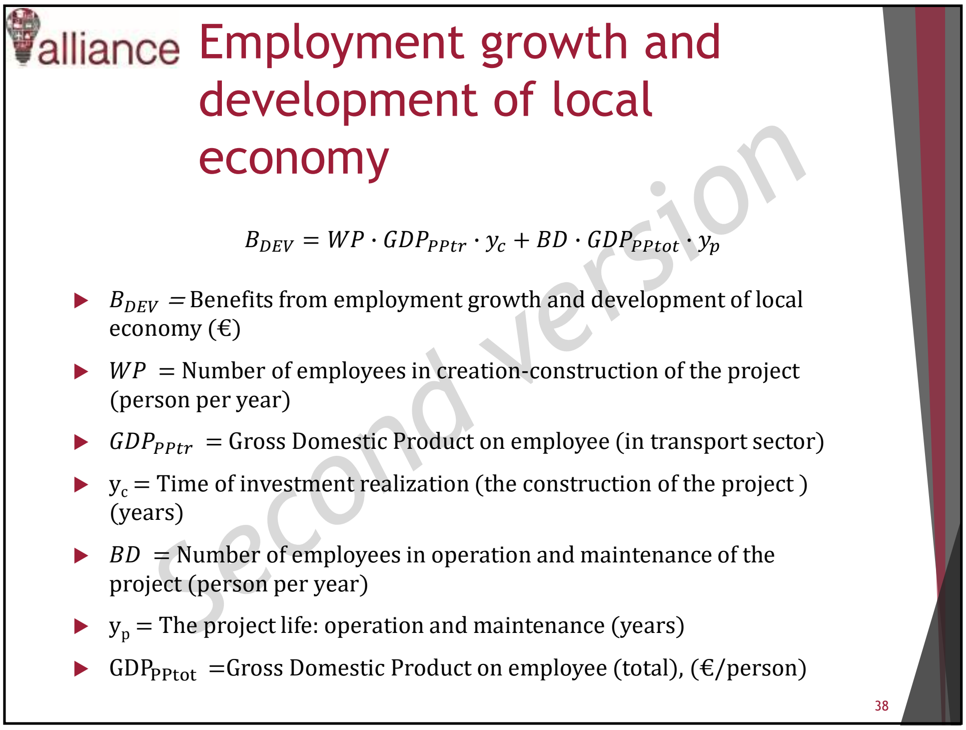
- CN_{ijk} =Noise costs of vehicle i (i=3 for car, LDV and HGV) in the time of the day j and traffic type k. (€ per 1000 vkm)
- VKM_{ijk} = Vehicle-kilometres of vehicle i travelled in the time of the day j and traffic type k before introduction of the measurement (annually)
- m = Number of vehicle types m=3 for car, LDV and HGV
- n =Time of the day (n=2 for day and night)
- o = Number of traffic types, k=2 for dense and thin traffic
- VKM'_{ijk} =Vehiclekilometers of vehicle i travelled in the time of the day j and traffic type k after introduction of the measurement (annually)



Marginal external noise costs ($\mathbf{CN_{ijk}}$) € per 1000 vkm

Vehicle (i)	Time of day (j)	Traffic type (k)	Urban
Car	Day	Dense	8.8
		Thin	21.4
	Night	Dense	16.1
		Thin	38.9
LCV	Day	Dense	44.0
		Thin	107.0
	Night	Dense	80.3
		Thin	194.7
HGV	Day	Dense	81.0
		Thin	196.6
	Night	Dense	147.8
		Thin	358.2

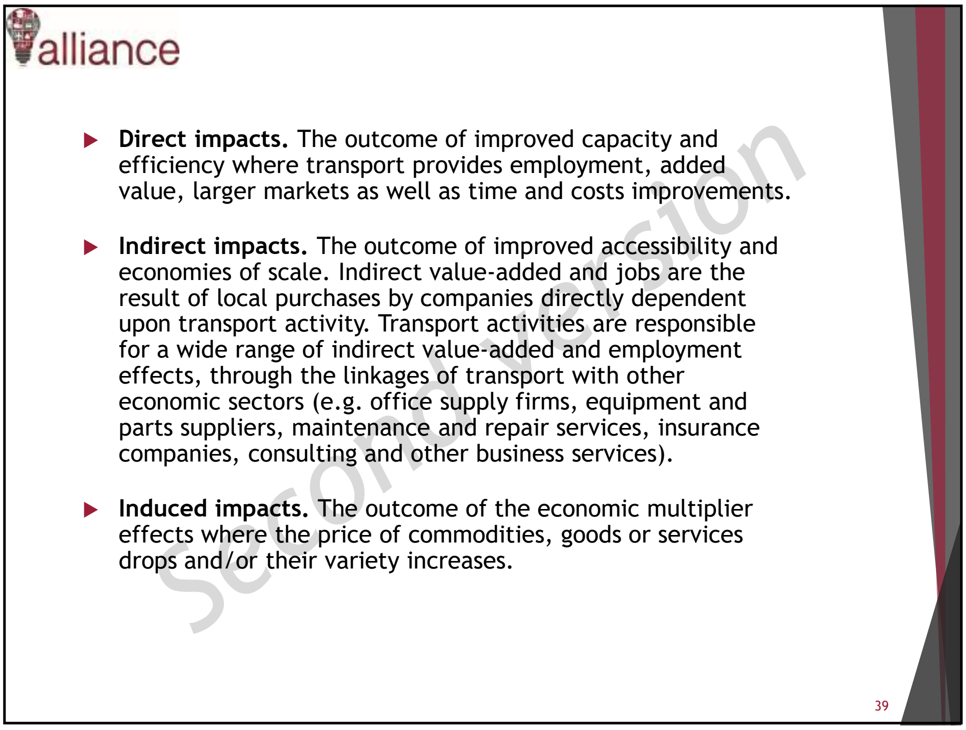
Reference: RICARDO-AEA (2014)



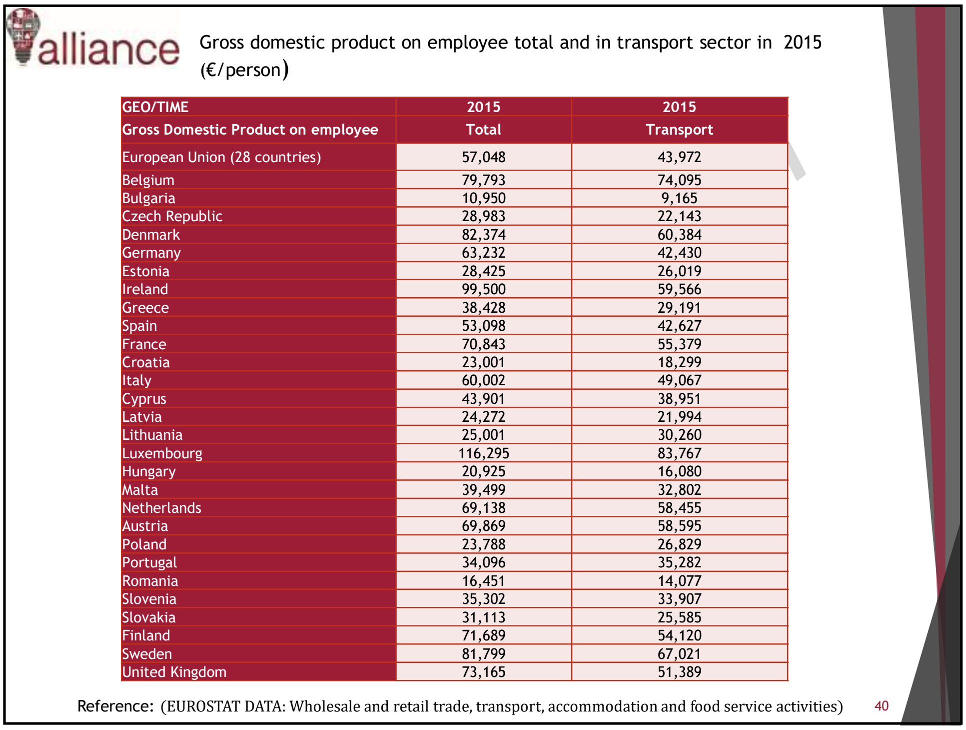
Employment growth and development of local economy

$$B_{DEV} = WP \cdot GDP_{PPtr} \cdot y_c + BD \cdot GDP_{PPtot} \cdot y_p$$

- B_{DEV} =Benefits from employment growth and development of local economy (€)
- WP = Number of employees in creation-construction of the project (person per year)
- GDP_{PPtr} = Gross Domestic Product on employee (in transport sector)
- y_c = Time of investment realization (the construction of the project) (years)
- BD = Number of employees in operation and maintenance of the project (person per year)
- y_p = The project life: operation and maintenance (years)
- GDP_{PPtot} =Gross Domestic Product on employee (total), (€/person)



- **Direct impacts.** The outcome of improved capacity and efficiency where transport provides employment, added value, larger markets as well as time and costs improvements.
- **Indirect impacts.** The outcome of improved accessibility and economies of scale. Indirect value-added and jobs are the result of local purchases by companies directly dependent upon transport activity. Transport activities are responsible for a wide range of indirect value-added and employment effects, through the linkages of transport with other economic sectors (e.g. office supply firms, equipment and parts suppliers, maintenance and repair services, insurance companies, consulting and other business services).
- **Induced impacts.** The outcome of the economic multiplier effects where the price of commodities, goods or services drops and/or their variety increases.



Gross domestic product on employee total and in transport sector in 2015 (€/person)

GEO/TIME	2015	2015
Gross Domestic Product on employee	Total	Transport
European Union (28 countries)	57,048	43,972
Belgium	79,793	74,095
Bulgaria	10,950	9,165
Czech Republic	28,983	22,143
Denmark	82,374	60,384
Germany	63,232	42,430
Estonia	28,425	26,019
Ireland	99,500	59,566
Greece	38,428	29,191
Spain	53,098	42,627
France	70,843	55,379
Croatia	23,001	18,299
Italy	60,002	49,067
Cyprus	43,901	38,951
Latvia	24,272	21,994
Lithuania	25,001	30,260
Luxembourg	116,295	83,767
Hungary	20,925	16,080
Malta	39,499	32,802
Netherlands	69,138	58,455
Austria	69,869	58,595
Poland	23,788	26,829
Portugal	34,096	35,282
Romania	16,451	14,077
Slovenia	35,302	33,907
Slovakia	31,113	25,585
Finland	71,689	54,120
Sweden	81,799	67,021
United Kingdom	73,165	51,389

Reference: (EUROSTAT DATA: Wholesale and retail trade, transport, accommodation and food service activities)

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Total costs (1/2)

- External costs are estimated per country
- The final costs for each country are estimated by using the Gross Domestic Product per capita per country.

$$B_{Si} = B_i \cdot \frac{GDP_S}{GDP_{EU}}$$

- B_{Si} = External costs in selected country in 2010
- B_i = External costs; $i \subset (B_{CC};\ B_{CON};\ B_N;\ B_{DEV})$ in 2010
- $B_{AC};\ B_{CC};\ B_{CON};\ B_N;\ B_{DEV}$ =External cost of air quality, climate change, congestion, noise and unemployment
- $GDP_S =$ Gross Domestic Product in selected country (2010)
- GDP_{EU} = Gross Domestic Product in European Union (2010)
- Note: This formula does not take into account the costs of accidents, which is already adapted to particular country.

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Total costs (2/2)

Total external cost:

$$EB_Y = \sum_{i-1}^{n} B_{Si}$$

- EB_Y = Total external benefits in 2010
- B_{Si} = External costs in selected country in 2010

To update the external benefits (with the increase in GDP for the desired country for the year of the analysis (GDP_{eoa}).

$$\mathrm{EB} = \mathrm{EB}_Y \cdot \frac{\mathrm{GDP_{eoa}}}{\mathrm{GDP_s}}$$

- GDP of the country of measurement for the year of the analysis
- Gross Domestic Product in selected country (2010)

Example

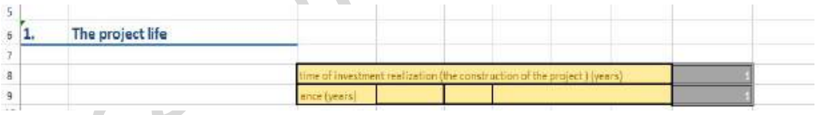
- Construct and operate a consolidation center in Riga, Latvia
- Consider three alternative locations
- Each alternative may be connected with different transport modes (e.g. rail, port, airport)
- Compare each alternative with the base scenario of doing nothing
- Conduct a social cost benefit analysis
- Estimated costs will include direct and indirect costs (externalities) as described in this course.

Step 1: Project life

- Open excel SCBA demo

Data sheet → Data collection

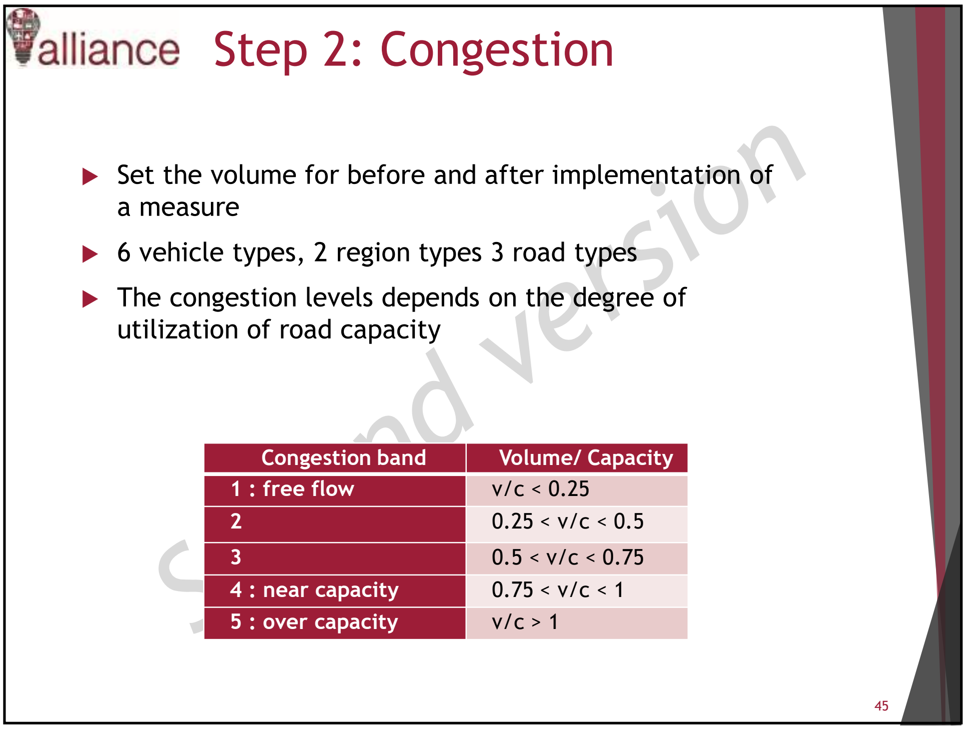
  - Set the time of investment realization (the construction of the project) (years)
  - Set the project life: operation and maintenance (years)



1. The project life

time of investment realization (the construction of the project) (years)

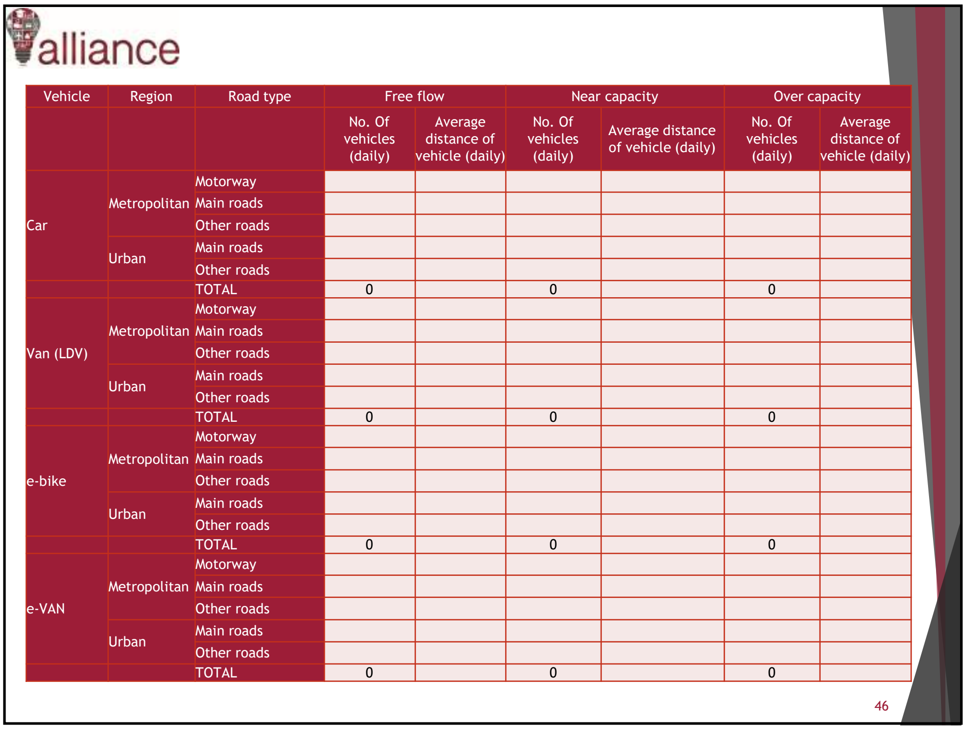
ance (years)



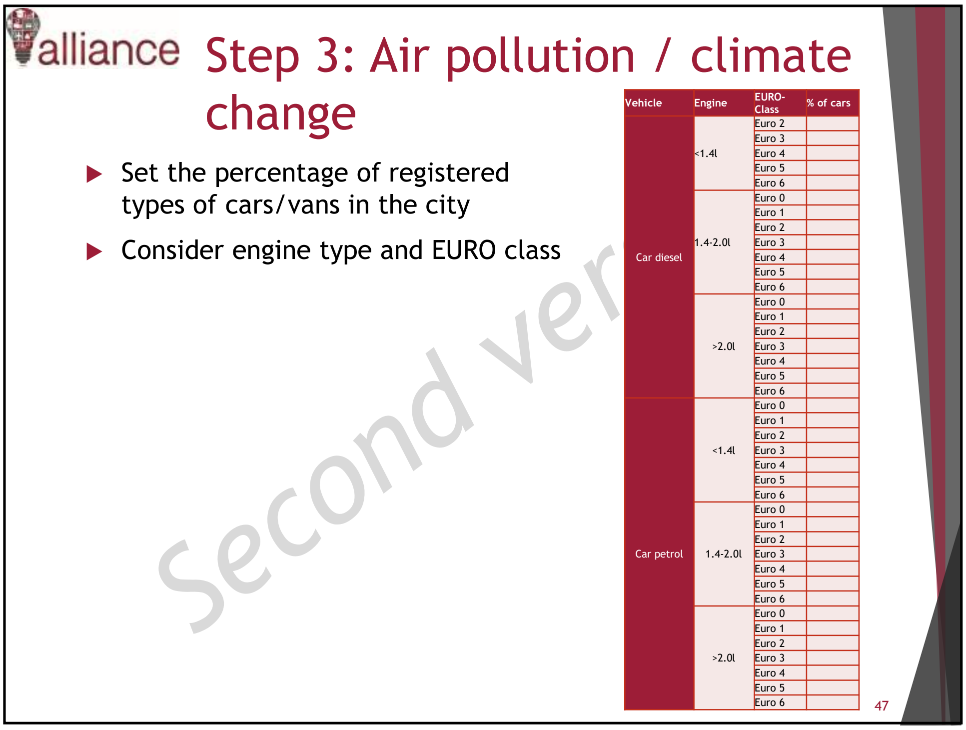
Step 2: Congestion

- Set the volume for before and after implementation of a measure
- 6 vehicle types, 2 region types 3 road types
- The congestion levels depends on the degree of utilization of road capacity

Congestion band	Volume/ Capacity
1 : free flow	v/c < 0.25
2	0.25 < v/c < 0.5
3	0.5 < v/c < 0.75
4 : near capacity	0.75 < v/c < 1
5 : over capacity	v/c > 1



Vehicle	Region	Road type	Free flow		Near capacity		Over capacity	
			No. Of vehicles (daily)	Average distance of vehicle (daily)	No. Of vehicles (daily)	Average distance of vehicle (daily)	No. Of vehicles (daily)	Average distance of vehicle (daily)
Car	Metropolitan	Motorway						
		Main roads						
		Other roads						
	Urban	Main roads						
		Other roads						
		TOTAL	0		0		0	
Van (LDV)	Metropolitan	Motorway						
		Main roads						
		Other roads						
	Urban	Main roads						
		Other roads						
		TOTAL	0		0		0	
e-bike	Metropolitan	Motorway						
		Main roads						
		Other roads						
	Urban	Main roads						
		Other roads						
		TOTAL	0		0		0	
e-VAN	Metropolitan	Motorway						
		Main roads						
		Other roads						
	Urban	Main roads						
		Other roads						
		TOTAL	0		0		0	



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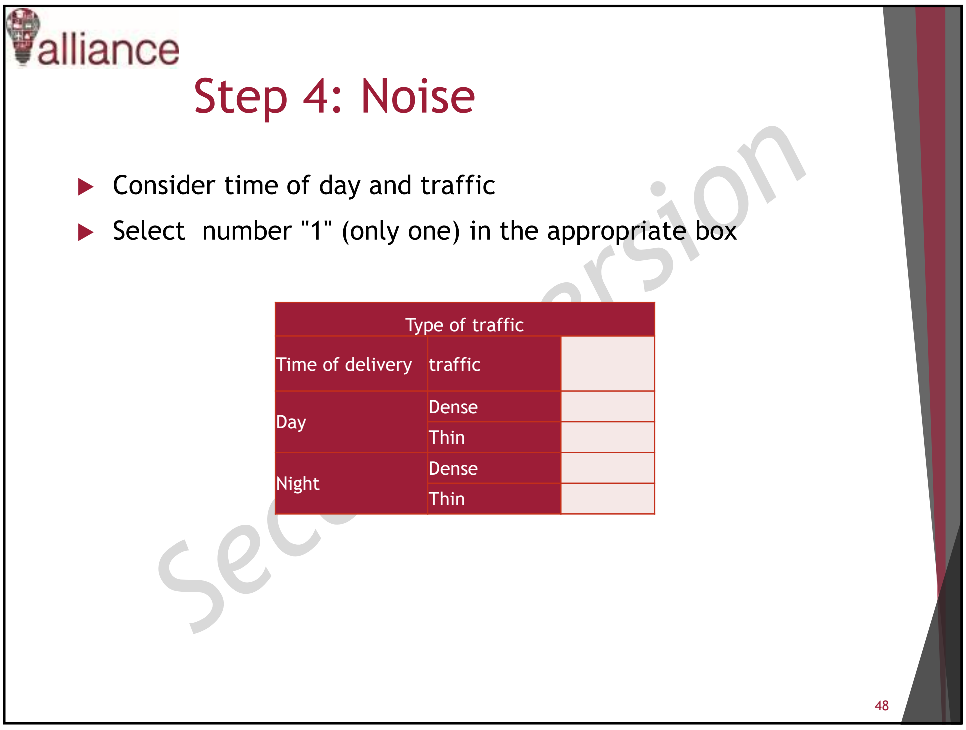
Step 3: Air pollution / climate change

- Set the percentage of registered types of cars/vans in the city
- Consider engine type and EURO class

Vehicle	Engine	EURO-Class	% of cars
Car diesel	<1.4l	Euro 2	
		Euro 3	
		Euro 4	
		Euro 5	
		Euro 6	
	1.4-2.0l	Euro 0	
		Euro 1	
		Euro 2	
		Euro 3	
		Euro 4	
		Euro 5	
		Euro 6	
	>2.0l	Euro 0	
		Euro 1	
		Euro 2	
		Euro 3	
		Euro 4	
		Euro 5	
		Euro 6	
Car petrol	<1.4l	Euro 0	
		Euro 1	
		Euro 2	
		Euro 3	
		Euro 4	
		Euro 5	
		Euro 6	
	1.4-2.0l	Euro 0	
		Euro 1	
		Euro 2	
		Euro 3	
		Euro 4	
		Euro 5	
		Euro 6	
	>2.0l	Euro 0	
		Euro 1	
		Euro 2	
		Euro 3	
		Euro 4	
		Euro 5	
		Euro 6	



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Step 4: Noise

- Consider time of day and traffic
- Select number "1" (only one) in the appropriate box

Type of traffic		
Time of delivery	traffic	
Day	Dense	
	Thin	
Night	Dense	
	Thin	

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Step 5: Employment growth and development of local economy

- Number of employees in creation-construction of the project (persons per year)
- Number of employees in operation and maintenance of the project (persons per year)

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Results

- Sheet→ SCBA results
- The output data include benefits from reducing the external costs

BENEFITS FROM REDUCING OF THE EXTERNAL COSTS						
	EU (2010)		Latvia (2010)		Latvia (2015)	
CONGESTION		€		€		€
AIR POLLUTION		€		€		€
CLIMATE CHANGE		€		€		€
ACCIDENTS		€		€		€
NOISE		€		€		€
EMPLOYMENT and DEVELOPMENT		€		€		€
TOTAL		€		€		€

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3. Multi-criteria multi-stakeholder decision making

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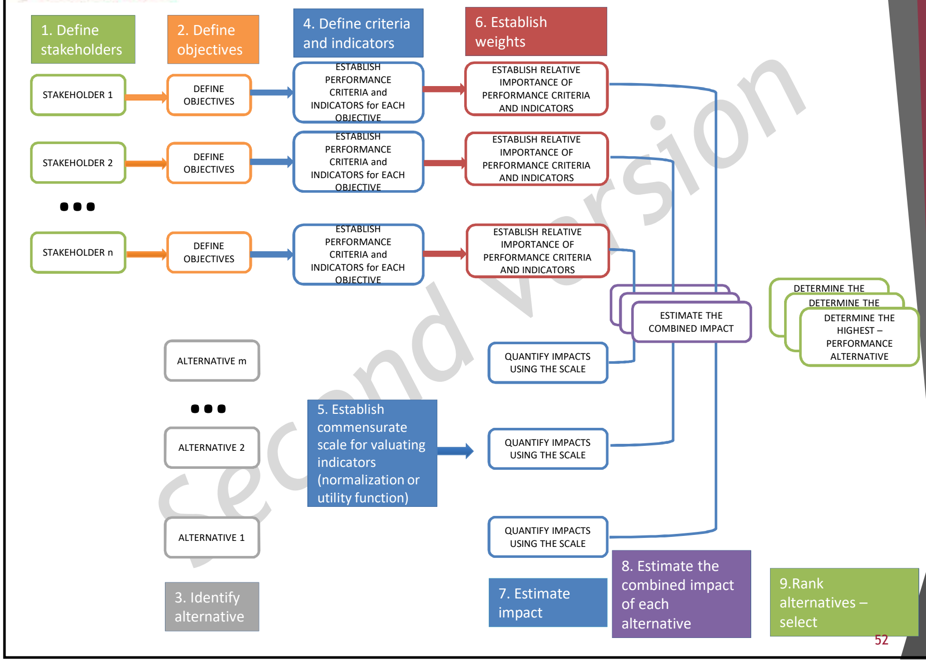

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Multicriteria decision making methodologies

- Multi-objective Mathematical Programming (Goal Programming)
  - Value Systems (American School) – Aims at developing one value system combining various preferences
- Multi-attribute Utility Theory
  - Multicriteria utility function – Aims at solving problems where there are not discrete alternatives and the objectives are more than one (e.g. AHP)
- Outranking Relations
  - Excludes alternatives (French School) – Compares alternatives (e.g. Electre, Promethee)

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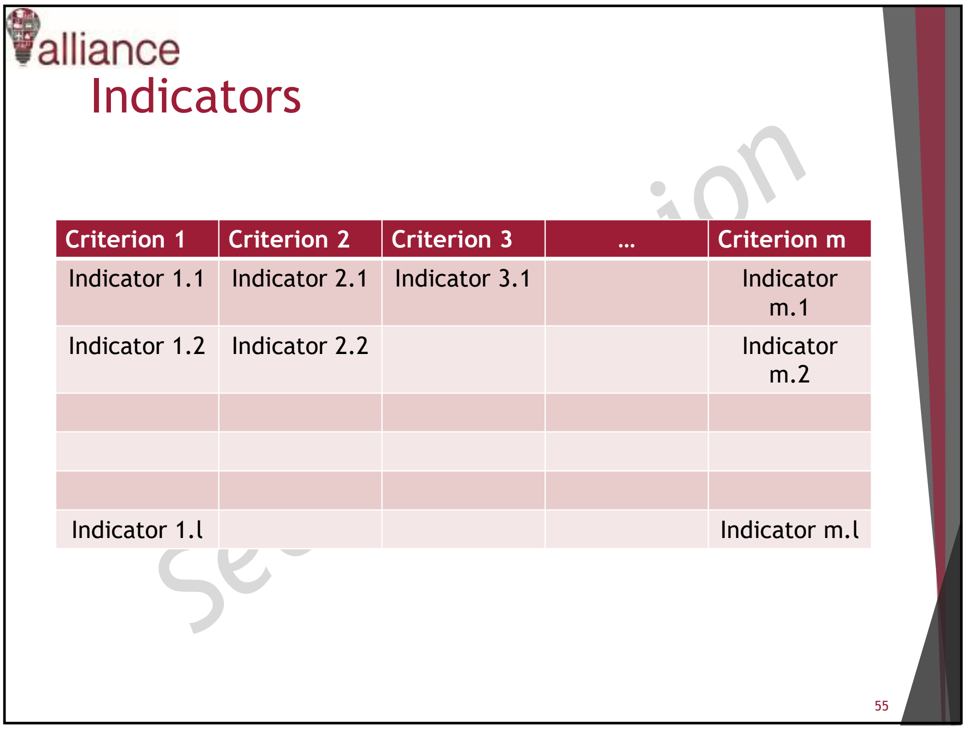
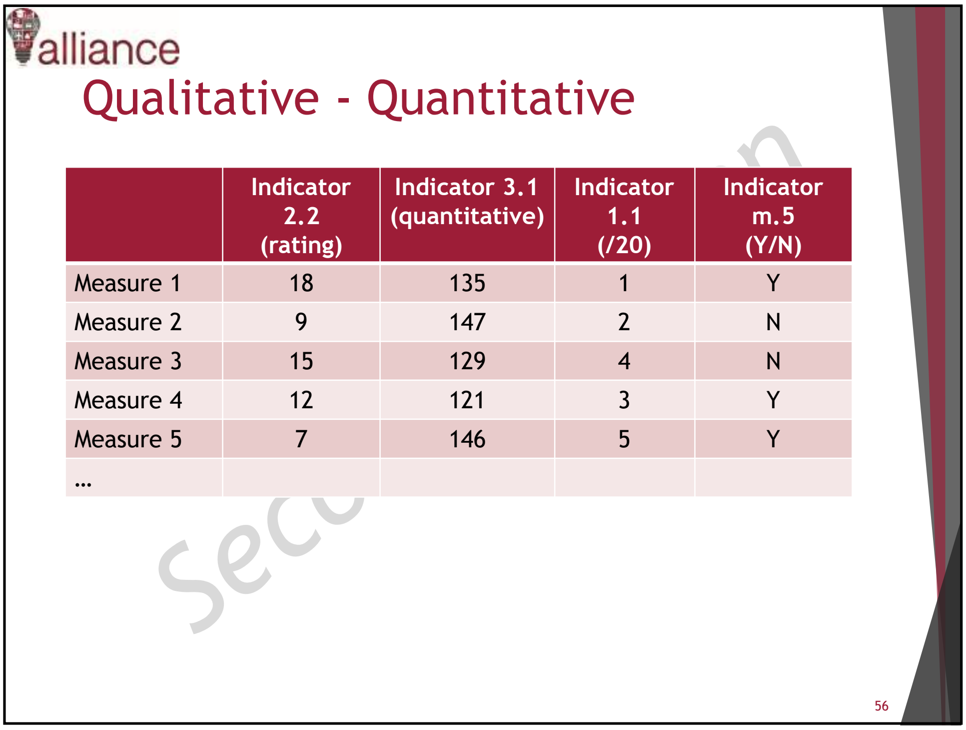
Criteria

	Criterion 1	Criterion 2	Criterion 3	…	Criterion m
Measure 1					
Measure 2					
Measure 3					
Measure n					



Indicators

Criterion 1	Criterion 2	Criterion 3	…	Criterion m
Indicator 1.1	Indicator 2.1	Indicator 3.1		Indicator m.1
Indicator 1.2	Indicator 2.2			Indicator m.2
Indicator 1.l				Indicator m.l



Qualitative - Quantitative

	Indicator 2.2 (rating)	Indicator 3.1 (quantitative)	Indicator 1.1 (/20)	Indicator m.5 (Y/N)
Measure 1	18	135	1	Y
Measure 2	9	147	2	N
Measure 3	15	129	4	N
Measure 4	12	121	3	Y
Measure 5	7	146	5	Y
…				

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Action - Indicator values

	Indicator 2.2 (rating)	Indicator 3.1 (quantitative)	Indicator 1.1 (/20)	Indicator m.5 (Y/N)
Measure 1	18	135	1	Y
Measure 2	9	147	2	N
Measure 3	15	129	4	N
Measure 4	12	121	3	Y
Measure 5	7	146	5	Y
…				

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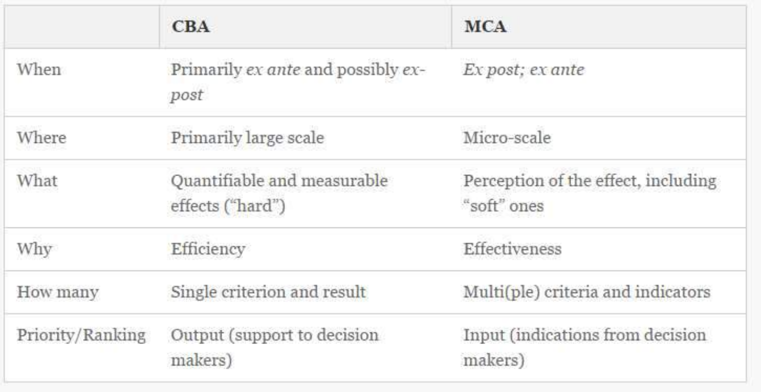
Comparing multicriteria and cost benefit analysis



	CBA	MCA
When	Primarily *ex ante* and possibly *ex-post*	*Ex post; ex ante*
Where	Primarily large scale	Micro-scale
What	Quantifiable and measurable effects ("hard")	Perception of the effect, including "soft" ones
Why	Efficiency	Effectiveness
How many	Single criterion and result	Multi(ple) criteria and indicators
Priority/Ranking	Output (support to decision makers)	Input (indications from decision makers)

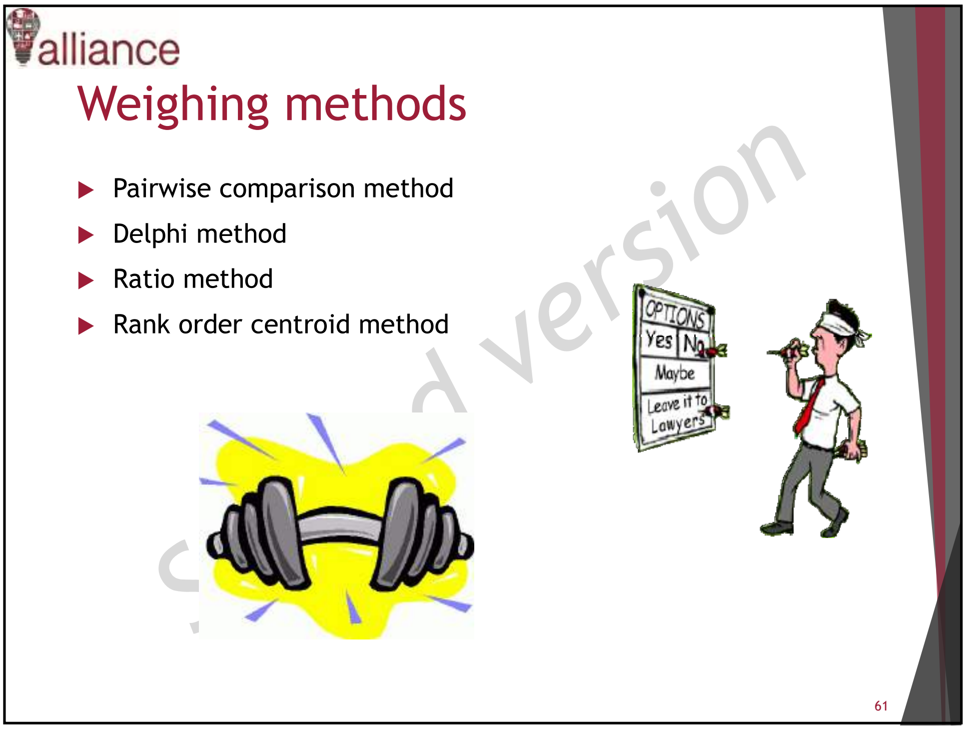
Reference: Beria et al. 2012

4. Weighing

Weighing

Assignment of relative weights to each performance criterion to reflect its importance compared to other criteria

- Equal weighing
- Direct weighing
- Regression-based observer-derived weighing
- Delphi technique
- Pair-wise comparison of performance criteria
    - Saaty Hierarchy Comparison
    - Analytical Hierarchy Process



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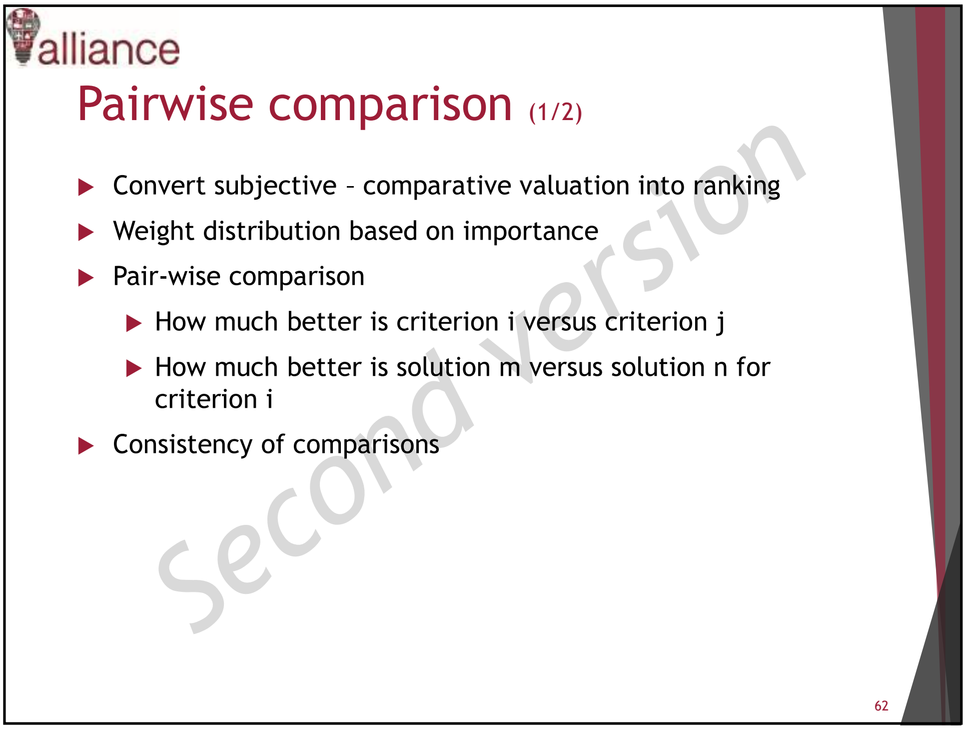
Weighing methods

- Pairwise comparison method
- Delphi method
- Ratio method
- Rank order centroid method



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Pairwise comparison (1/2)

- Convert subjective – comparative valuation into ranking
- Weight distribution based on importance
- Pair-wise comparison
  - How much better is criterion i versus criterion j
  - How much better is solution m versus solution n for criterion i
- Consistency of comparisons

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Pairwise comparison (2/2)

How much more important is criterion i versus criterion j	Comparison index
same	1
moderately	3
very	5
much more	7
exceptionally more	9

Intermediate values may be used

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Number of comparisons

Number of elements	1	2	3	4	5	6	7	n
Number of comparisons	0	1	3	6	10	15	21	$\frac{n(n-1)}{2}$

Comparison matrix (1/2)

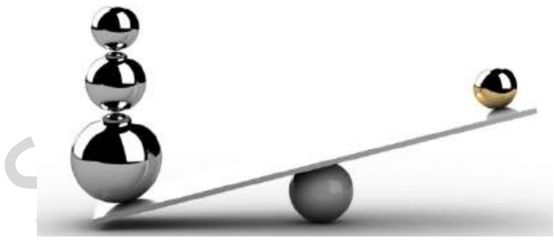
	A	B	C
A	1	1/3	5
B		1	7
C			1

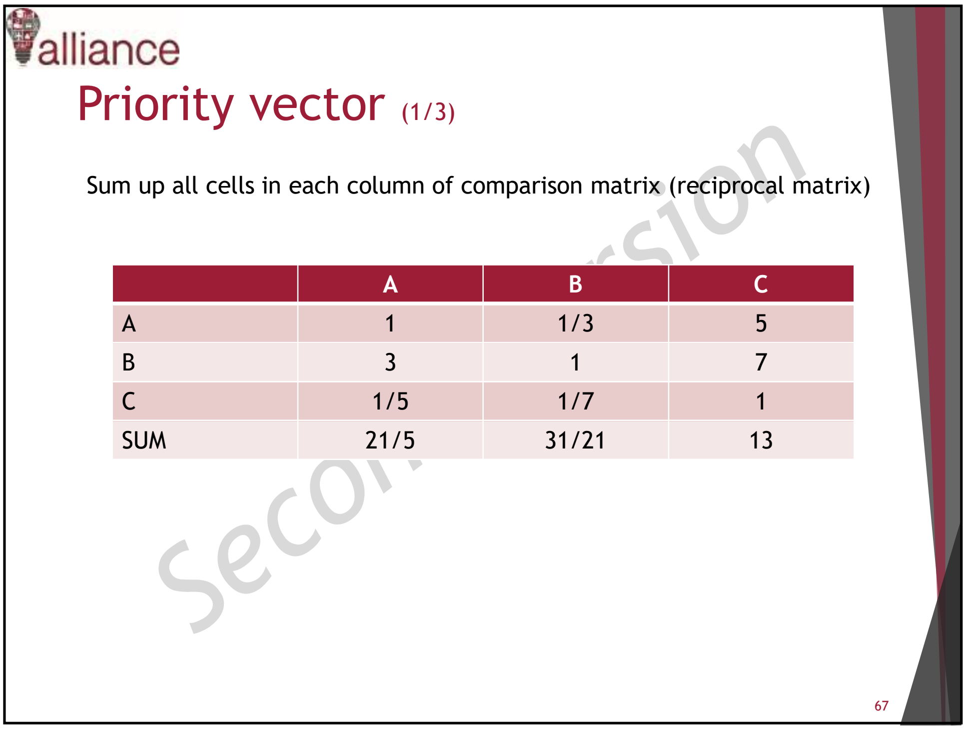
To fill the matrix we use reciprocal values of the upper diagonal.

$$a_{ij} = \frac{1}{a_{ji}}$$

Comparison matrix (2/2)

	A	B	C
A	1	1/3	5
B	3	1	7
C	1/5	1/7	1

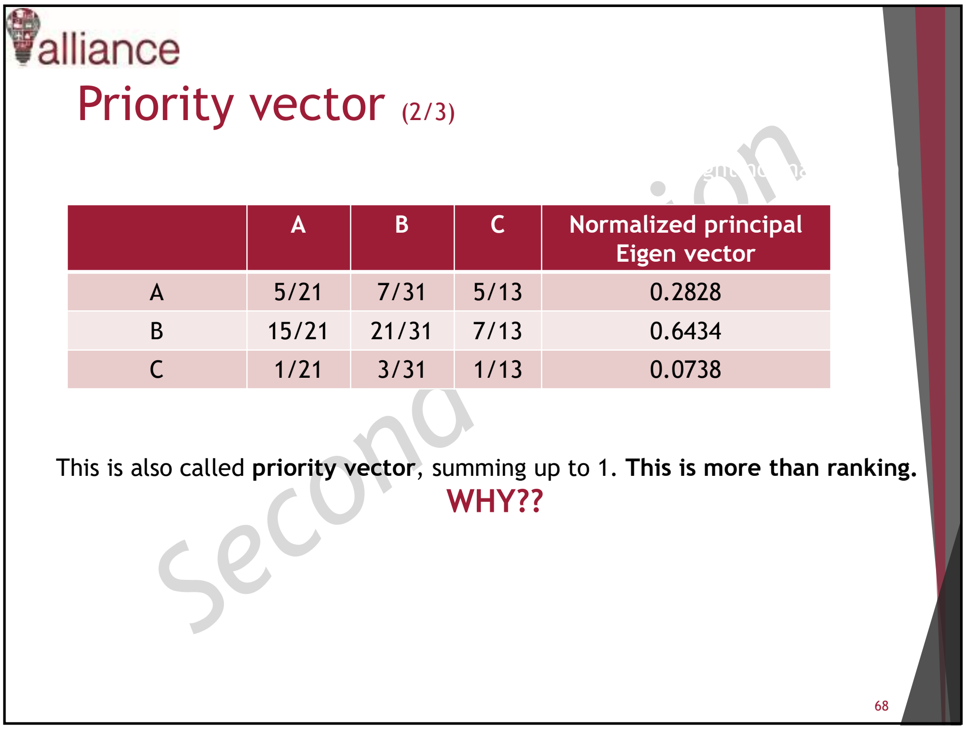




Priority vector (1/3)

Sum up all cells in each column of comparison matrix (reciprocal matrix)

	A	B	C
A	1	1/3	5
B	3	1	7
C	1/5	1/7	1
SUM	21/5	31/21	13

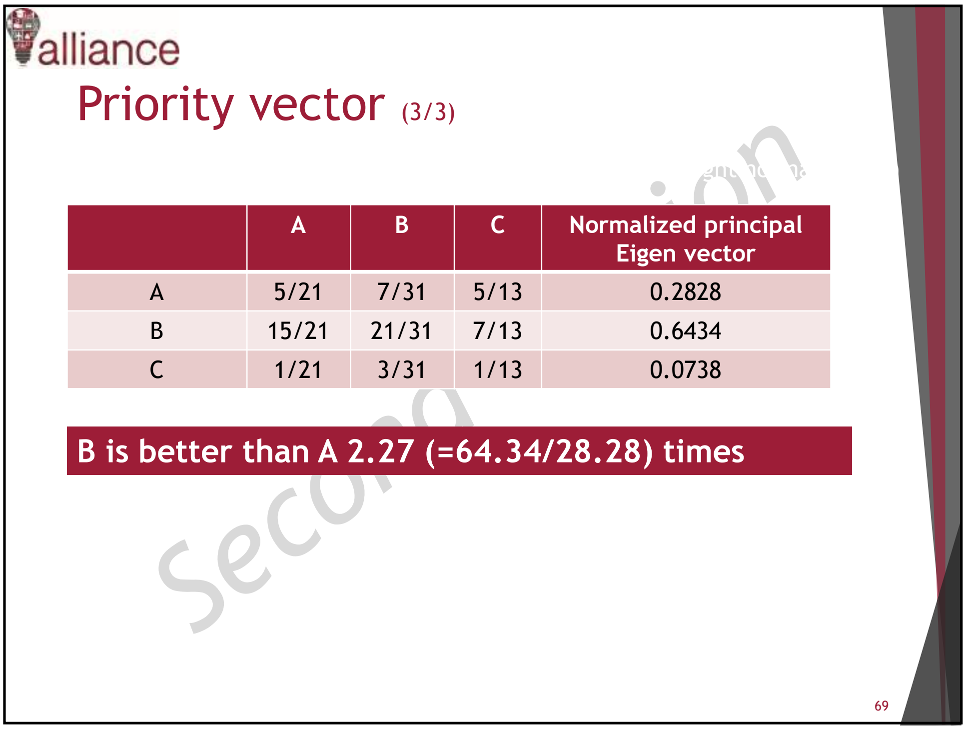


Priority vector (2/3)

	A	B	C	Normalized principal Eigen vector
A	5/21	7/31	5/13	0.2828
B	15/21	21/31	7/13	0.6434
C	1/21	3/31	1/13	0.0738

This is also called **priority vector**, summing up to 1. **This is more than ranking.**

WHY??



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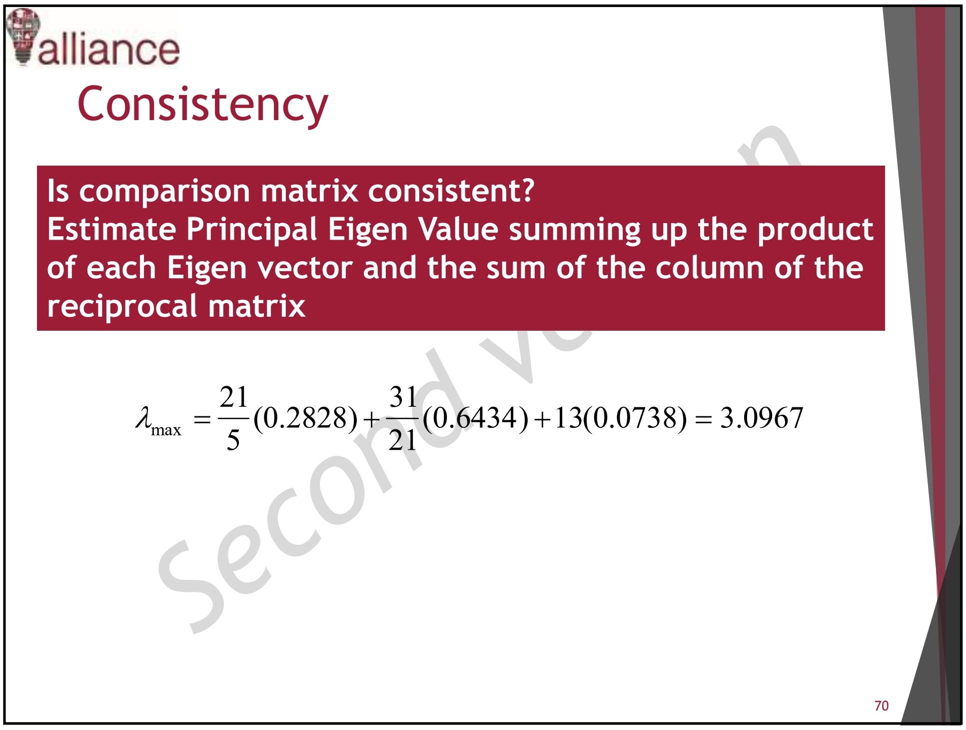
Priority vector (3/3)

	A	B	C	Normalized principal Eigen vector
A	5/21	7/31	5/13	0.2828
B	15/21	21/31	7/13	0.6434
C	1/21	3/31	1/13	0.0738

B is better than A 2.27 (=64.34/28.28) times



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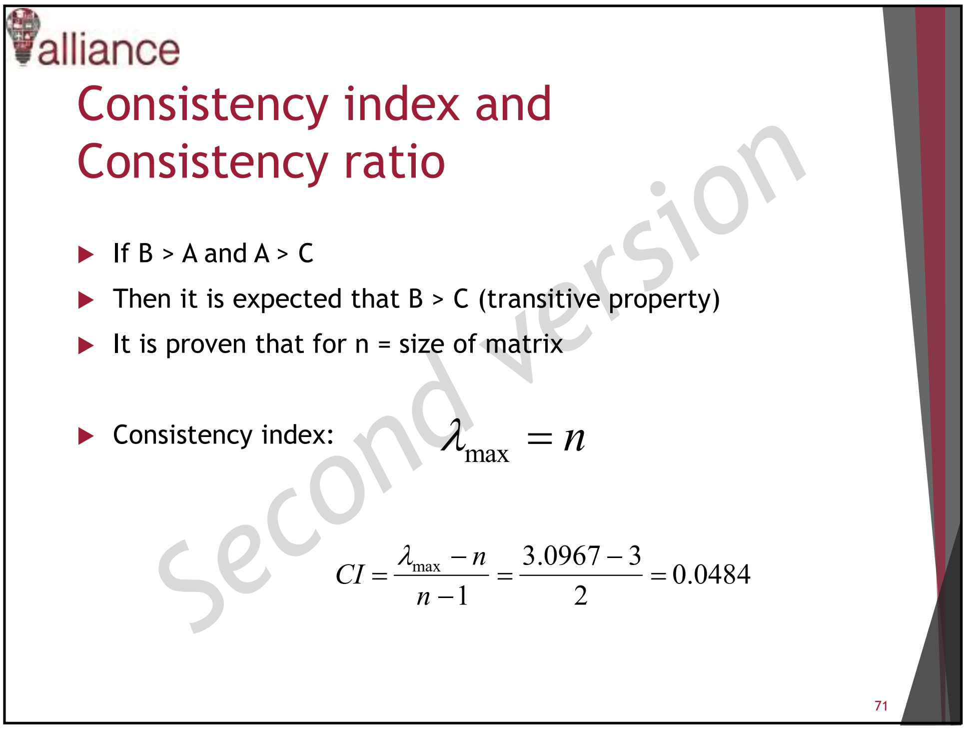
Consistency

Is comparison matrix consistent?
Estimate Principal Eigen Value summing up the product of each Eigen vector and the sum of the column of the reciprocal matrix

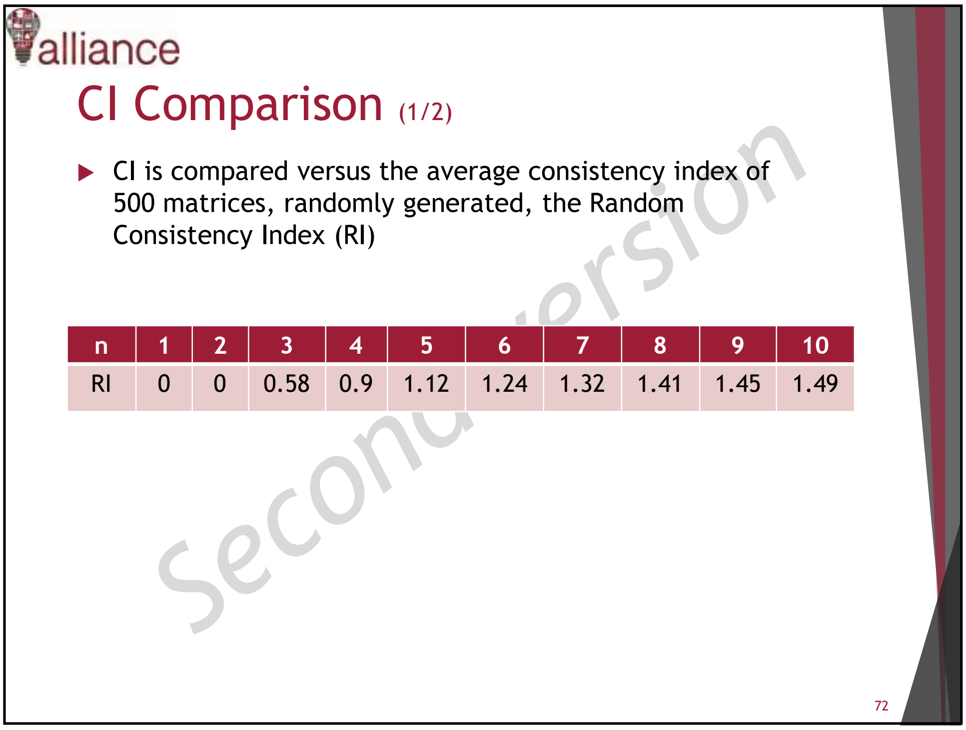
$$\lambda_{\max} = \frac{21}{5}(0.2828) + \frac{31}{21}(0.6434) + 13(0.0738) = 3.0967$$



Consistency index and Consistency ratio

- If B > A and A > C
- Then it is expected that B > C (transitive property)
- It is proven that for n = size of matrix
- Consistency index: $\lambda_{\max} = n$

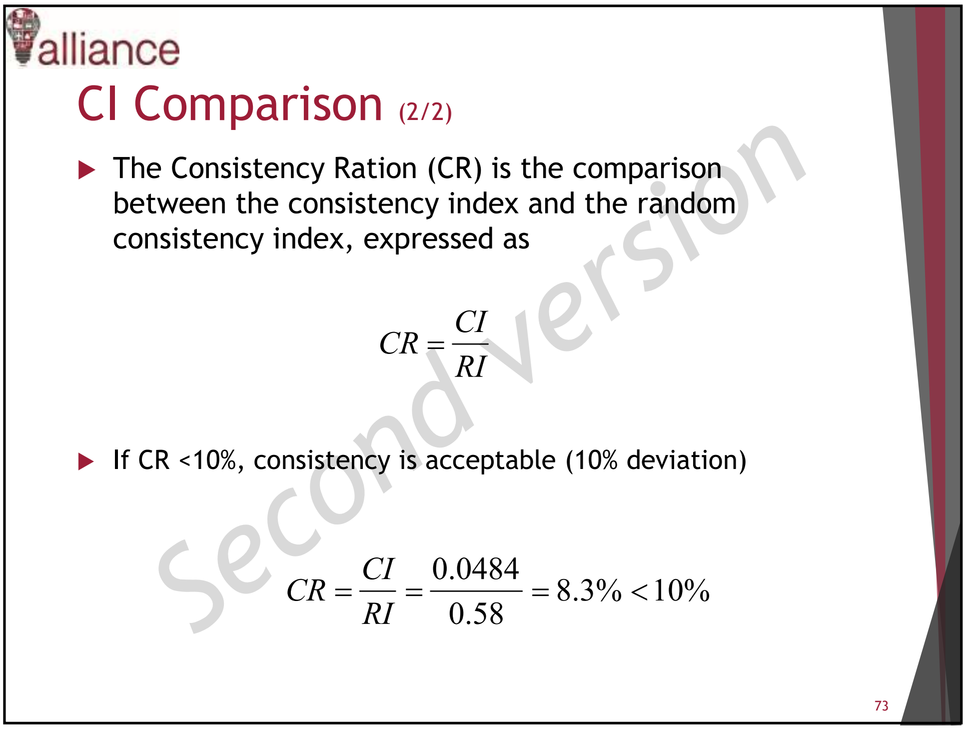
$$CI = \frac{\lambda_{\max} - n}{n-1} = \frac{3.0967 - 3}{2} = 0.0484$$



CI Comparison (1/2)

- CI is compared versus the average consistency index of 500 matrices, randomly generated, the Random Consistency Index (RI)

n	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49



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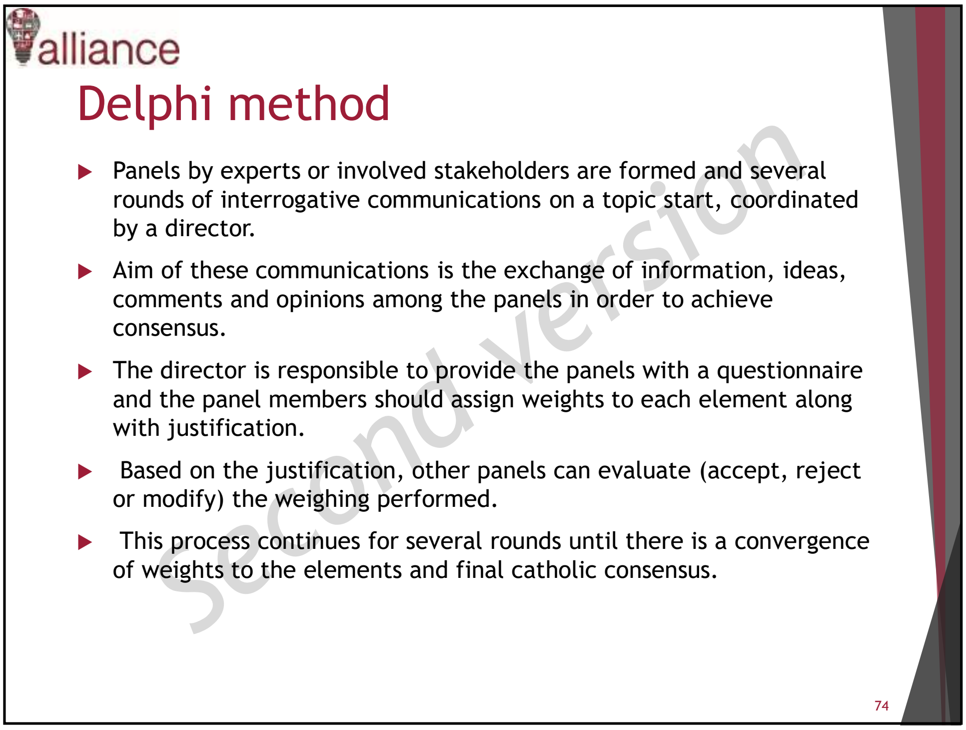
CI Comparison (2/2)

- The Consistency Ration (CR) is the comparison between the consistency index and the random consistency index, expressed as

$$CR = \frac{CI}{RI}$$

- If CR <10%, consistency is acceptable (10% deviation)

$$CR = \frac{CI}{RI} = \frac{0.0484}{0.58} = 8.3\% < 10\%$$



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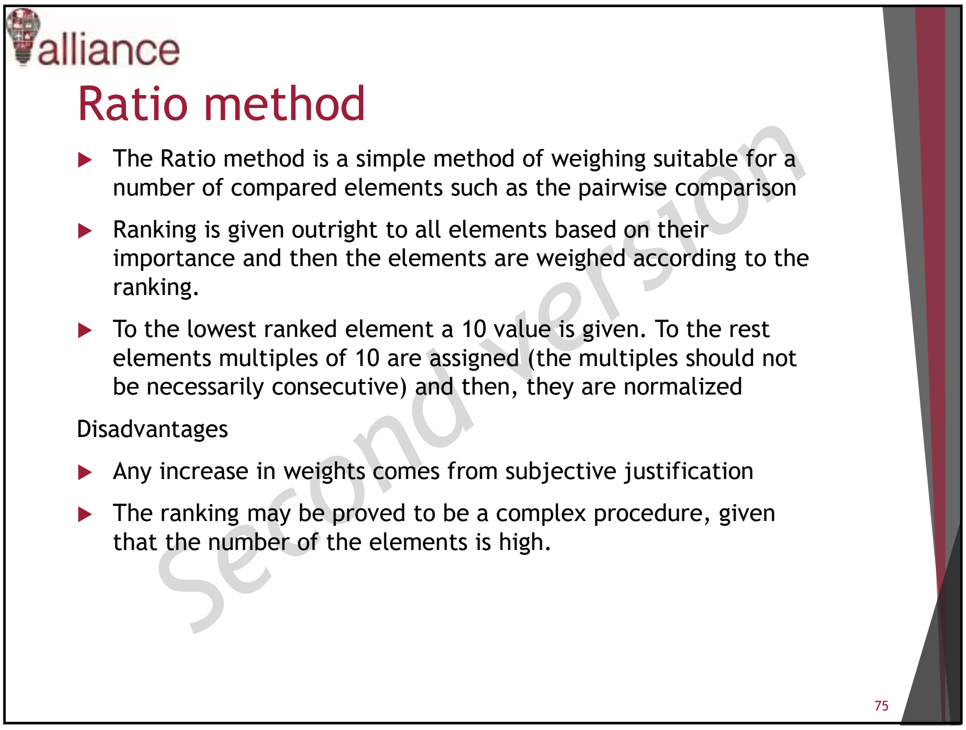
Delphi method

- Panels by experts or involved stakeholders are formed and several rounds of interrogative communications on a topic start, coordinated by a director.
- Aim of these communications is the exchange of information, ideas, comments and opinions among the panels in order to achieve consensus.
- The director is responsible to provide the panels with a questionnaire and the panel members should assign weights to each element along with justification.
- Based on the justification, other panels can evaluate (accept, reject or modify) the weighing performed.
- This process continues for several rounds until there is a convergence of weights to the elements and final catholic consensus.



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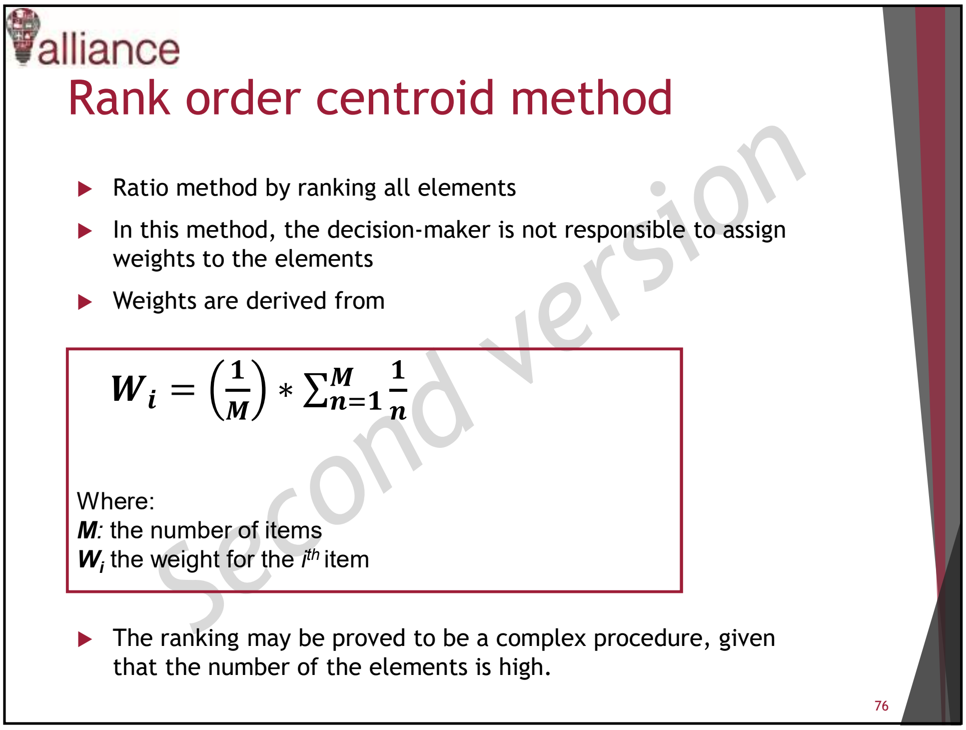
Ratio method

- The Ratio method is a simple method of weighing suitable for a number of compared elements such as the pairwise comparison
- Ranking is given outright to all elements based on their importance and then the elements are weighed according to the ranking.
- To the lowest ranked element a 10 value is given. To the rest elements multiples of 10 are assigned (the multiples should not be necessarily consecutive) and then, they are normalized

Disadvantages

- Any increase in weights comes from subjective justification
- The ranking may be proved to be a complex procedure, given that the number of the elements is high.



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Rank order centroid method

- Ratio method by ranking all elements
- In this method, the decision-maker is not responsible to assign weights to the elements
- Weights are derived from

$$W_i = \left(\frac{1}{M}\right) * \sum_{n=1}^{M} \frac{1}{n}$$

Where:
M: the number of items
W_i the weight for the i^{th} item

- The ranking may be proved to be a complex procedure, given that the number of the elements is high.

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5. Normalization

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Scaling or normalization

- Using indicators of different context, nature and values in a common assessment methodology, requires establishment of a commensurate scale, thus making indicator values dimensionless.
- Data normalization consists of rescaling the attribute values of the data into a single specified range, such as from 0 to 1 or from 0 to 100.

Normalization techniques (1/3)

- Normalization by comparison with the best alternative

$$\bar{r}_{ij} = \frac{I_{ij}}{max_j I_{ij}}$$

- Classic normalization

$$\bar{r}_{ij} = \frac{I_{ij}}{\sum_{j=1}^{m} I_{ij}}$$

Normalization techniques (2/3)

- Max and min normalization

$$\bar{r}_{ij} = \frac{I_{ij} - min_j I_{ij}}{max_j I_{ij} - min_j I_{ij}}$$

- Vector normalization

$$\bar{r}_{ij} = \frac{I_{ij}}{\sqrt{\sum_{j=1}^{n} {I_{ij}}^2}}$$

- Statistical z score

$$\bar{r}_{ij} = exp^{-z^2/2}, \textbf{where } z = \frac{(I_{ij} - I_i^0)}{\sigma_i}$$

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Normalization techniques (3/3)

- Different MCDM methods prefer their specific methods of normalization.
- Different normalization techniques have been used in transportation given different needs and data availability.
- Indicators have a positive (+) impact, or a negative (-) impact; the larger the absolute value of the indicator is, the more positive or negative impact it has in the assessment of alternatives. Usually, in MCDMs both types of indicators are used.

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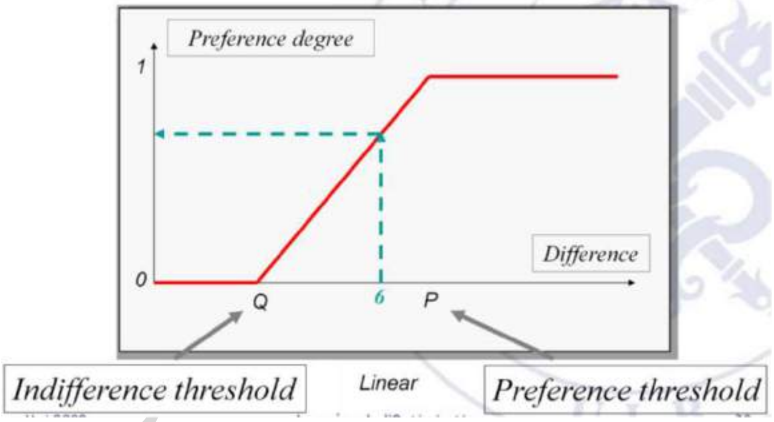
Preference function



Reference: Promethee-gaia 203

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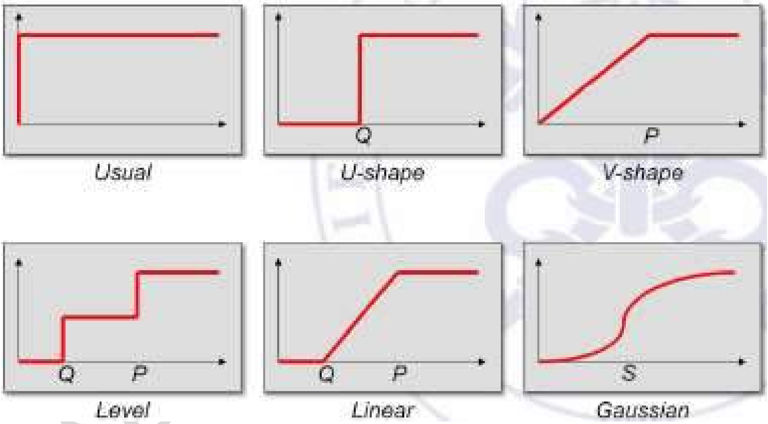
More preference functions



Reference: Promethee-gaia 203

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6. Sustainable Urban Logistics
The Evalog Tool

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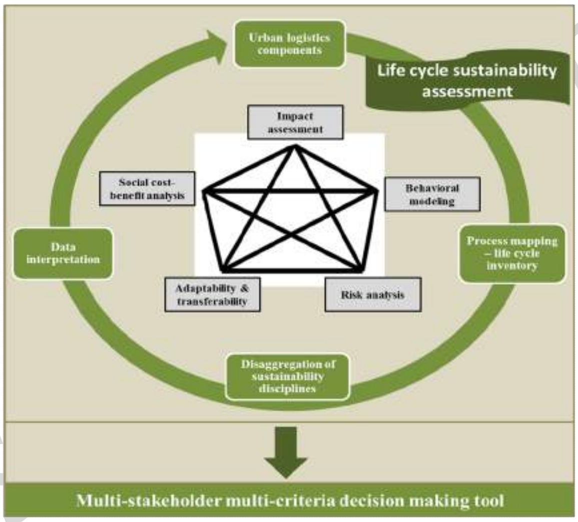
The concept



Urban logistics components

Life cycle sustainability assessment

Impact assessment

Social cost-benefit analysis

Behavioral modeling

Data interpretation

Process mapping – life cycle inventory

Adaptability & transferability

Risk analysis

Disaggregation of sustainability disciplines

Multi-stakeholder multi-criteria decision making tool

Source: Novelog project

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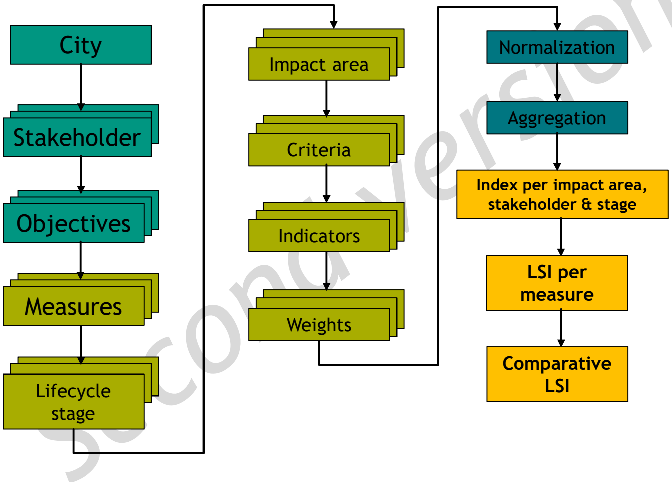
The sequence of actions



City

Stakeholder

Objectives

Measures

Lifecycle stage

Impact area

Criteria

Indicators

Weights

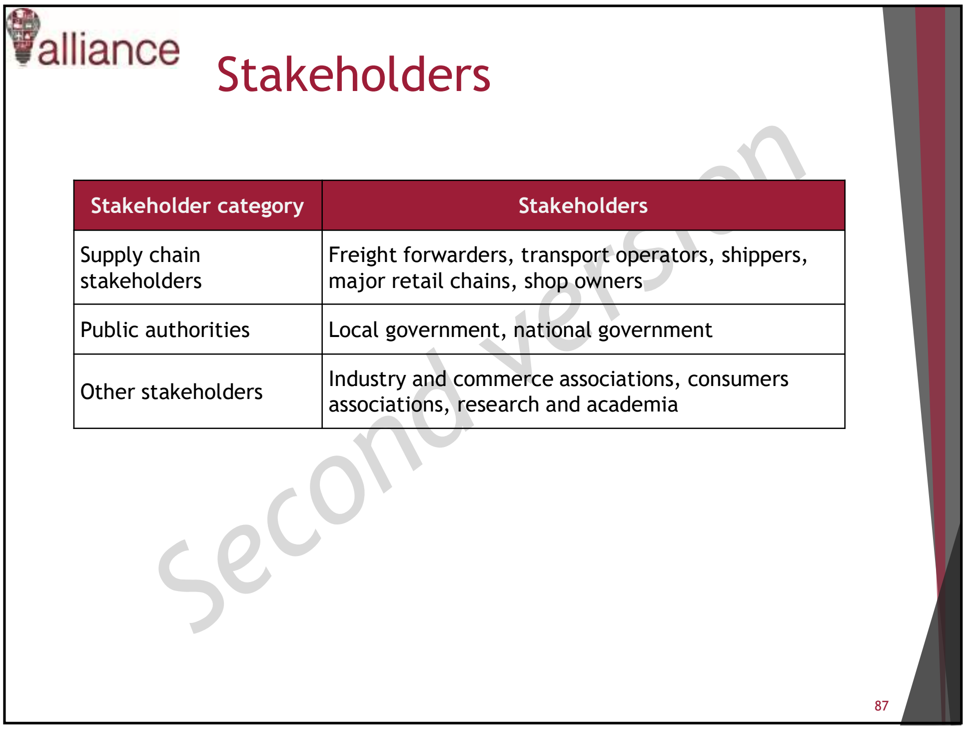
Normalization

Aggregation

Index per impact area, stakeholder & stage

LSI per measure

Comparative LSI



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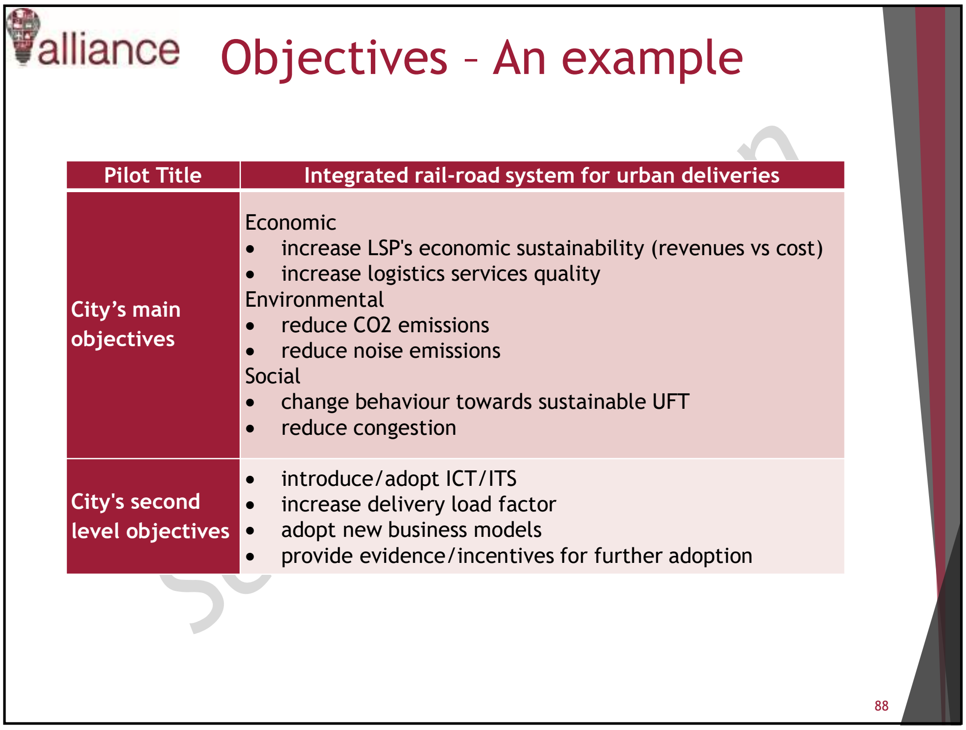
Stakeholders

Stakeholder category	Stakeholders
Supply chain stakeholders	Freight forwarders, transport operators, shippers, major retail chains, shop owners
Public authorities	Local government, national government
Other stakeholders	Industry and commerce associations, consumers associations, research and academia



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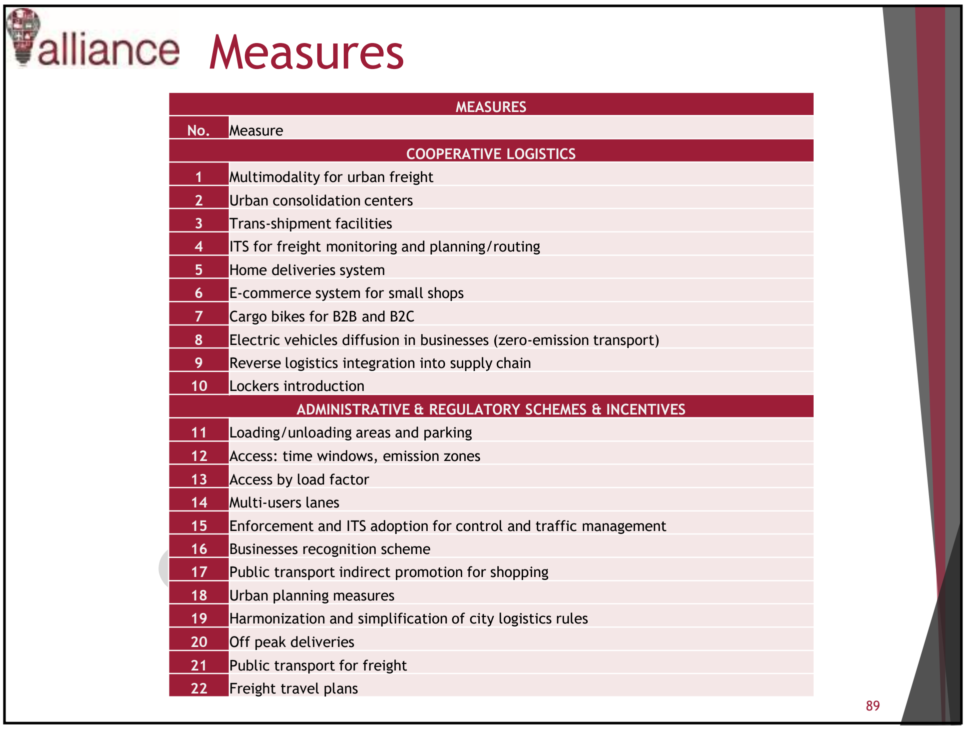
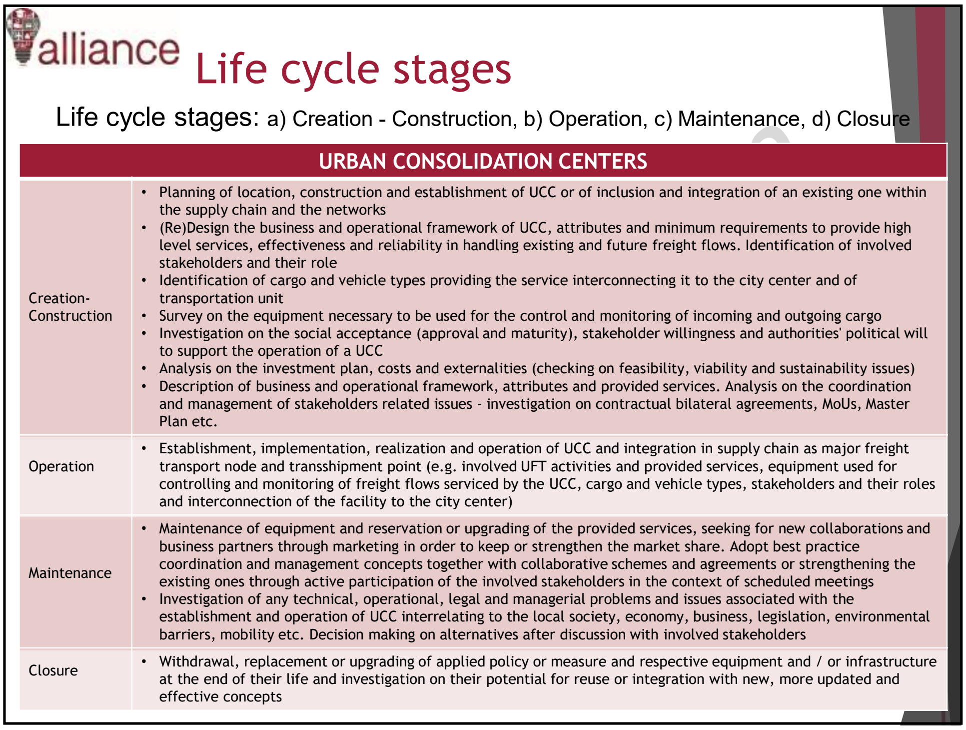
Objectives – An example

Pilot Title	Integrated rail-road system for urban deliveries
City's main objectives	Economic • increase LSP's economic sustainability (revenues vs cost) • increase logistics services quality Environmental • reduce CO2 emissions • reduce noise emissions Social • change behaviour towards sustainable UFT • reduce congestion
City's second level objectives	• introduce/adopt ICT/ITS • increase delivery load factor • adopt new business models • provide evidence/incentives for further adoption



Measures

MEASURES	
No.	Measure
COOPERATIVE LOGISTICS	
1	Multimodality for urban freight
2	Urban consolidation centers
3	Trans-shipment facilities
4	ITS for freight monitoring and planning/routing
5	Home deliveries system
6	E-commerce system for small shops
7	Cargo bikes for B2B and B2C
8	Electric vehicles diffusion in businesses (zero-emission transport)
9	Reverse logistics integration into supply chain
10	Lockers introduction
ADMINISTRATIVE & REGULATORY SCHEMES & INCENTIVES	
11	Loading/unloading areas and parking
12	Access: time windows, emission zones
13	Access by load factor
14	Multi-users lanes
15	Enforcement and ITS adoption for control and traffic management
16	Businesses recognition scheme
17	Public transport indirect promotion for shopping
18	Urban planning measures
19	Harmonization and simplification of city logistics rules
20	Off peak deliveries
21	Public transport for freight
22	Freight travel plans



Life cycle stages

Life cycle stages: a) Creation - Construction, b) Operation, c) Maintenance, d) Closure

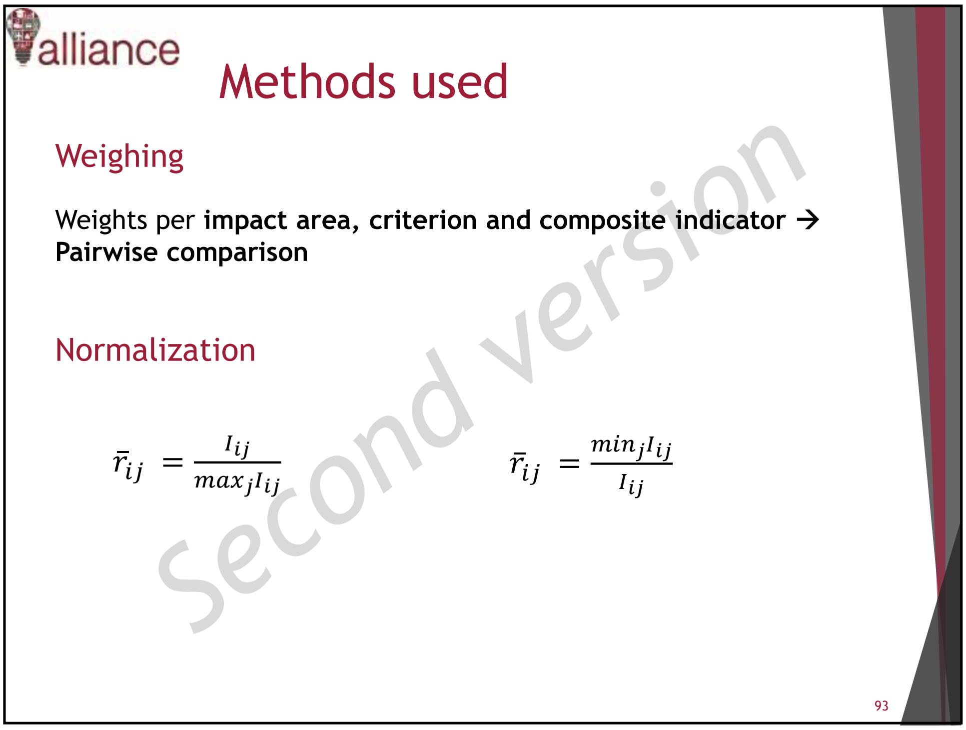
URBAN CONSOLIDATION CENTERS	
Creation-Construction	• Planning of location, construction and establishment of UCC or of inclusion and integration of an existing one within the supply chain and the networks • (Re)Design the business and operational framework of UCC, attributes and minimum requirements to provide high level services, effectiveness and reliability in handling existing and future freight flows. Identification of involved stakeholders and their role • Identification of cargo and vehicle types providing the service interconnecting it to the city center and of transportation unit • Survey on the equipment necessary to be used for the control and monitoring of incoming and outgoing cargo • Investigation on the social acceptance (approval and maturity), stakeholder willingness and authorities' political will to support the operation of a UCC • Analysis on the investment plan, costs and externalities (checking on feasibility, viability and sustainability issues) • Description of business and operational framework, attributes and provided services. Analysis on the coordination and management of stakeholders related issues - investigation on contractual bilateral agreements, MoUs, Master Plan etc.
Operation	• Establishment, implementation, realization and operation of UCC and integration in supply chain as major freight transport node and transshipment point (e.g. involved UFT activities and provided services, equipment used for controlling and monitoring of freight flows serviced by the UCC, cargo and vehicle types, stakeholders and their roles and interconnection of the facility to the city center)
Maintenance	• Maintenance of equipment and reservation or upgrading of the provided services, seeking for new collaborations and business partners through marketing in order to keep or strengthen the market share. Adopt best practice coordination and management concepts together with collaborative schemes and agreements or strengthening the existing ones through active participation of the involved stakeholders in the context of scheduled meetings • Investigation of any technical, operational, legal and managerial problems and issues associated with the establishment and operation of UCC interrelating to the local society, economy, business, legislation, environmental barriers, mobility etc. Decision making on alternatives after discussion with involved stakeholders
Closure	• Withdrawal, replacement or upgrading of applied policy or measure and respective equipment and / or infrastructure at the end of their life and investigation on their potential for reuse or integration with new, more updated and effective concepts

Impact areas

Impact Areas	Criteria	Indicators
Economy and energy	5	36
Environment	3	10
Transport & mobility	5	29
Society	3	20
Policy and measure maturity	3	24
Social acceptance	2	9
User uptake	5	9
Total	26	137

Economy and energy: criteria & indicators

Criteria	Composite Indicator (KPIs)	Indicators (KPIs)	Stakeholders			1. Multimodality for urban freight			
			Supply Chain Stakeholders	Public Authorities	Other	creation	operation	maintenance	closure
Energy		Energy consumption	X	-	-	-	v	v	-
Development		Working potential	-	X	X	v	v	-	-
		Business development	-	X	X	v	v	-	-
		Local / Regional development	X	X	X	-	v	-	-
Benefits		Income generated	X	-	-	-	v	v	-
		Strength and diversification of local economy	-	X	X	-	v	v	-
Costs	Creation cost	Planning and managerial costs	X	X	-	v	-	v	-
		Investment costs	X	X	-	v	-	v	-
	Operating cost	Management	X	-	-	-	v	-	-
		Wages	X	-	-	-	v	-	-
		Fuels	X	-	-	-	v	-	-
		Warehousing and / or handling	X	-	-	-	v	-	-
		Transhipment	X	-	-	-	v	-	-
		Depreciation - infrastructure	X	-	-	-	v	-	-
		Depreciation - equipment	X	-	-	-	v	-	-
		Training	X	-	-	-	v	-	-
	Maintenance cost	Personnel	X	-	-	-	-	v	-
		Equipment/Materials/ Infrastructure	X	-	-	-	-	v	-
		Consumer cost	X	-	X	-	v	v	-
		Enforcement cost	X	X	-	-	v	-	-
		Shipper/receiver costs	X	-	-	-	v	-	-
	End of life associated costs	End of life associated costs (infrastructure)	X	X	-	-	-	-	v
		End of life associated costs (equipment)	X	X	-	-	-	-	v



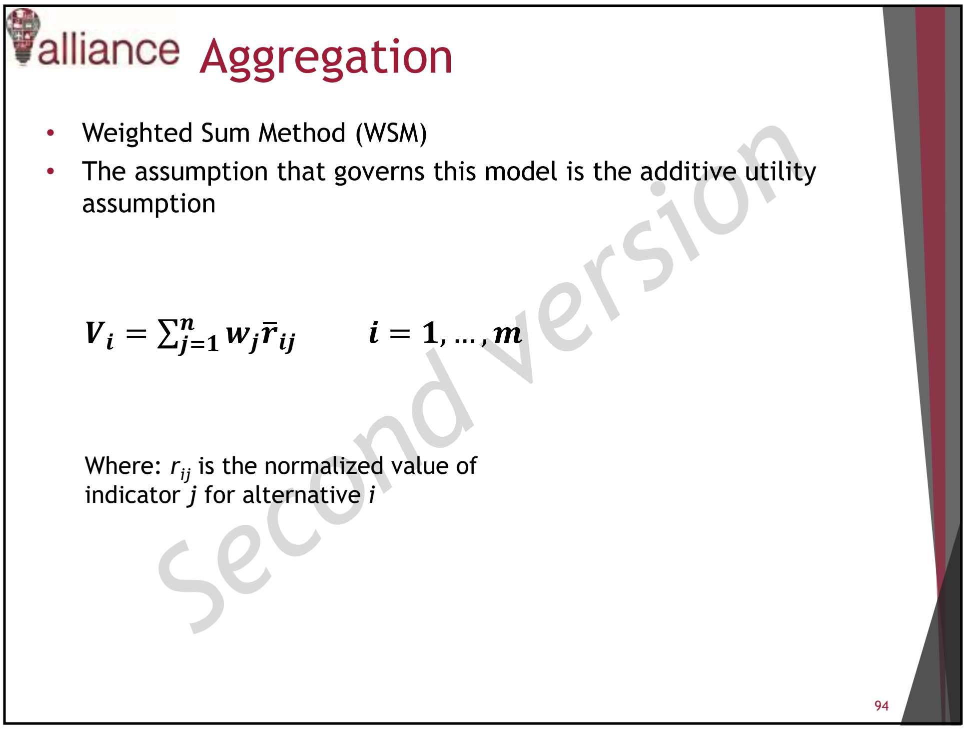
Methods used

Weighing

Weights per **impact area, criterion and composite indicator → Pairwise comparison**

Normalization

$$\bar{r}_{ij} = \frac{I_{ij}}{max_j I_{ij}} \qquad \bar{r}_{ij} = \frac{min_j I_{ij}}{I_{ij}}$$

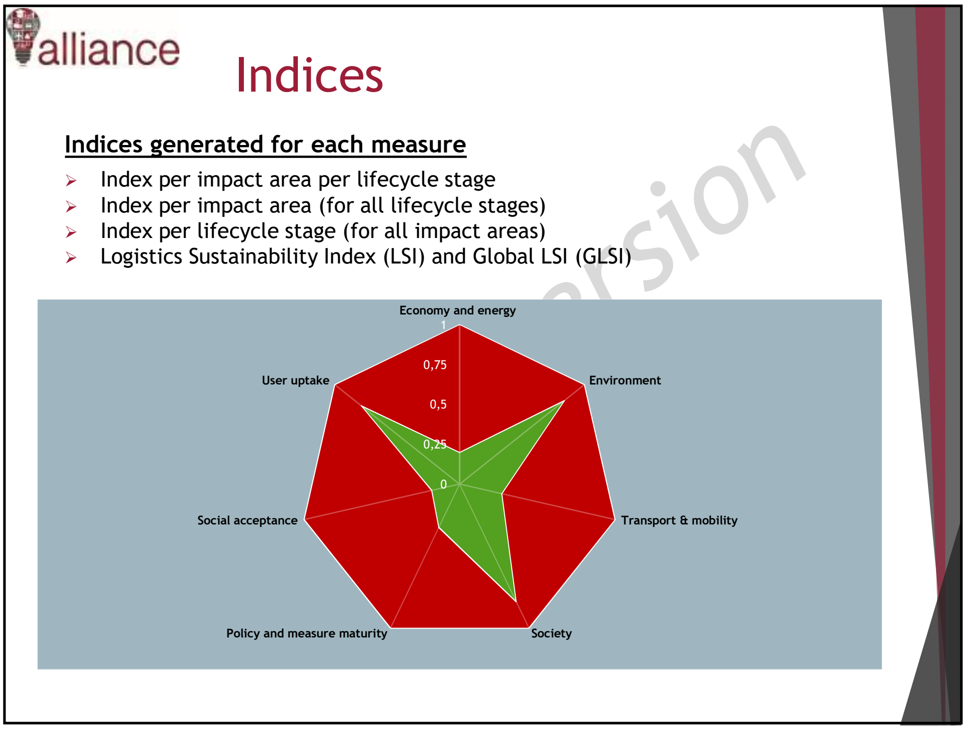


Aggregation

- Weighted Sum Method (WSM)
- The assumption that governs this model is the additive utility assumption

$$\boldsymbol{V_i = \sum_{j=1}^{n} w_j \bar{r}_{ij} \qquad i = 1, \dots, m}$$

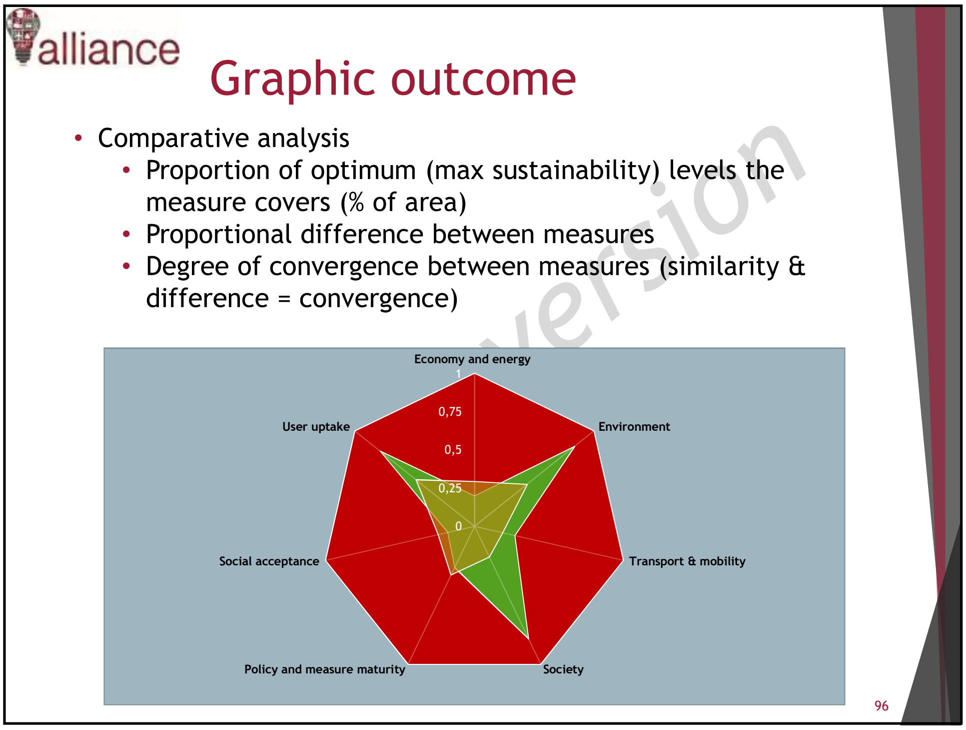
Where: r_{ij} is the normalized value of indicator j for alternative i



Indices

Indices generated for each measure

- Index per impact area per lifecycle stage
- Index per impact area (for all lifecycle stages)
- Index per lifecycle stage (for all impact areas)
- Logistics Sustainability Index (LSI) and Global LSI (GLSI)



Graphic outcome

- Comparative analysis
  - Proportion of optimum (max sustainability) levels the measure covers (% of area)
  - Proportional difference between measures
  - Degree of convergence between measures (similarity & difference = convergence)

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References

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Suggested literature

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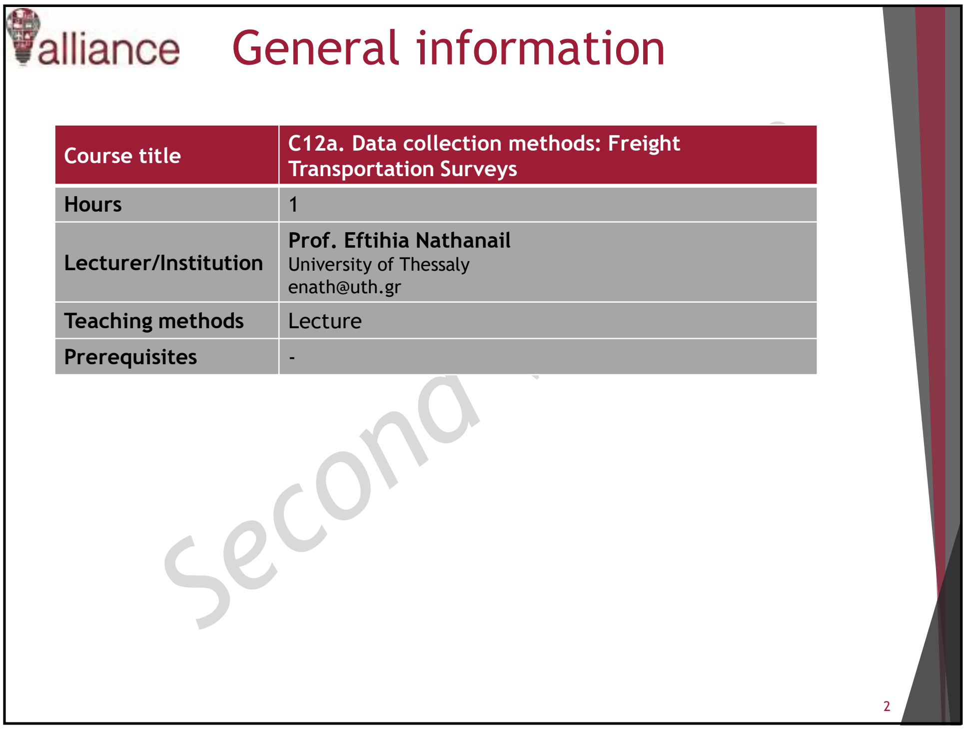
Data collection methods: Freight Transportation Surveys

Prof. Eftihia Nathanail
University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



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General information

Course title	C12a. Data collection methods: Freight Transportation Surveys
Hours	1
Lecturer/Institution	**Prof. Eftihia Nathanail** University of Thessaly enath@uth.gr
Teaching methods	Lecture
Prerequisites	-

Aim and learning outcomes

- **Aim:**
  - Provide an understanding of qualitative methods in data collection
  - Present how a qualitative freight transportion survey is organized
  - Provide an overview of the practical problems of sample design, the collection and application of transport-related data
  - Introduce the process of surveys' analysis results in order to draw useful conclusions
- **Learning outcomes:**
  - Identify appropriate methods for urban freight transport, traffic and spatial data collection.
  - Understand the role of sampling in data collection
  - Setting up a transport survey

Content

Qualitative data collection methods

- Introduction
- Sampling & Statistical analysis
- Data collection methods
- Strengths and weaknesses of each method
- Urban freight transport survey
- Guidance to further knowledge acquisition

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Introduction

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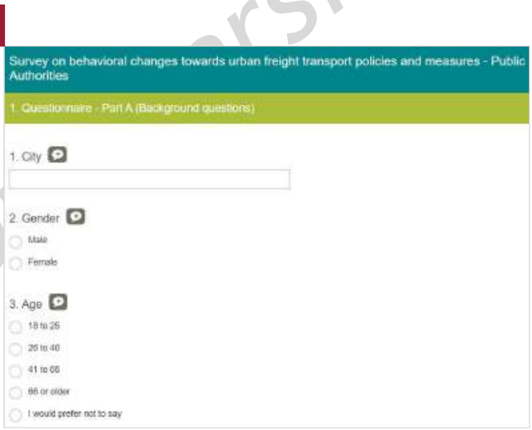
Introduction

> "Research is an art of scientific and systematic investigation to get information about a specific topic. To perform a research different approaches and methods are required which are typically categorised as either quantitative or qualitative."

(Source: Resham Bahadur Bist, 2014)

Qualitative research

- ✓ Gathers information that are not numerical
- ✓ Uncovers the reasons for behaviors, attitudes and motivation
- ✓ Uses unstructured data collection methods (observations, interviews, surveys, documents etc.)
- ✓ Scope of implementation: Nearly all disciplines



Survey on behavioral changes towards urban freight transport policies and measures - Public Authorities

1. Questionnaire - Part A (Background questions)

1. City

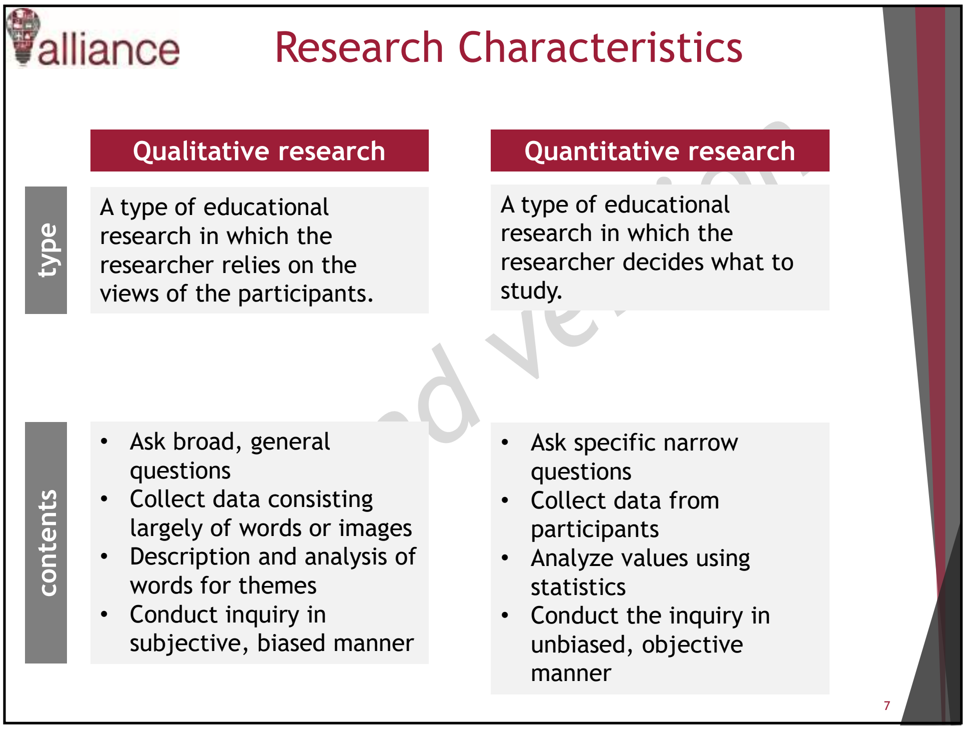
2. Gender

○ Male
○ Female

3. Age

○ 18 to 25
○ 26 to 40
○ 41 to 65
○ 66 or older
○ I would prefer not to say

Source: https://www.surveymonkey.com/r/novelog_BM_PA



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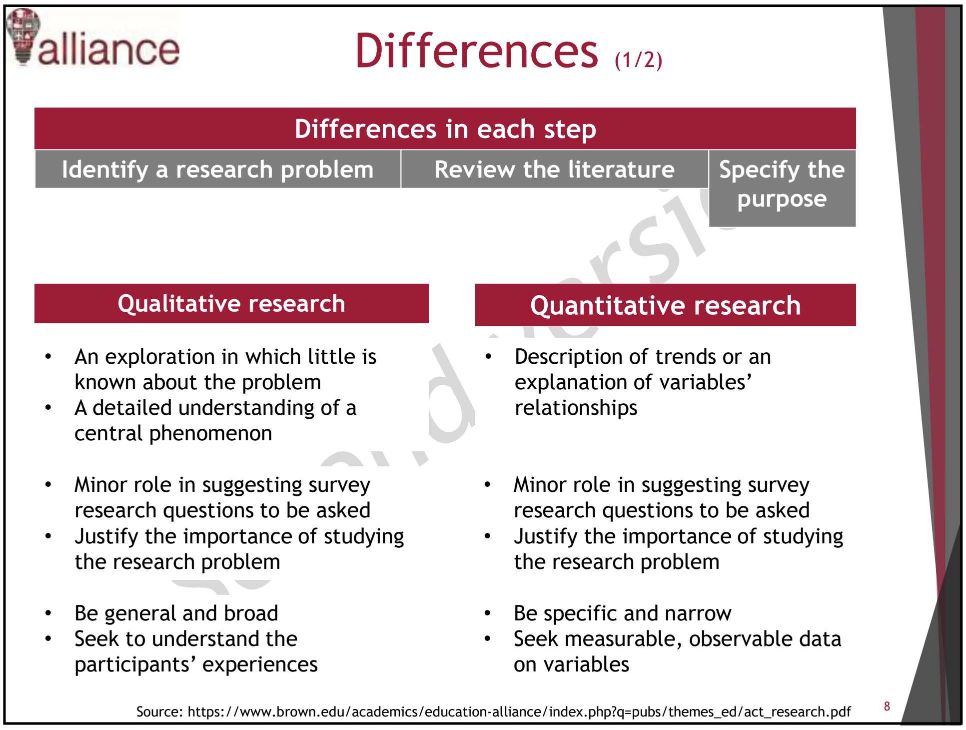
Research Characteristics

	Qualitative research	Quantitative research
type	A type of educational research in which the researcher relies on the views of the participants.	A type of educational research in which the researcher decides what to study.
contents	• Ask broad, general questions • Collect data consisting largely of words or images • Description and analysis of words for themes • Conduct inquiry in subjective, biased manner	• Ask specific narrow questions • Collect data from participants • Analyze values using statistics • Conduct the inquiry in unbiased, objective manner



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Differences (1/2)

Differences in each step

Identify a research problem	Review the literature	Specify the purpose

Qualitative research	Quantitative research
• An exploration in which little is known about the problem • A detailed understanding of a central phenomenon	• Description of trends or an explanation of variables' relationships
• Minor role in suggesting survey research questions to be asked • Justify the importance of studying the research problem	• Minor role in suggesting survey research questions to be asked • Justify the importance of studying the research problem
• Be general and broad • Seek to understand the participants' experiences	• Be specific and narrow • Seek measurable, observable data on variables

Source: https://www.brown.edu/academics/education-alliance/index.php?q=pubs/themes_ed/act_research.pdf

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Differences (2/2)

Differences in each step

Identify a research problem
Review the literature
Specify the purpose
Collect data
Analyze & interpret data
Report & Evaluate data

Qualitative research	Quantitative research
• Collect data forms with general, emerging questions to permit the participant to generate responses • Collect info from a small number of individuals or sites	• Collect data using instruments with preset questions & responses • Collect info from a large number of individuals
• Text analysis • A description of themes • State the larger meaning of findings	• Data analysis trends to consist of statistical analysis • Describe trends, comparing group differences, relating variables
• Flexible, emerging structure and evaluation criteria • Subjective and biased approach	• Standard fixed structure and evaluation criteria • Objective approach

Source: https://www.brown.edu/academics/education-alliance/index.php?q=pubs/themes_ed/act_research.pdf

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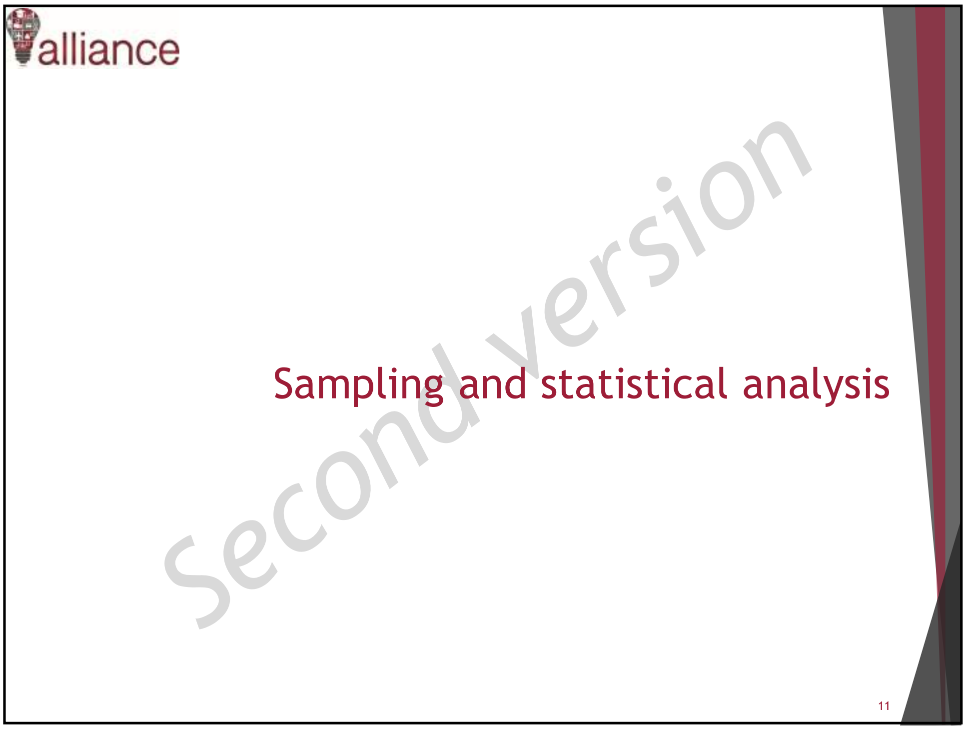
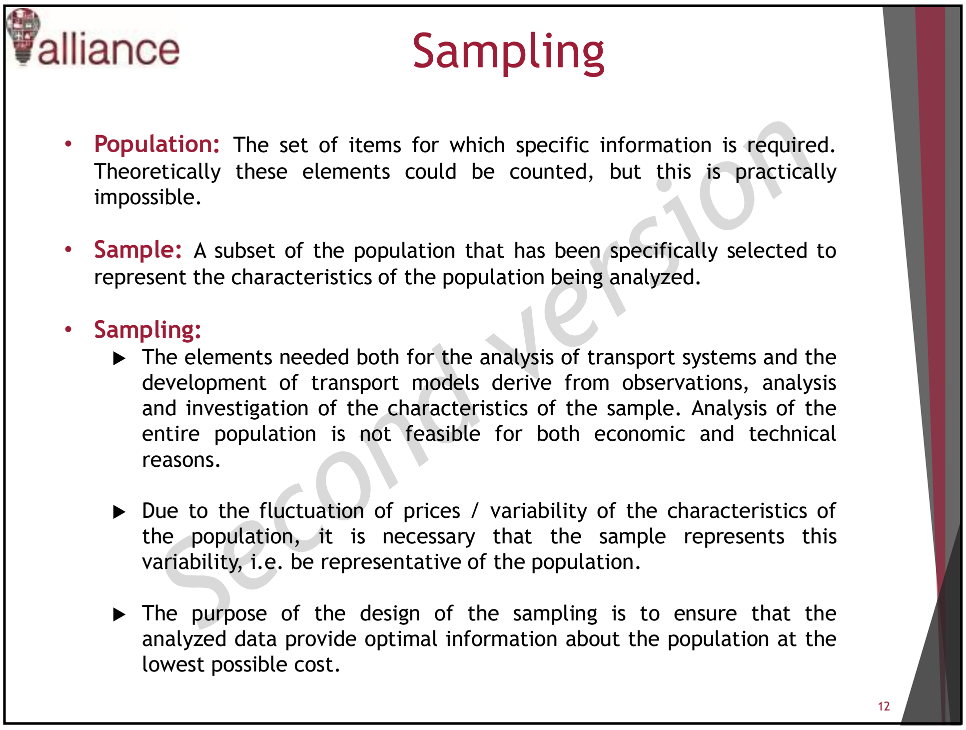
Key differences

Criteria	Qualitative research	Quantitative research
Research perspective	The interests of those affected are the focus of interest	View from the outside perspective of the researcher
Type of knowledge	Subjective	Objective
Aim	Exploratory and observational	Generalisable and testing
Characteristics	Flexible	Fixed and controlled
	Contextual portrayal	Independent and dependent variables
	Dynamic, continuous view of change	Pre- and post-measurement of change
Sampling	Purposeful	Random
Data collection	Semi-structured or unstructured	Structured
Nature of data	Narratives, quotations, descriptions	Numbers, statistics
	Value uniqueness, particularity	Replication
Analysis	Thematic	Statistical

Source: [The Open University, 2017]

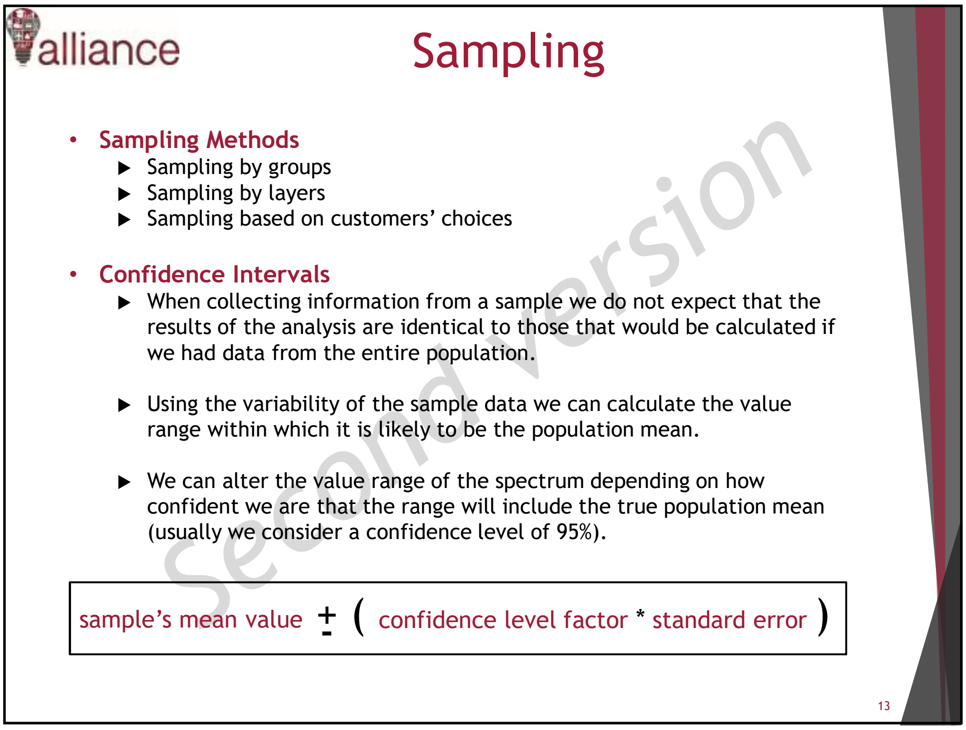


Sampling and statistical analysis



Sampling

- **Population:** The set of items for which specific information is required. Theoretically these elements could be counted, but this is practically impossible.
- **Sample:** A subset of the population that has been specifically selected to represent the characteristics of the population being analyzed.
- **Sampling:**
  - ▶ The elements needed both for the analysis of transport systems and the development of transport models derive from observations, analysis and investigation of the characteristics of the sample. Analysis of the entire population is not feasible for both economic and technical reasons.
  - ▶ Due to the fluctuation of prices / variability of the characteristics of the population, it is necessary that the sample represents this variability, i.e. be representative of the population.
  - ▶ The purpose of the design of the sampling is to ensure that the analyzed data provide optimal information about the population at the lowest possible cost.

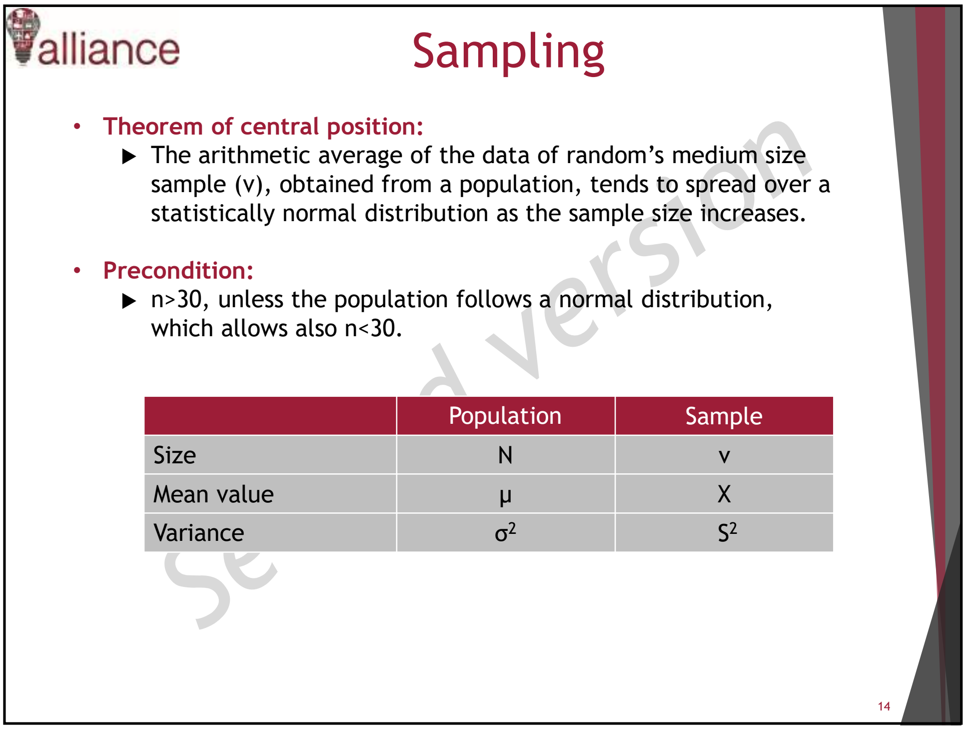


Sampling

- **Sampling Methods**
  - Sampling by groups
  - Sampling by layers
  - Sampling based on customers’ choices

- **Confidence Intervals**
  - When collecting information from a sample we do not expect that the results of the analysis are identical to those that would be calculated if we had data from the entire population.
  - Using the variability of the sample data we can calculate the value range within which it is likely to be the population mean.
  - We can alter the value range of the spectrum depending on how confident we are that the range will include the true population mean (usually we consider a confidence level of 95%).

sample’s mean value ± (confidence level factor * standard error)

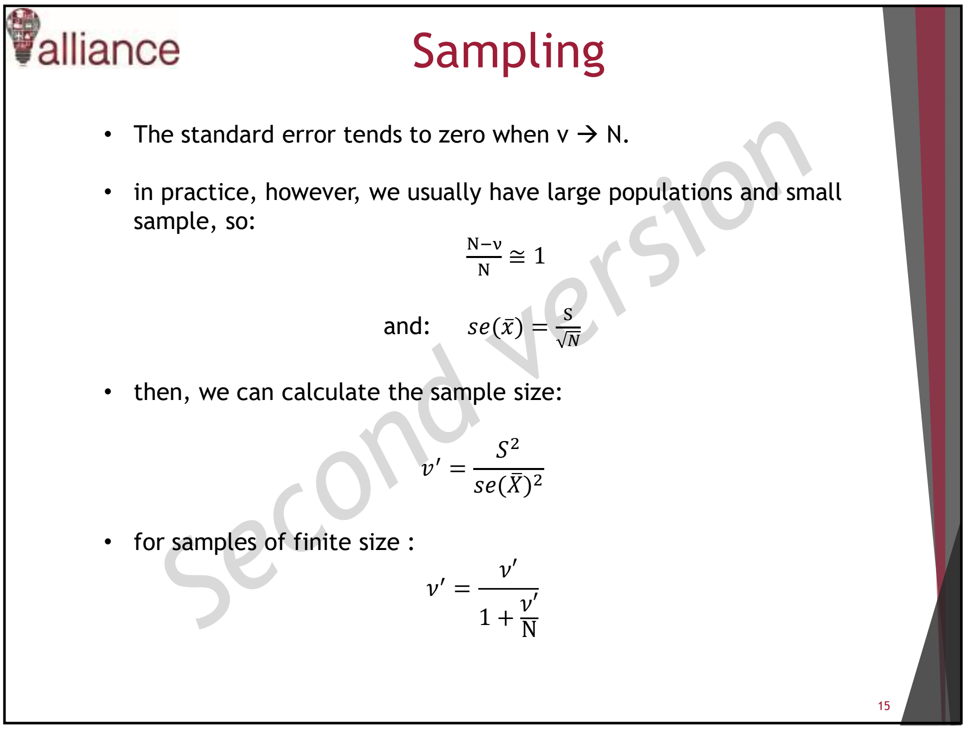


Sampling

- **Theorem of central position:**
  - The arithmetic average of the data of random’s medium size sample (v), obtained from a population, tends to spread over a statistically normal distribution as the sample size increases.

- **Precondition:**
  - n>30, unless the population follows a normal distribution, which allows also n<30.

	Population	Sample
Size	N	v
Mean value	μ	X
Variance	σ^2	S^2



Sampling

- The standard error tends to zero when v → N.
- in practice, however, we usually have large populations and small sample, so:

$$\frac{N-\nu}{N} \cong 1$$

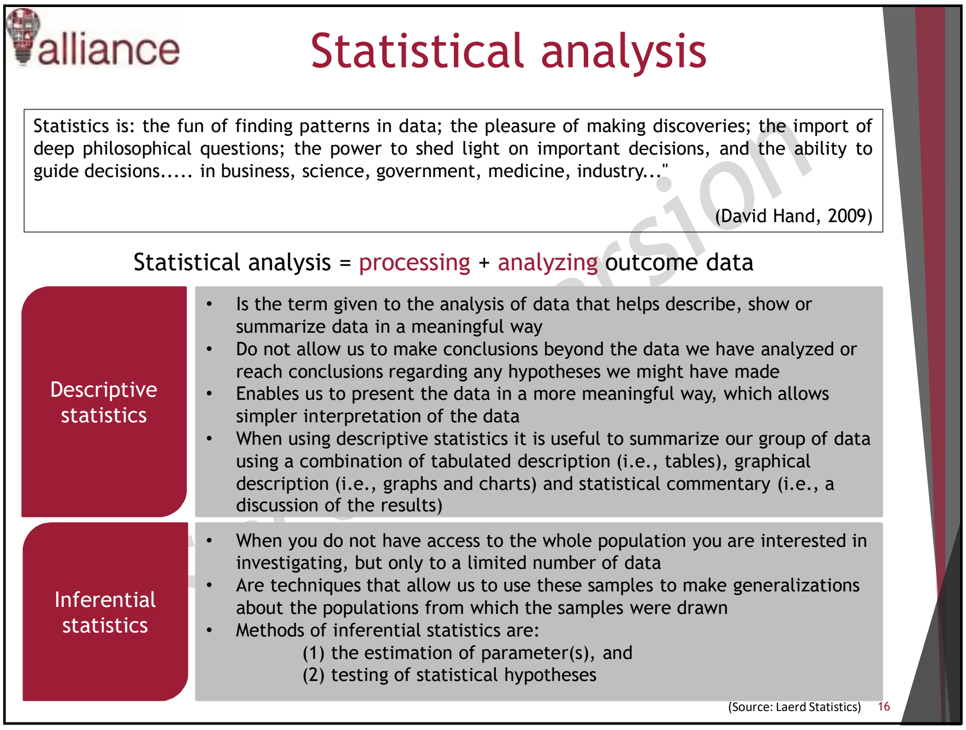
and: $$se(\bar{x}) = \frac{S}{\sqrt{N}}$$

- then, we can calculate the sample size:

$$v' = \frac{S^2}{se(\bar{X})^2}$$

- for samples of finite size :

$$v' = \frac{v'}{1+\frac{v'}{N}}$$



Statistical analysis

Statistics is: the fun of finding patterns in data; the pleasure of making discoveries; the import of deep philosophical questions; the power to shed light on important decisions, and the ability to guide decisions..... in business, science, government, medicine, industry..."

(David Hand, 2009)

Statistical analysis = processing + analyzing outcome data

Descriptive statistics

- Is the term given to the analysis of data that helps describe, show or summarize data in a meaningful way
- Do not allow us to make conclusions beyond the data we have analyzed or reach conclusions regarding any hypotheses we might have made
- Enables us to present the data in a more meaningful way, which allows simpler interpretation of the data
- When using descriptive statistics it is useful to summarize our group of data using a combination of tabulated description (i.e., tables), graphical description (i.e., graphs and charts) and statistical commentary (i.e., a discussion of the results)

Inferential statistics

- When you do not have access to the whole population you are interested in investigating, but only to a limited number of data
- Are techniques that allow us to use these samples to make generalizations about the populations from which the samples were drawn
- Methods of inferential statistics are:
  (1) the estimation of parameter(s), and
  (2) testing of statistical hypotheses

(Source: Laerd Statistics)

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Data collection methods

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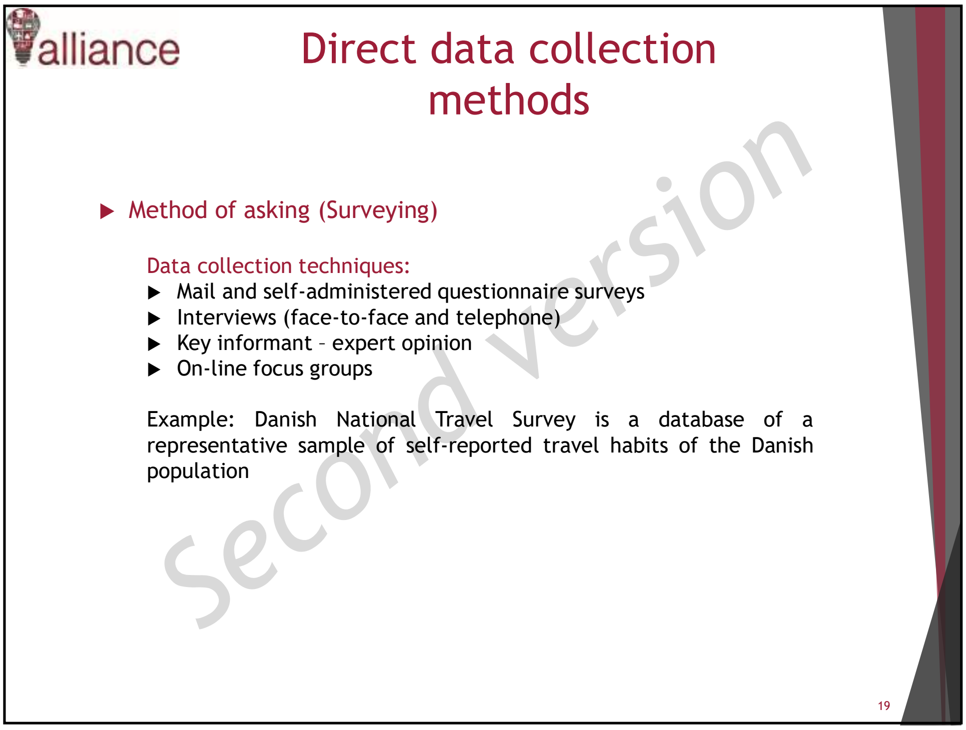
Data collection methods

Data collection method is the general orientation towards data collection. The chosen collection procedure depends on its strengths and weaknesses, costs, data availability, and convenience.

Data collection technique is the actual means / instruments / procedures for data collection

Data collection methods:

- Direct (obtrusive data collection)
  - subjects are aware of the fact that they are being studied
- Indirect (unobtrusive data collection)
  - subjects are not aware of the fact that they are being studied

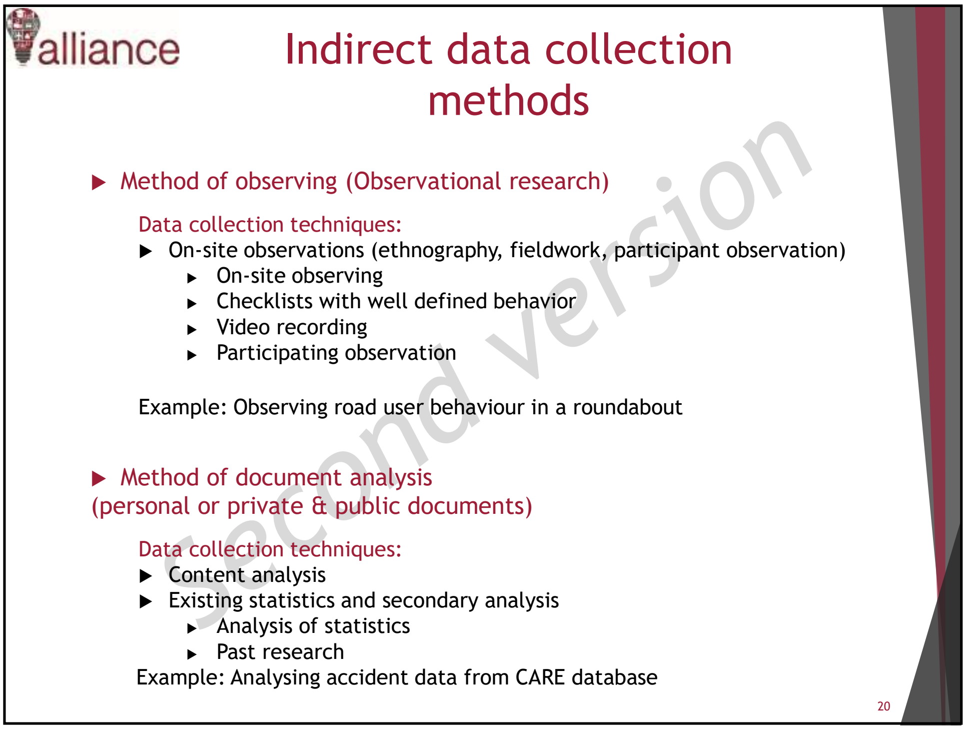


Direct data collection methods

- Method of asking (Surveying)

Data collection techniques:
- Mail and self-administered questionnaire surveys
- Interviews (face-to-face and telephone)
- Key informant – expert opinion
- On-line focus groups

Example: Danish National Travel Survey is a database of a representative sample of self-reported travel habits of the Danish population



Indirect data collection methods

- Method of observing (Observational research)

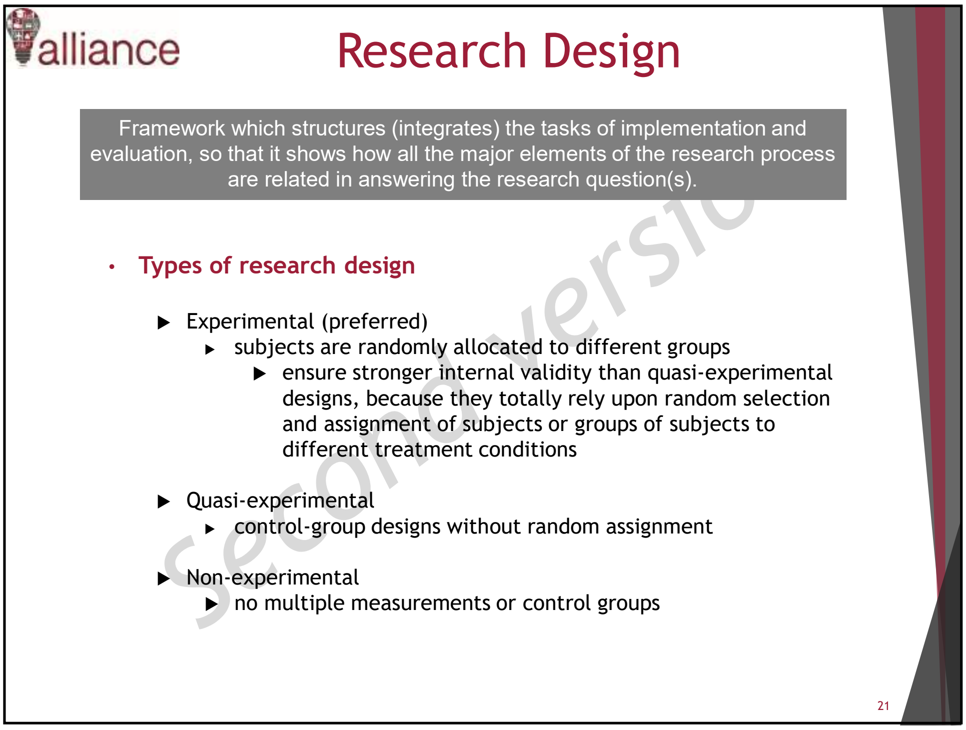
Data collection techniques:
- On-site observations (ethnography, fieldwork, participant observation)
  - On-site observing
  - Checklists with well defined behavior
  - Video recording
  - Participating observation

Example: Observing road user behaviour in a roundabout

- Method of document analysis (personal or private & public documents)

Data collection techniques:
- Content analysis
- Existing statistics and secondary analysis
  - Analysis of statistics
  - Past research

Example: Analysing accident data from CARE database



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Research Design

Framework which structures (integrates) the tasks of implementation and evaluation, so that it shows how all the major elements of the research process are related in answering the research question(s).

- **Types of research design**
  - Experimental (preferred)
    - subjects are randomly allocated to different groups
      - ensure stronger internal validity than quasi-experimental designs, because they totally rely upon random selection and assignment of subjects or groups of subjects to different treatment conditions
  - Quasi-experimental
    - control-group designs without random assignment
  - Non-experimental
    - no multiple measurements or control groups

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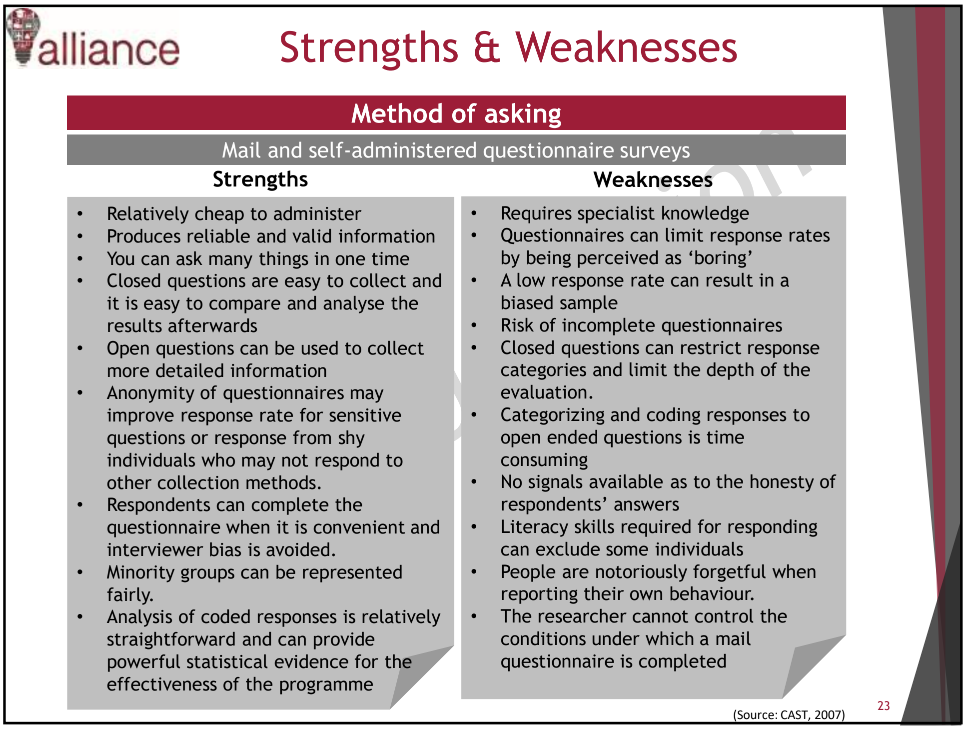
Strengths and weaknesses of each method



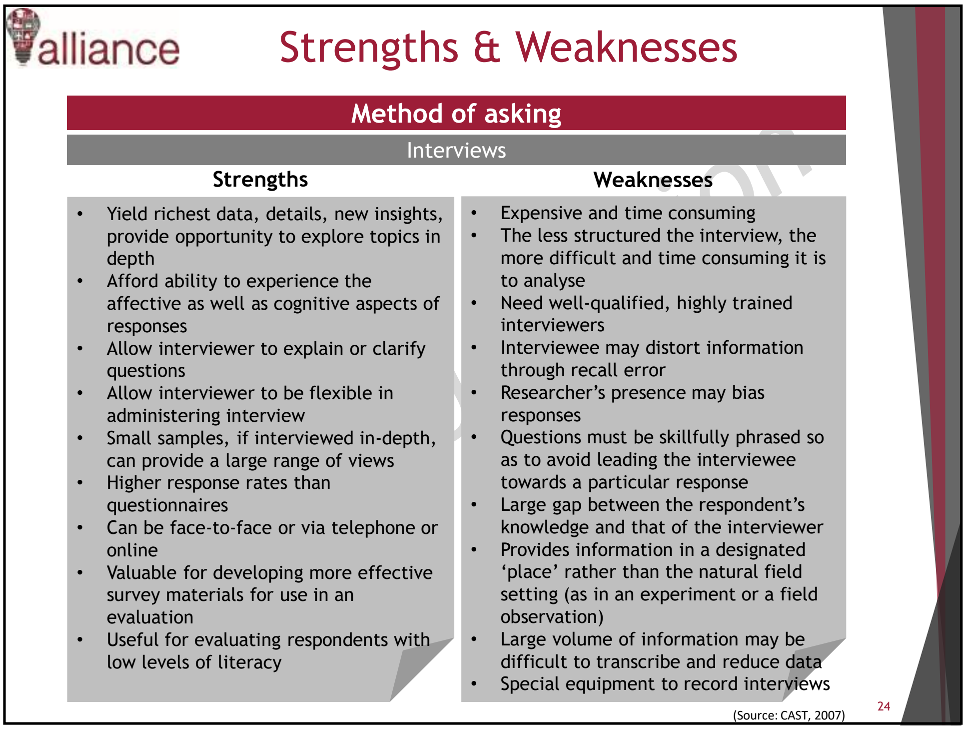
Strengths & Weaknesses

Method of asking

Mail and self-administered questionnaire surveys

Strengths	Weaknesses
Relatively cheap to administer Produces reliable and valid information You can ask many things in one time Closed questions are easy to collect and it is easy to compare and analyse the results afterwards Open questions can be used to collect more detailed information Anonymity of questionnaires may improve response rate for sensitive questions or response from shy individuals who may not respond to other collection methods. Respondents can complete the questionnaire when it is convenient and interviewer bias is avoided. Minority groups can be represented fairly. Analysis of coded responses is relatively straightforward and can provide powerful statistical evidence for the effectiveness of the programme	Requires specialist knowledge Questionnaires can limit response rates by being perceived as ‘boring’ A low response rate can result in a biased sample Risk of incomplete questionnaires Closed questions can restrict response categories and limit the depth of the evaluation. Categorizing and coding responses to open ended questions is time consuming No signals available as to the honesty of respondents’ answers Literacy skills required for responding can exclude some individuals People are notoriously forgetful when reporting their own behaviour. The researcher cannot control the conditions under which a mail questionnaire is completed

(Source: CAST, 2007)



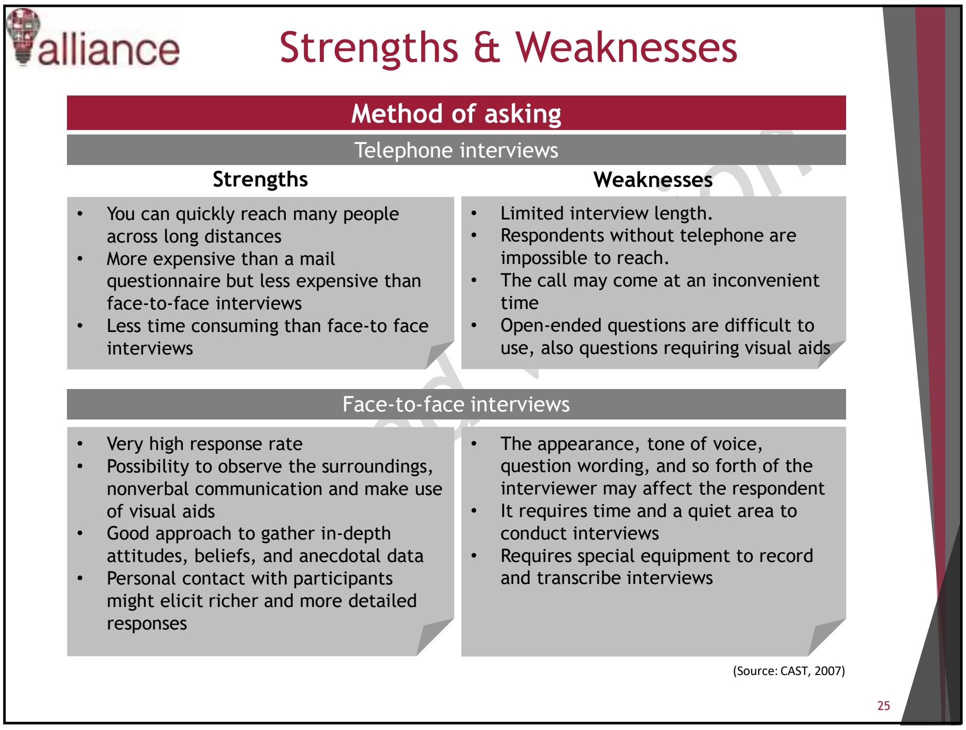
Strengths & Weaknesses

Method of asking

Interviews

Strengths	Weaknesses
Yield richest data, details, new insights, provide opportunity to explore topics in depth Afford ability to experience the affective as well as cognitive aspects of responses Allow interviewer to explain or clarify questions Allow interviewer to be flexible in administering interview Small samples, if interviewed in-depth, can provide a large range of views Higher response rates than questionnaires Can be face-to-face or via telephone or online Valuable for developing more effective survey materials for use in an evaluation Useful for evaluating respondents with low levels of literacy	Expensive and time consuming The less structured the interview, the more difficult and time consuming it is to analyse Need well-qualified, highly trained interviewers Interviewee may distort information through recall error Researcher’s presence may bias responses Questions must be skillfully phrased so as to avoid leading the interviewee towards a particular response Large gap between the respondent’s knowledge and that of the interviewer Provides information in a designated ‘place’ rather than the natural field setting (as in an experiment or a field observation) Large volume of information may be difficult to transcribe and reduce data Special equipment to record interviews

(Source: CAST, 2007)



Strengths & Weaknesses

Method of asking

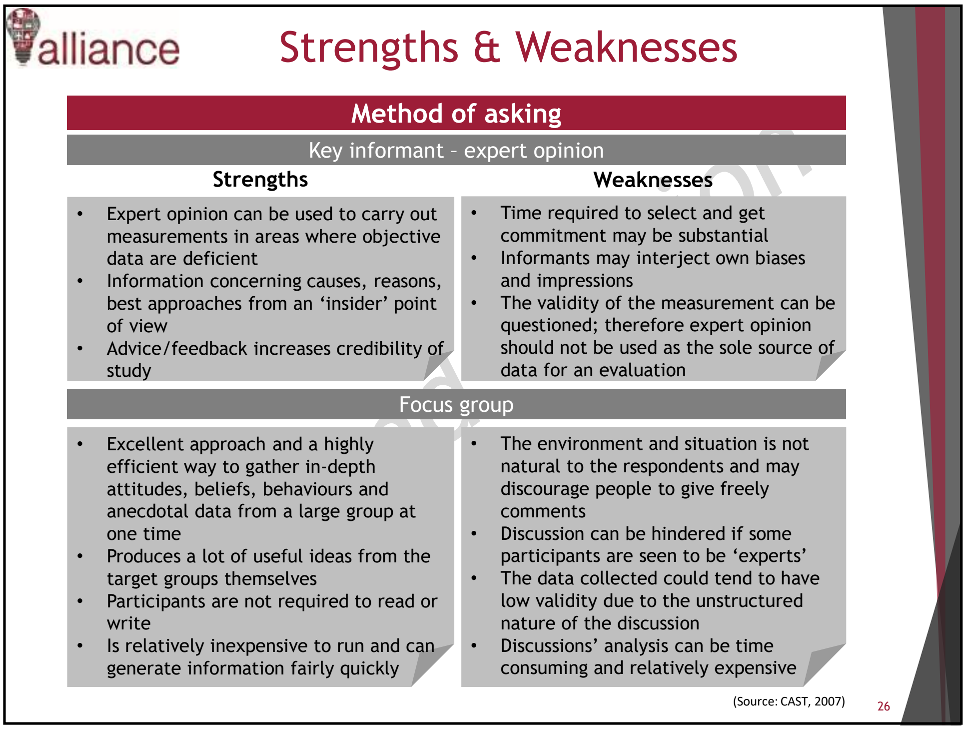
Telephone interviews

Strengths	Weaknesses
• You can quickly reach many people across long distances • More expensive than a mail questionnaire but less expensive than face-to-face interviews • Less time consuming than face-to face interviews	• Limited interview length. • Respondents without telephone are impossible to reach. • The call may come at an inconvenient time • Open-ended questions are difficult to use, also questions requiring visual aids

Face-to-face interviews

Strengths	Weaknesses
• Very high response rate • Possibility to observe the surroundings, nonverbal communication and make use of visual aids • Good approach to gather in-depth attitudes, beliefs, and anecdotal data • Personal contact with participants might elicit richer and more detailed responses	• The appearance, tone of voice, question wording, and so forth of the interviewer may affect the respondent • It requires time and a quiet area to conduct interviews • Requires special equipment to record and transcribe interviews

(Source: CAST, 2007)



Strengths & Weaknesses

Method of asking

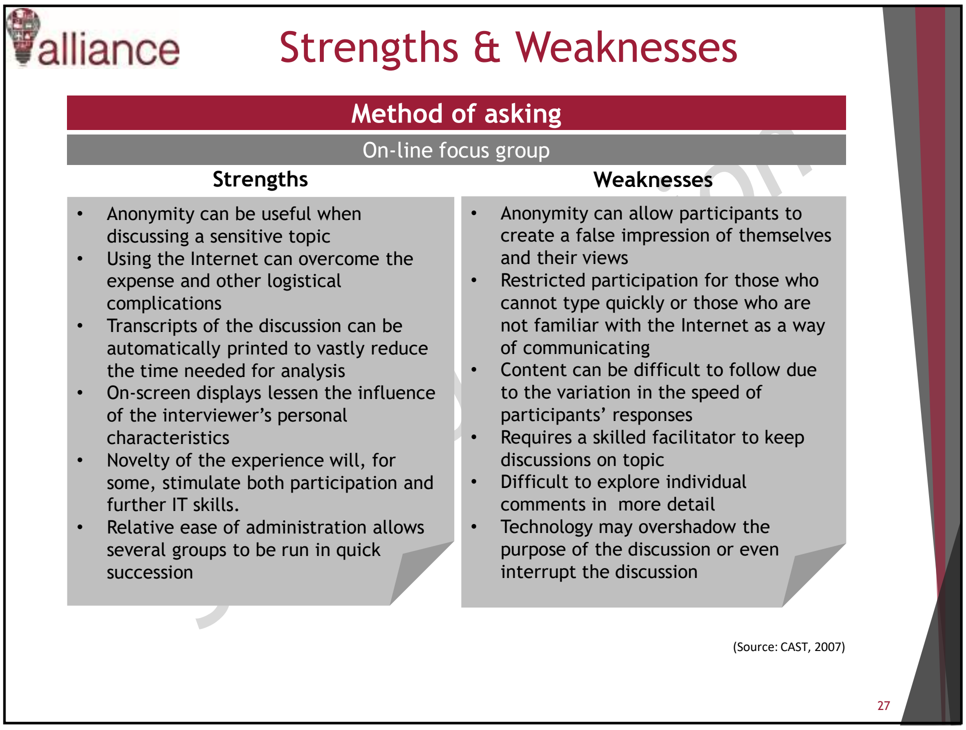
Key informant - expert opinion

Strengths	Weaknesses
• Expert opinion can be used to carry out measurements in areas where objective data are deficient • Information concerning causes, reasons, best approaches from an 'insider' point of view • Advice/feedback increases credibility of study	• Time required to select and get commitment may be substantial • Informants may interject own biases and impressions • The validity of the measurement can be questioned; therefore expert opinion should not be used as the sole source of data for an evaluation

Focus group

Strengths	Weaknesses
• Excellent approach and a highly efficient way to gather in-depth attitudes, beliefs, behaviours and anecdotal data from a large group at one time • Produces a lot of useful ideas from the target groups themselves • Participants are not required to read or write • Is relatively inexpensive to run and can generate information fairly quickly	• The environment and situation is not natural to the respondents and may discourage people to give freely comments • Discussion can be hindered if some participants are seen to be 'experts' • The data collected could tend to have low validity due to the unstructured nature of the discussion • Discussions' analysis can be time consuming and relatively expensive

(Source: CAST, 2007)



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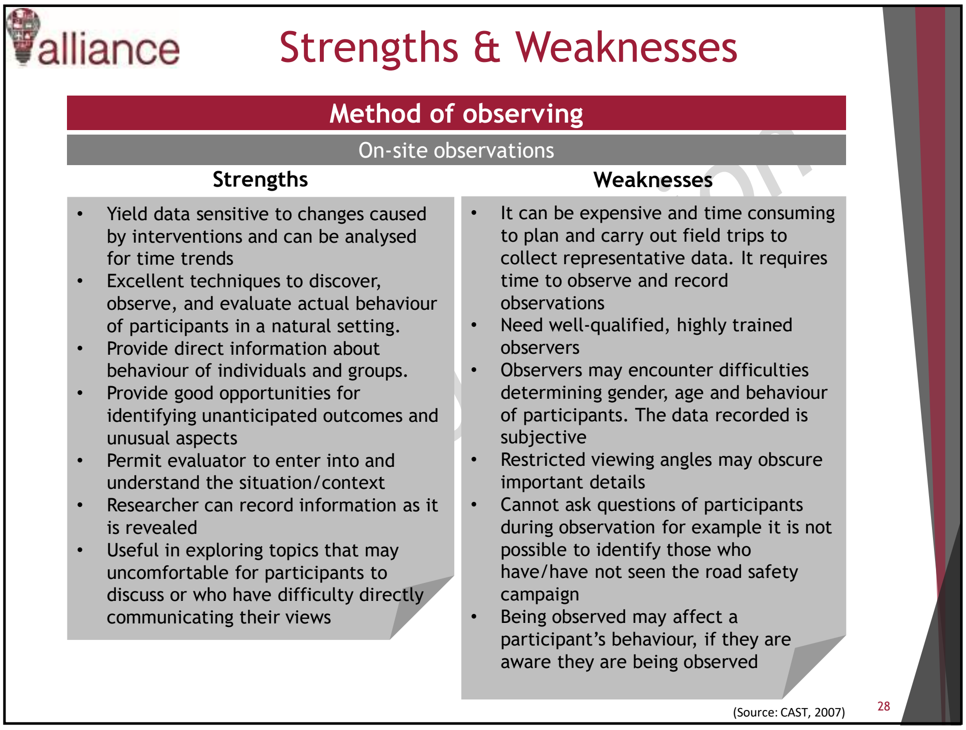
Strengths & Weaknesses

Method of asking

On-line focus group

Strengths	Weaknesses
• Anonymity can be useful when discussing a sensitive topic • Using the Internet can overcome the expense and other logistical complications • Transcripts of the discussion can be automatically printed to vastly reduce the time needed for analysis • On-screen displays lessen the influence of the interviewer's personal characteristics • Novelty of the experience will, for some, stimulate both participation and further IT skills. • Relative ease of administration allows several groups to be run in quick succession	• Anonymity can allow participants to create a false impression of themselves and their views • Restricted participation for those who cannot type quickly or those who are not familiar with the Internet as a way of communicating • Content can be difficult to follow due to the variation in the speed of participants' responses • Requires a skilled facilitator to keep discussions on topic • Difficult to explore individual comments in more detail • Technology may overshadow the purpose of the discussion or even interrupt the discussion

(Source: CAST, 2007)



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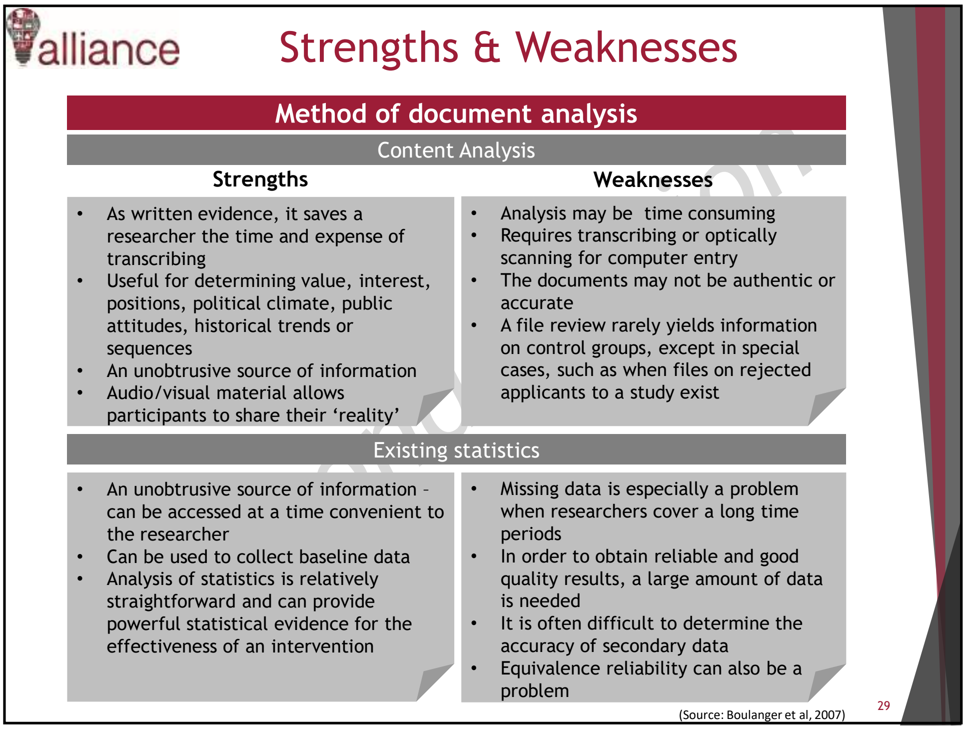
Strengths & Weaknesses

Method of observing

On-site observations

Strengths	Weaknesses
• Yield data sensitive to changes caused by interventions and can be analysed for time trends • Excellent techniques to discover, observe, and evaluate actual behaviour of participants in a natural setting. • Provide direct information about behaviour of individuals and groups. • Provide good opportunities for identifying unanticipated outcomes and unusual aspects • Permit evaluator to enter into and understand the situation/context • Researcher can record information as it is revealed • Useful in exploring topics that may uncomfortable for participants to discuss or who have difficulty directly communicating their views	• It can be expensive and time consuming to plan and carry out field trips to collect representative data. It requires time to observe and record observations • Need well-qualified, highly trained observers • Observers may encounter difficulties determining gender, age and behaviour of participants. The data recorded is subjective • Restricted viewing angles may obscure important details • Cannot ask questions of participants during observation for example it is not possible to identify those who have/have not seen the road safety campaign • Being observed may affect a participant's behaviour, if they are aware they are being observed

(Source: CAST, 2007)

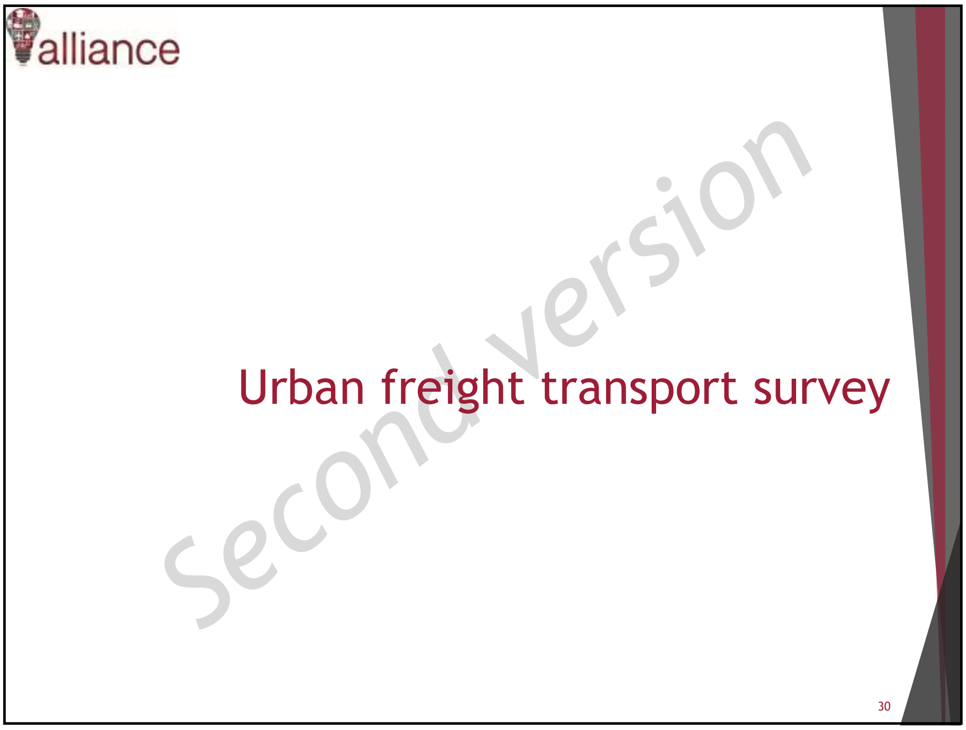


Strengths & Weaknesses

Method of document analysis

Strengths	Weaknesses
Content Analysis	
• As written evidence, it saves a researcher the time and expense of transcribing • Useful for determining value, interest, positions, political climate, public attitudes, historical trends or sequences • An unobtrusive source of information • Audio/visual material allows participants to share their 'reality'	• Analysis may be time consuming • Requires transcribing or optically scanning for computer entry • The documents may not be authentic or accurate • A file review rarely yields information on control groups, except in special cases, such as when files on rejected applicants to a study exist
Existing statistics	
• An unobtrusive source of information – can be accessed at a time convenient to the researcher • Can be used to collect baseline data • Analysis of statistics is relatively straightforward and can provide powerful statistical evidence for the effectiveness of an intervention	• Missing data is especially a problem when researchers cover a long time periods • In order to obtain reliable and good quality results, a large amount of data is needed • It is often difficult to determine the accuracy of secondary data • Equivalence reliability can also be a problem

(Source: Boulanger et al, 2007)



Urban freight transport survey

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Setting up an urban freight survey

NOVELOG’s data and knowledge collection framework

- identify the supply chains operating their last mile functions in a specific city area;
- understand involved actors’ behaviour and needs;
- identify goods and services that are produced and consumed in the specific city area;
- quantify the freight distribution demand and supply;
- map urban freight trips and activities;
- identify the city structure and the legal framework that is applied in city logistics;
- identify policies, measures, methods and techniques able to facilitate and improve UFT in the specific area, in order to implement a CO_2 free city logistics.

novelog (Source: NOVELOG, 2015)

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Aspects and topics for data collection in urban freight studies

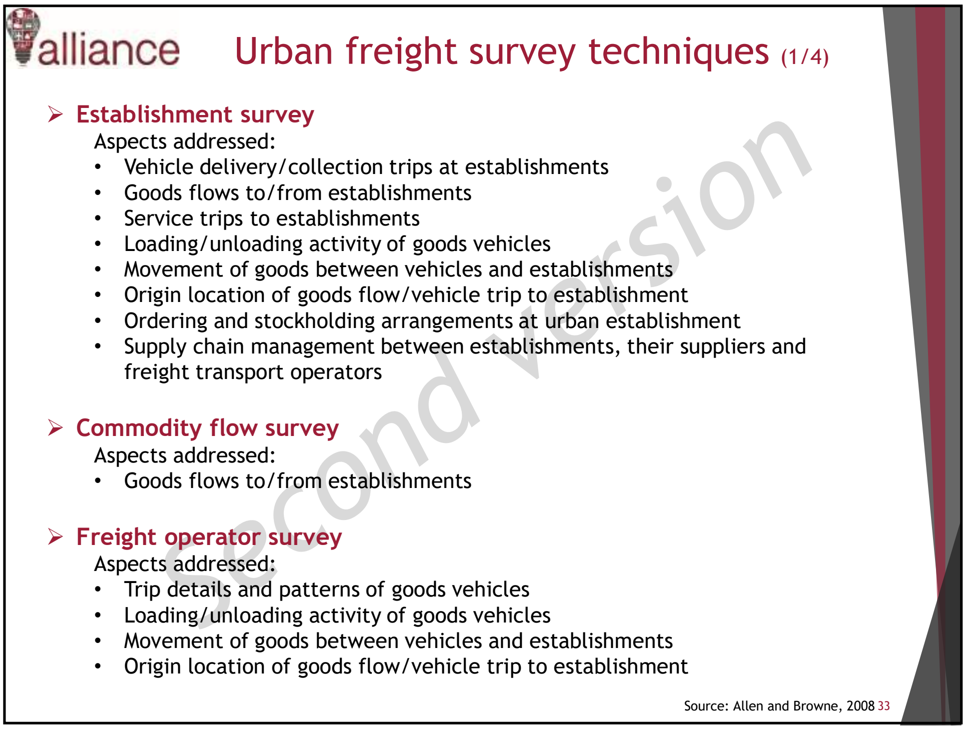
❖ **Service trips to establishments in the urban area:**
Type and number of service trips, Time of day, Variation by day of week, Variation during year ..

❖ **Trip details and patterns of goods/service vehicles:**
Type of operator, Vehicle type, Vehicle weight, Type of goods carried and delivered/collected, Type of establishments/land use served, No. of stops per round, No. of rounds per day, Vehicle speed ..

❖ **Loading/unloading activity of goods vehicles:**
Type of vehicle, Time of day, Load/unload/ location, Time taken to load/unload, Number of deliveries/collections by driver from vehicle without moving it, Legal: illegal loading activities ..

❖ **Movement of goods between vehicles and establishments**
Method of goods handling from vehicle to establishment, Proximity of location to delivery/collection point, Quantity of goods, End destination for delivery (shop floor, etc.), Whether goods have to be checked by receiver ..

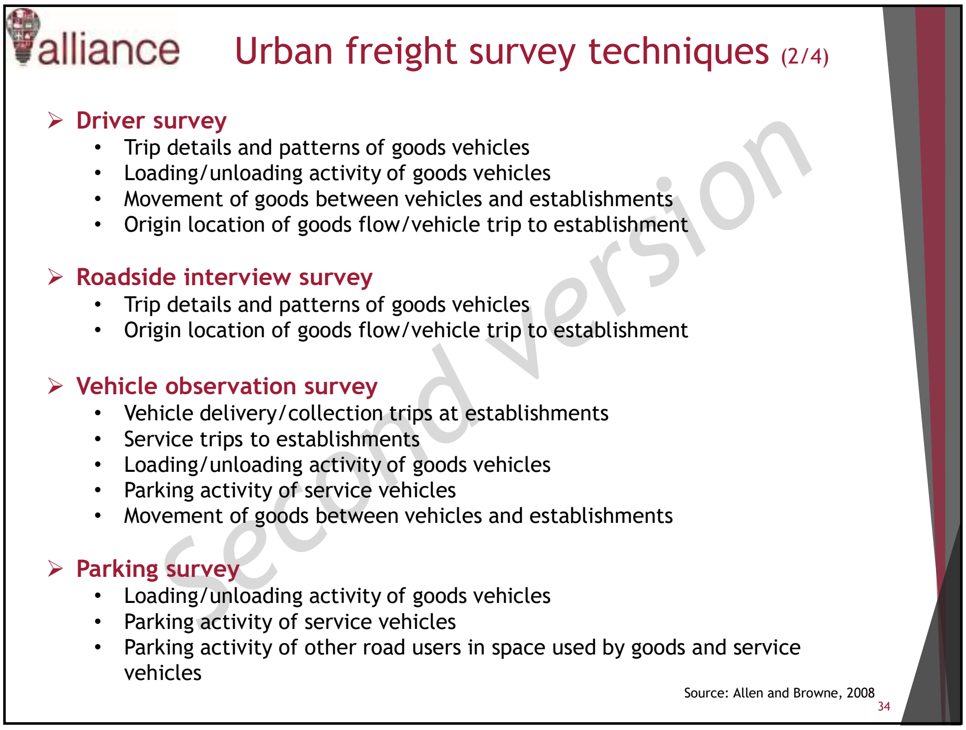
❖ **Ordering and stockholding arrangements at urban premises ..**



Urban freight survey techniques (1/4)

- **Establishment survey**
  Aspects addressed:
  - Vehicle delivery/collection trips at establishments
  - Goods flows to/from establishments
  - Service trips to establishments
  - Loading/unloading activity of goods vehicles
  - Movement of goods between vehicles and establishments
  - Origin location of goods flow/vehicle trip to establishment
  - Ordering and stockholding arrangements at urban establishment
  - Supply chain management between establishments, their suppliers and freight transport operators
- **Commodity flow survey**
  Aspects addressed:
  - Goods flows to/from establishments
- **Freight operator survey**
  Aspects addressed:
  - Trip details and patterns of goods vehicles
  - Loading/unloading activity of goods vehicles
  - Movement of goods between vehicles and establishments
  - Origin location of goods flow/vehicle trip to establishment

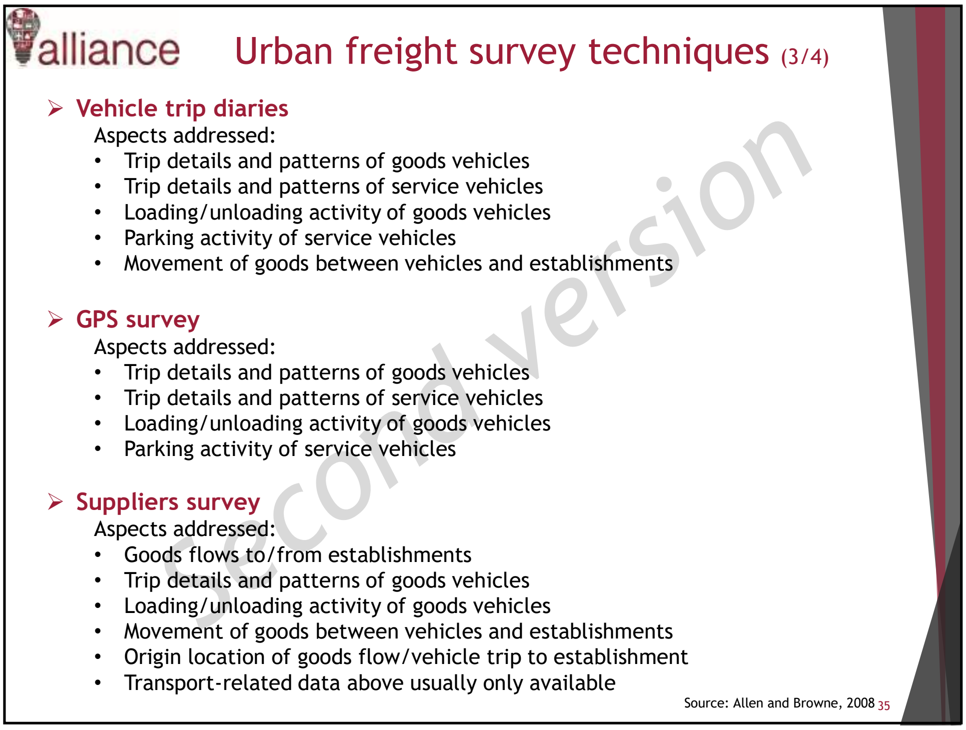
Source: Allen and Browne, 2008



Urban freight survey techniques (2/4)

- **Driver survey**
  - Trip details and patterns of goods vehicles
  - Loading/unloading activity of goods vehicles
  - Movement of goods between vehicles and establishments
  - Origin location of goods flow/vehicle trip to establishment
- **Roadside interview survey**
  - Trip details and patterns of goods vehicles
  - Origin location of goods flow/vehicle trip to establishment
- **Vehicle observation survey**
  - Vehicle delivery/collection trips at establishments
  - Service trips to establishments
  - Loading/unloading activity of goods vehicles
  - Parking activity of service vehicles
  - Movement of goods between vehicles and establishments
- **Parking survey**
  - Loading/unloading activity of goods vehicles
  - Parking activity of service vehicles
  - Parking activity of other road users in space used by goods and service vehicles

Source: Allen and Browne, 2008



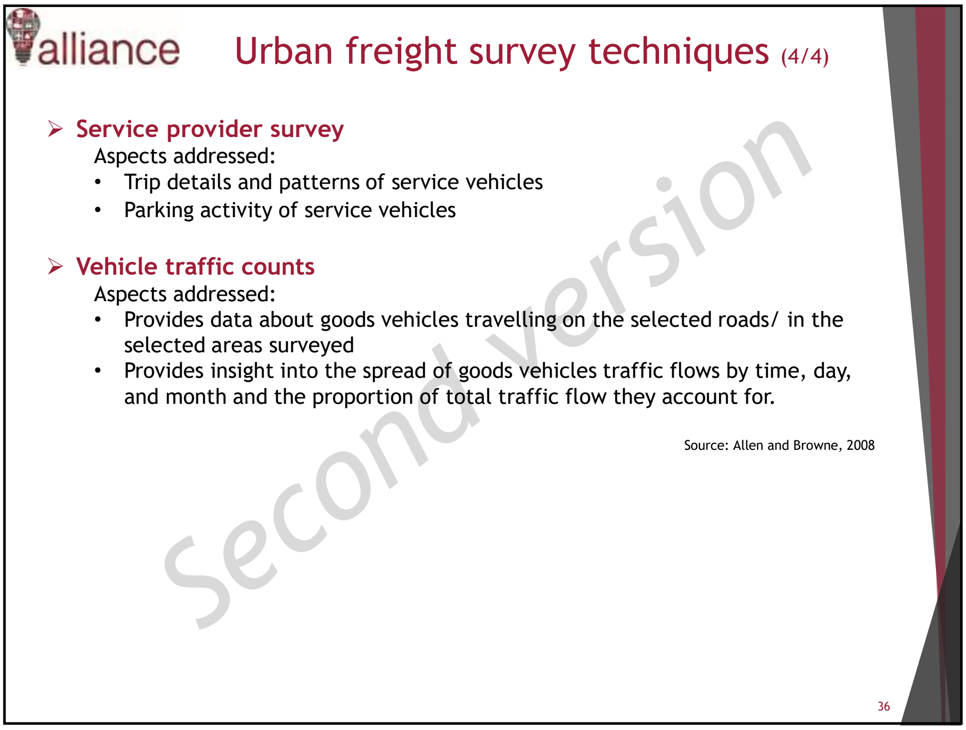
Urban freight survey techniques (3/4)

- **Vehicle trip diaries**
  Aspects addressed:
  - Trip details and patterns of goods vehicles
  - Trip details and patterns of service vehicles
  - Loading/unloading activity of goods vehicles
  - Parking activity of service vehicles
  - Movement of goods between vehicles and establishments

- **GPS survey**
  Aspects addressed:
  - Trip details and patterns of goods vehicles
  - Trip details and patterns of service vehicles
  - Loading/unloading activity of goods vehicles
  - Parking activity of service vehicles

- **Suppliers survey**
  Aspects addressed:
  - Goods flows to/from establishments
  - Trip details and patterns of goods vehicles
  - Loading/unloading activity of goods vehicles
  - Movement of goods between vehicles and establishments
  - Origin location of goods flow/vehicle trip to establishment
  - Transport-related data above usually only available

Source: Allen and Browne, 2008



Urban freight survey techniques (4/4)

- **Service provider survey**
  Aspects addressed:
  - Trip details and patterns of service vehicles
  - Parking activity of service vehicles

- **Vehicle traffic counts**
  Aspects addressed:
  - Provides data about goods vehicles travelling on the selected roads/ in the selected areas surveyed
  - Provides insight into the spread of goods vehicles traffic flows by time, day, and month and the proportion of total traffic flow they account for.

Source: Allen and Browne, 2008

Guidance to further knowledge acquisition

Suggested literature

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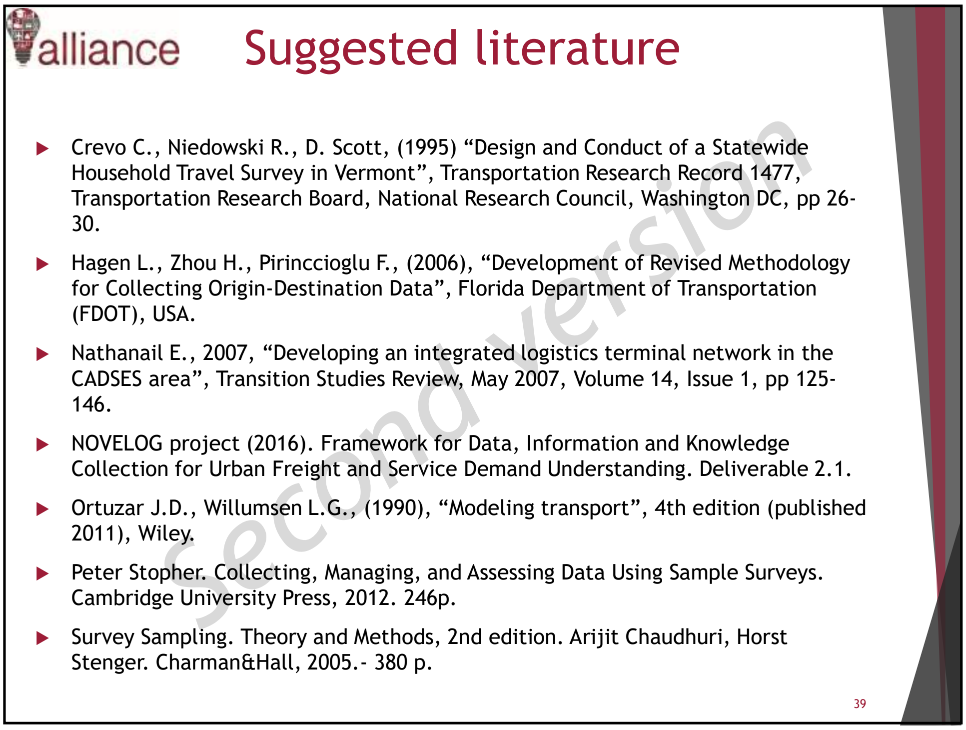

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- Crevo C., Niedowski R., D. Scott, (1995) “Design and Conduct of a Statewide Household Travel Survey in Vermont”, Transportation Research Record 1477, Transportation Research Board, National Research Council, Washington DC, pp 26-30.
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- Peter Stopher. Collecting, Managing, and Assessing Data Using Sample Surveys. Cambridge University Press, 2012. 246p.
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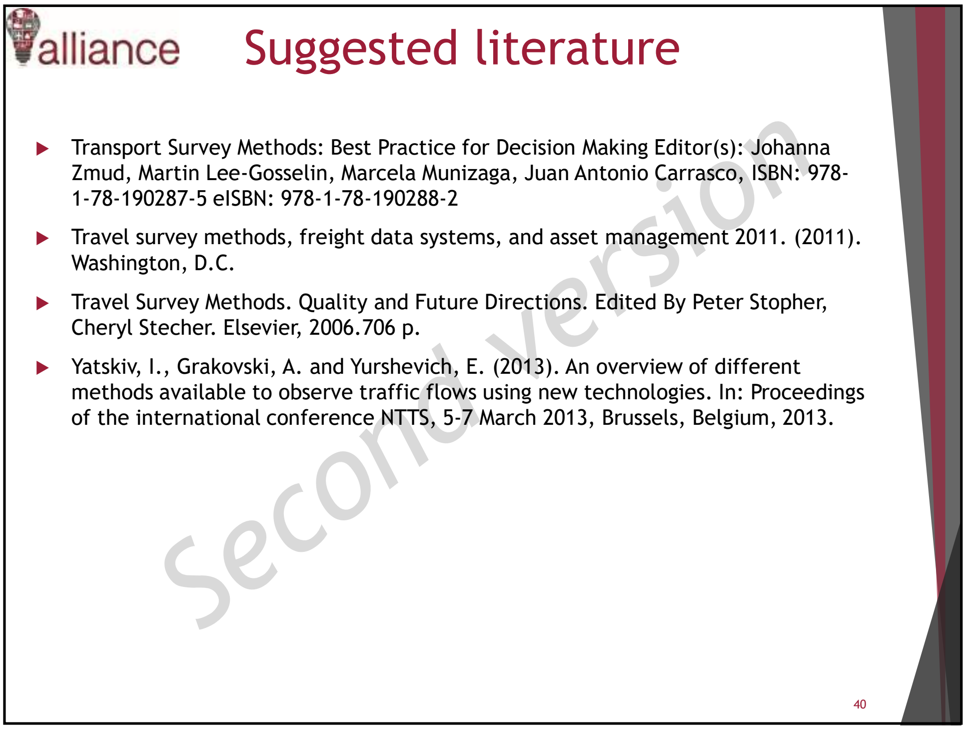

Suggested literature

- Transport Survey Methods: Best Practice for Decision Making Editor(s): Johanna Zmud, Martin Lee-Gosselin, Marcela Munizaga, Juan Antonio Carrasco, ISBN: 978-1-78-190287-5 eISBN: 978-1-78-190288-2
- Travel survey methods, freight data systems, and asset management 2011. (2011). Washington, D.C.
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Thank you for your attention!

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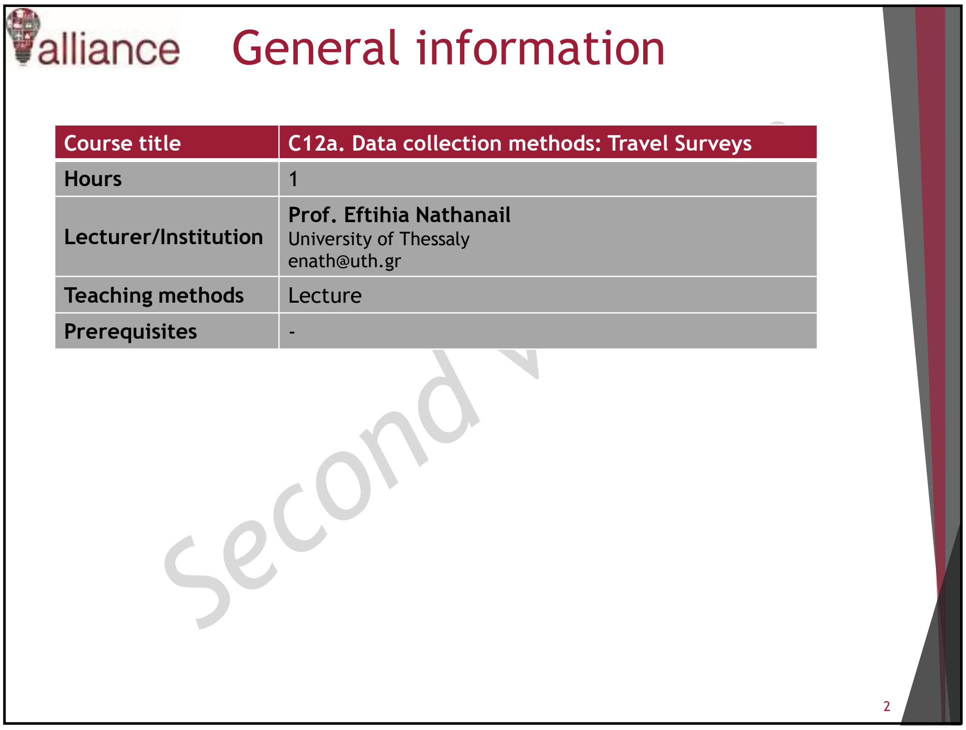
Data collection methods: Travel Surveys

Prof. Eftihia Nathanail
University of Thessaly, Greece

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



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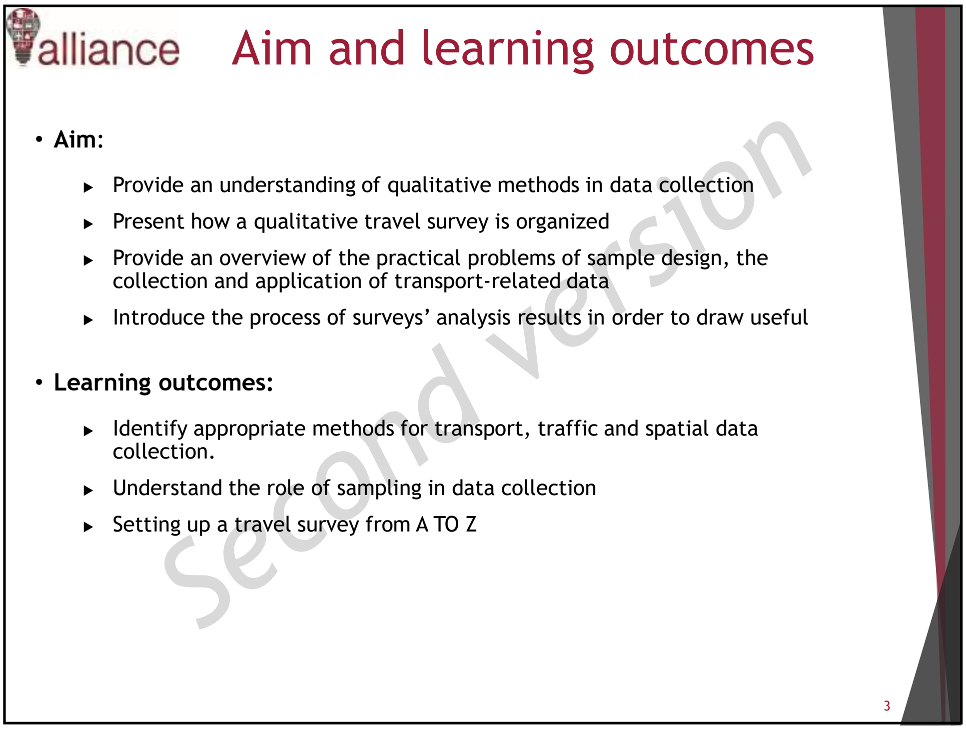
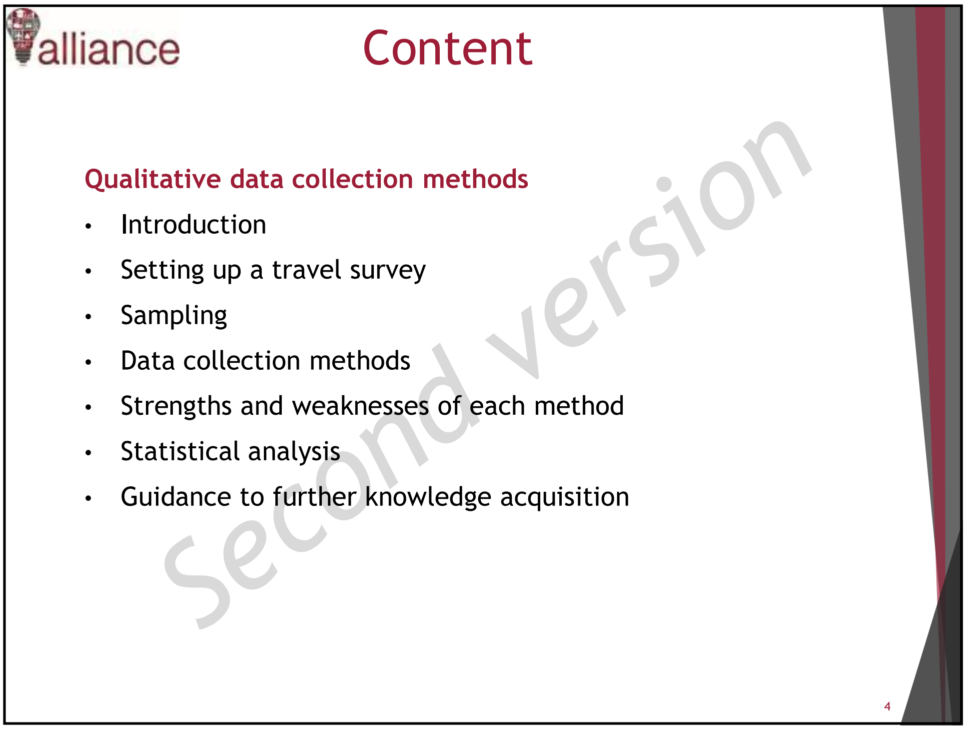
General information

Course title	C12a. Data collection methods: Travel Surveys
Hours	1
Lecturer/Institution	**Prof. Eftihia Nathanail** University of Thessaly enath@uth.gr
Teaching methods	Lecture
Prerequisites	-



Aim and learning outcomes

- **Aim**:
  - Provide an understanding of qualitative methods in data collection
  - Present how a qualitative travel survey is organized
  - Provide an overview of the practical problems of sample design, the collection and application of transport-related data
  - Introduce the process of surveys’ analysis results in order to draw useful
- **Learning outcomes:**
  - Identify appropriate methods for transport, traffic and spatial data collection.
  - Understand the role of sampling in data collection
  - Setting up a travel survey from A TO Z



Content

Qualitative data collection methods

- Introduction
- Setting up a travel survey
- Sampling
- Data collection methods
- Strengths and weaknesses of each method
- Statistical analysis
- Guidance to further knowledge acquisition

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Introduction

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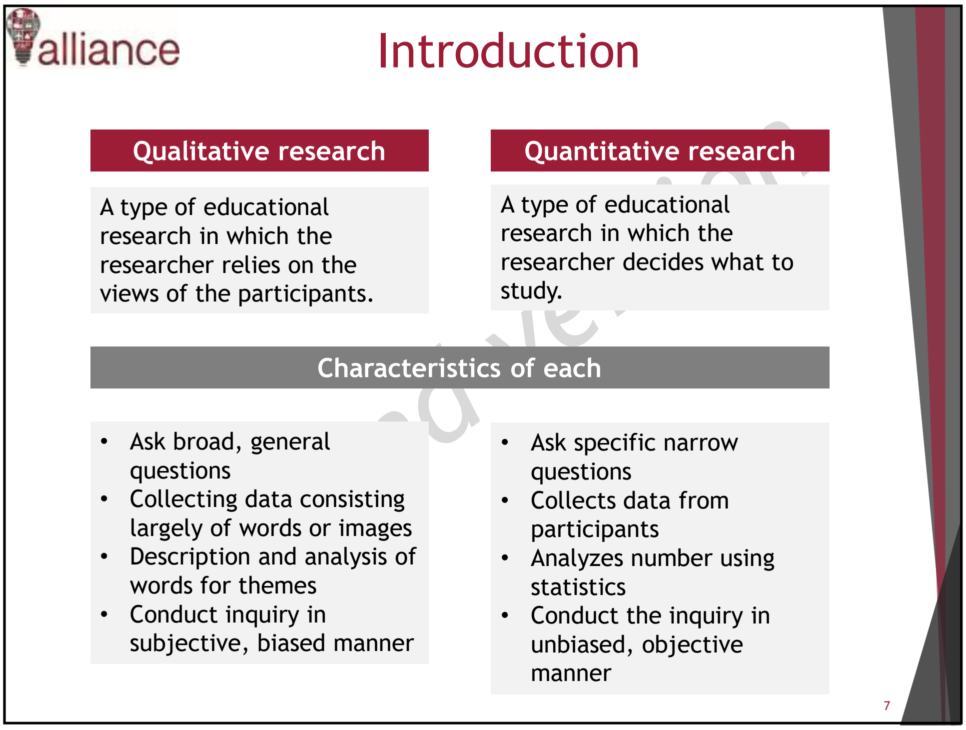
Introduction

> “Research is an art of scientific and systematic investigation to get information about a specific topic. To perform a research different approaches and methods are required which are typically categorised as either quantitative or qualitative.”

(Source: Resham Bahadur Bist, 2014)

Qualitative research

- ✓ Gathers information that are not numerical
- ✓ Uncovers the reasons for behaviors, attitudes and motivation
- ✓ Uses unstructured data collection methods (observations, interviews, surveys, documents etc.)
- ✓ Scope of implementation: Nearly all disciplines



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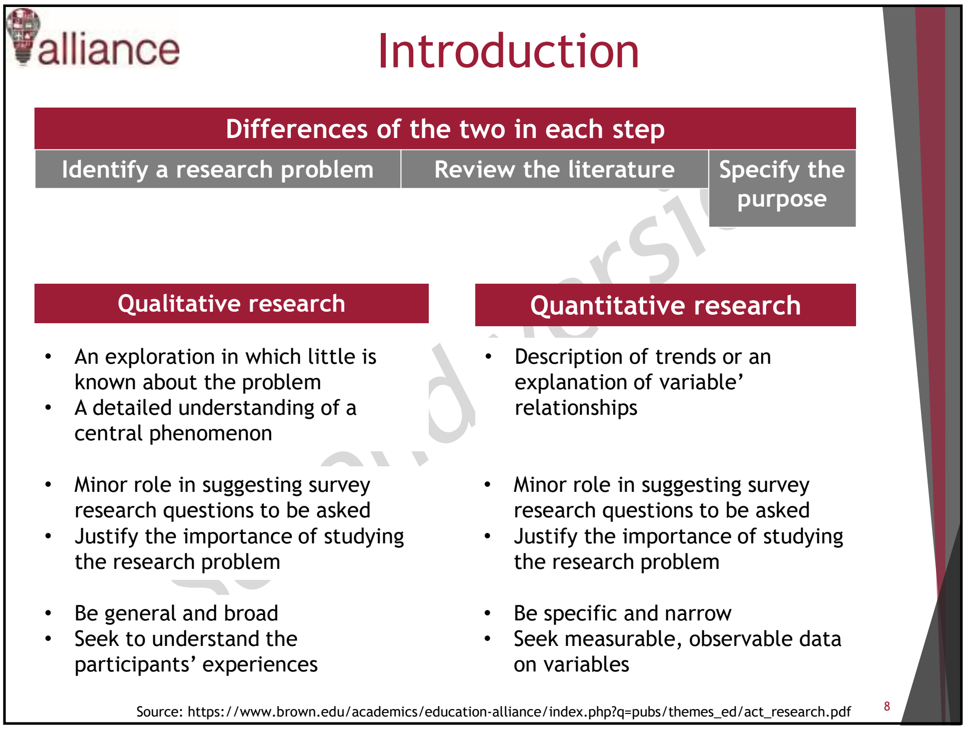
Introduction

Qualitative research	Quantitative research
A type of educational research in which the researcher relies on the views of the participants.	A type of educational research in which the researcher decides what to study.

Characteristics of each

• Ask broad, general questions • Collecting data consisting largely of words or images • Description and analysis of words for themes • Conduct inquiry in subjective, biased manner	• Ask specific narrow questions • Collects data from participants • Analyzes number using statistics • Conduct the inquiry in unbiased, objective manner



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Introduction

Differences of the two in each step

Identify a research problem | Review the literature | Specify the purpose

Qualitative research

- An exploration in which little is known about the problem
- A detailed understanding of a central phenomenon

- Minor role in suggesting survey research questions to be asked
- Justify the importance of studying the research problem

- Be general and broad
- Seek to understand the participants' experiences

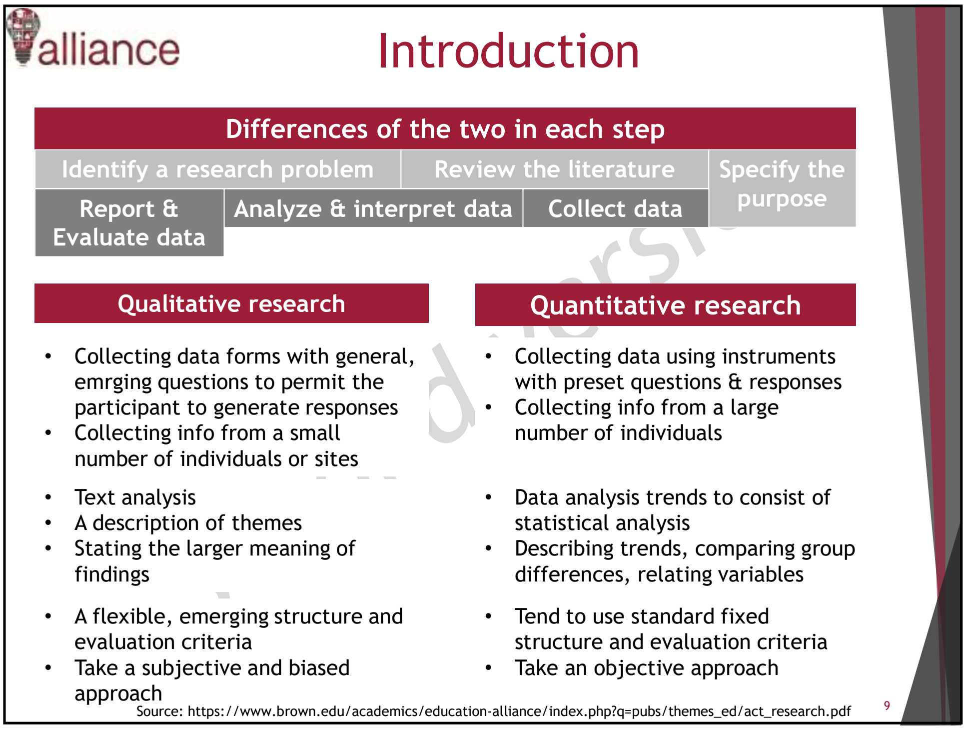
Quantitative research

- Description of trends or an explanation of variable' relationships

- Minor role in suggesting survey research questions to be asked
- Justify the importance of studying the research problem

- Be specific and narrow
- Seek measurable, observable data on variables

Source: https://www.brown.edu/academics/education-alliance/index.php?q=pubs/themes_ed/act_research.pdf



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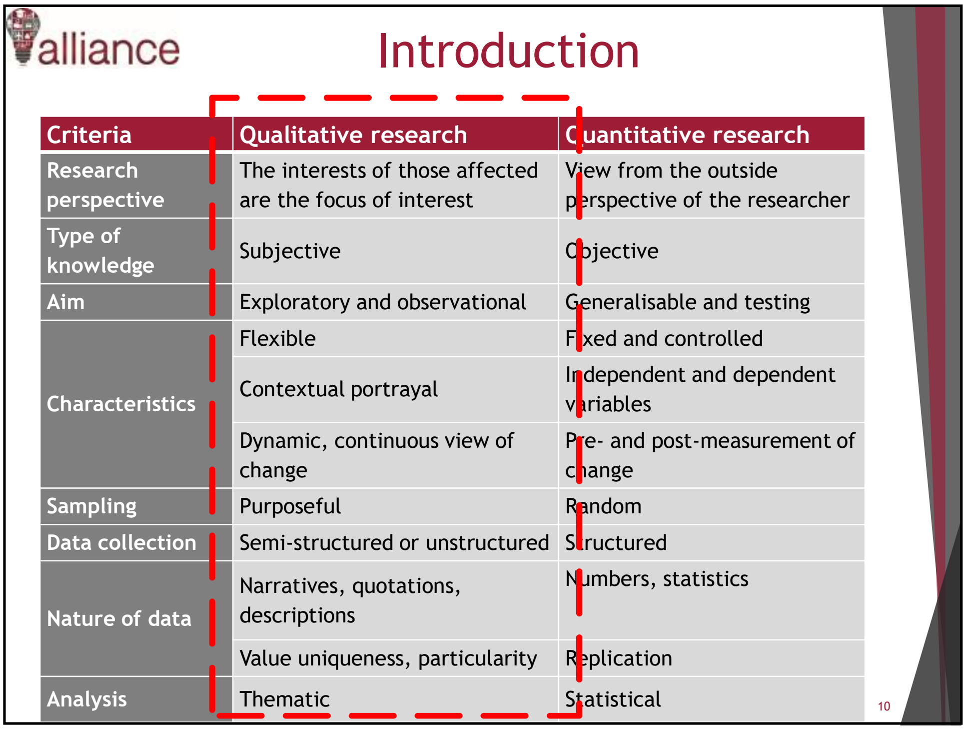
Introduction

Differences of the two in each step

Identify a research problem → Review the literature → Specify the purpose → Collect data → Analyze & interpret data → Report & Evaluate data

Qualitative research	Quantitative research
Collecting data forms with general, emrging questions to permit the participant to generate responses Collecting info from a small number of individuals or sites	Collecting data using instruments with preset questions & responses Collecting info from a large number of individuals
Text analysis A description of themes Stating the larger meaning of findings	Data analysis trends to consist of statistical analysis Describing trends, comparing group differences, relating variables
A flexible, emerging structure and evaluation criteria Take a subjective and biased approach	Tend to use standard fixed structure and evaluation criteria Take an objective approach

Source: https://www.brown.edu/academics/education-alliance/index.php?q=pubs/themes_ed/act_research.pdf



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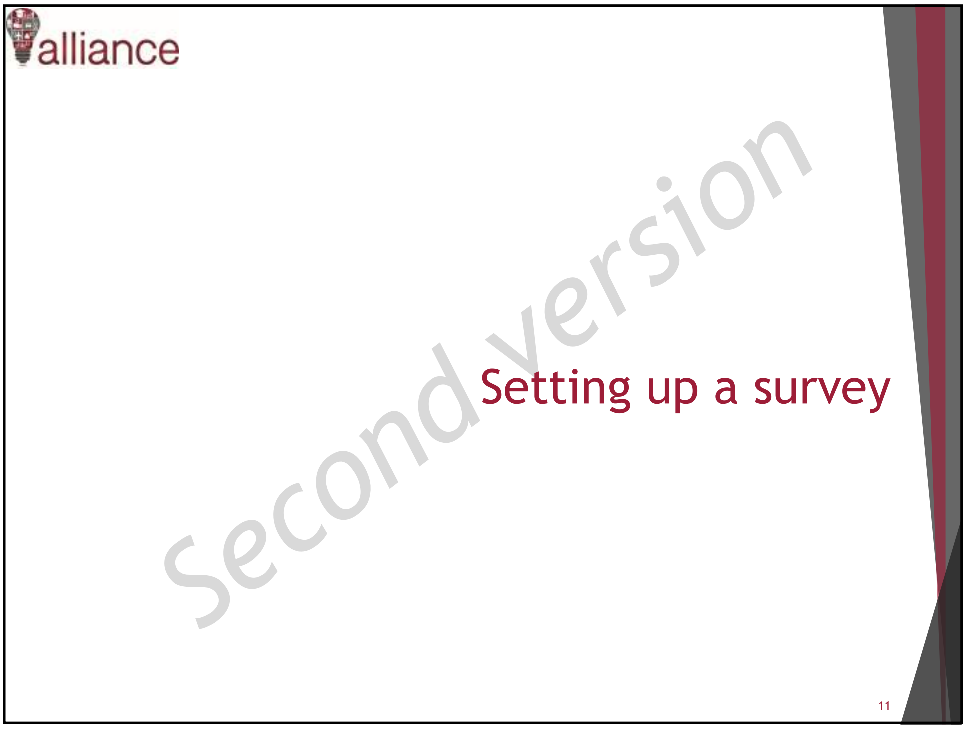
Introduction

Criteria	Qualitative research	Quantitative research
Research perspective	The interests of those affected are the focus of interest	View from the outside perspective of the researcher
Type of knowledge	Subjective	Objective
Aim	Exploratory and observational	Generalisable and testing
Characteristics	Flexible	Fixed and controlled
	Contextual portrayal	Independent and dependent variables
	Dynamic, continuous view of change	Pre- and post-measurement of change
Sampling	Purposeful	Random
Data collection	Semi-structured or unstructured	Structured
Nature of data	Narratives, quotations, descriptions	Numbers, statistics
	Value uniqueness, particularity	Replication
Analysis	Thematic	Statistical



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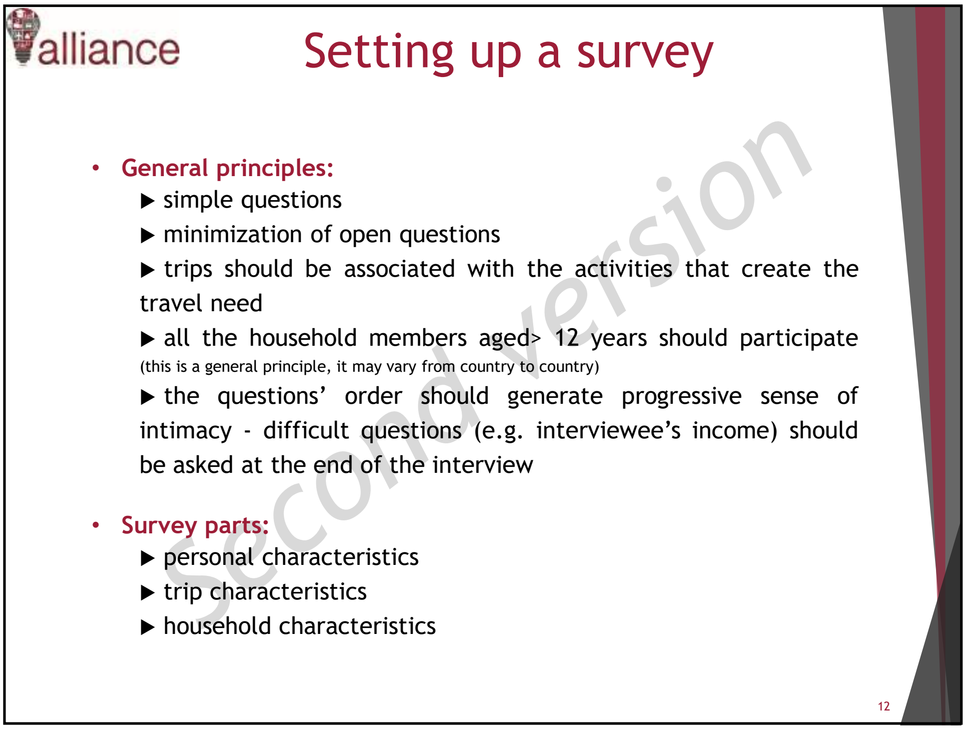
Setting up a survey



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Setting up a survey

- **General principles:**
  - ▶ simple questions
  - ▶ minimization of open questions
  - ▶ trips should be associated with the activities that create the travel need
  - ▶ all the household members aged> 12 years should participate (this is a general principle, it may vary from country to country)
  - ▶ the questions' order should generate progressive sense of intimacy - difficult questions (e.g. interviewee's income) should be asked at the end of the interview
- **Survey parts:**
  - ▶ personal characteristics
  - ▶ trip characteristics
  - ▶ household characteristics

Setting up a survey

- **Personal characteristics:**
  - gender - age
  - possession of a driving license
  - education - employment
  - participation in activities
- **Trip characteristics**
  - origin - destination
  - trip purpose
  - departure time and arrival time
  - mean of transport
  - distance traveled on foot (including transit)
  - public transport line, waiting time and transit time, boarding/ alighting station

Setting up a survey

- **Household characteristics:**
  - socioeconomic characteristics
  - income
  - possession of private car
  - property and characteristics oh the house

!Date of survey: It depends on the purpose of the research, usually refers to the data collection of the commuters behavior during a typical weekday.

!Day of survey: excluded days Monday and Friday, preferred days Wednesday and Thursday.

!Period (duration) of the survey: given the large number of interviews required, the survey is usually conducted over several days by a relatively small group of specialized researchers that can be easily trained and inspected.

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Types of travel survey

Type of survey	Subject of survey	Data that can be obtained by survey	Sample units	Sampling approach	Survey instrument	Survey method
Transport System inventory survey	Infrastructure of UPTS	Characteristics of UPTS infrastructure: modes of transport, network length, the number of routes and stops, schedules, etc.	Public transport operators	All UPTS operators, random, multistage, systematic sampling	Questionnaire	Documentary Searches, PAPI, face to face CATI, CAPI
Transport System Performance survey	Performance of UPTS	Characteristics of UPTS performance: travel time, waiting time, vehicle load, system safety, delays, etc.	Public transport operators, Routes, Trips	All UPTS operators; for routes and trips: random, multistage, systematic sampling	AVL, APC, Questionnaire	By observers un PAPI, video
Travel survey	Trip	Trip characteristics: departure and destination points, travel time, modes, goal of trip, route, etc.; traveller's characteristics	Individuals/households	random, stratified sampling, multistage sampling, systematic, cluster sampling	Travel diary, GPS	face to face, PAPI, CATI, CAPI, CAWI, GPS trackers
Customer satisfaction survey	Level of satisfaction of UPTS services	General satisfaction in UPTS service - global satisfaction; level of satisfaction with the individual components of UPTS services - accessibility, comfort, travel time, etc. - specific satisfactions; significance of UPTS quality characteristics for users	individuals/ households	Random, stratified sampling, multistage sampling, systematic, cluster sampling	Questionnaire	face to face, PAPI, CATI, CAPI, CAWI

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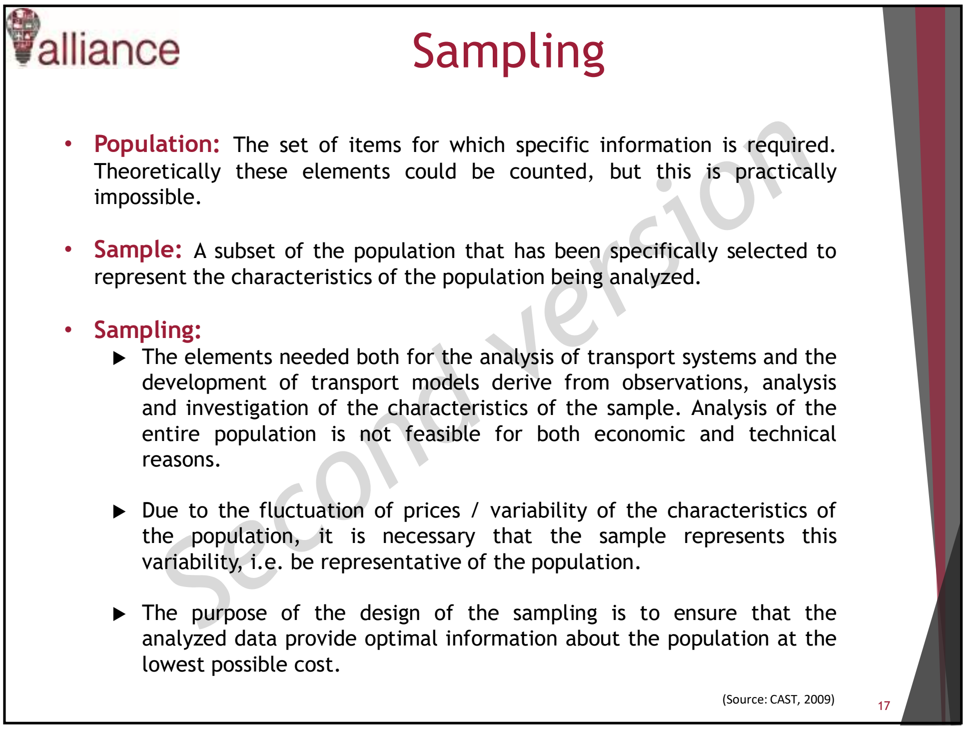
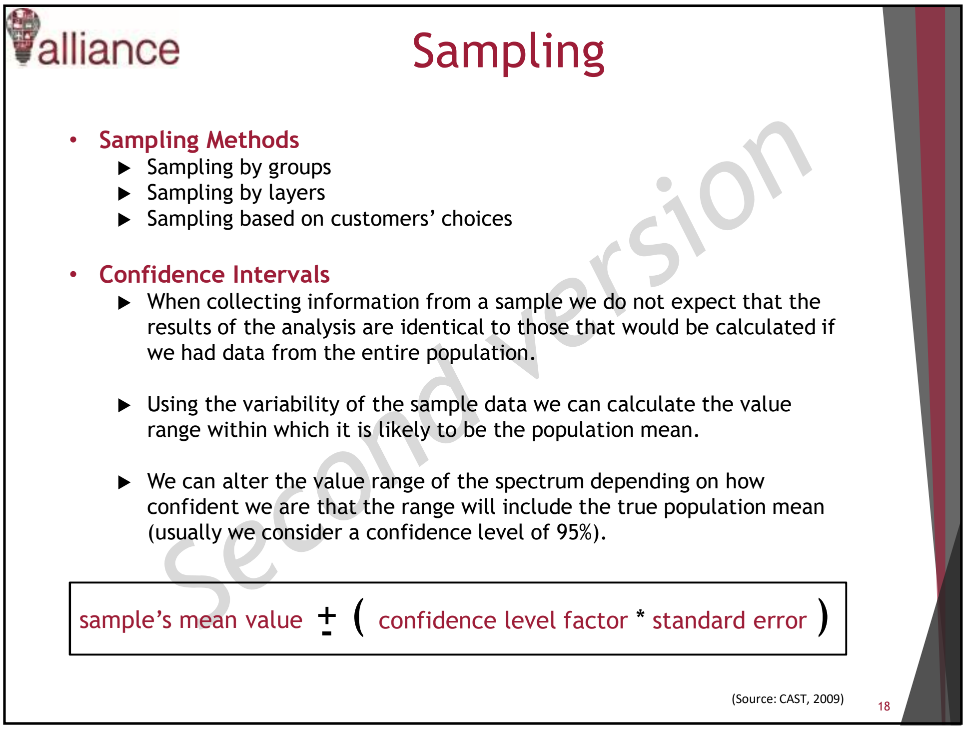
Sampling



Sampling

- **Population:** The set of items for which specific information is required. Theoretically these elements could be counted, but this is practically impossible.
- **Sample:** A subset of the population that has been specifically selected to represent the characteristics of the population being analyzed.
- **Sampling:**
  - ▶ The elements needed both for the analysis of transport systems and the development of transport models derive from observations, analysis and investigation of the characteristics of the sample. Analysis of the entire population is not feasible for both economic and technical reasons.
  - ▶ Due to the fluctuation of prices / variability of the characteristics of the population, it is necessary that the sample represents this variability, i.e. be representative of the population.
  - ▶ The purpose of the design of the sampling is to ensure that the analyzed data provide optimal information about the population at the lowest possible cost.

(Source: CAST, 2009)

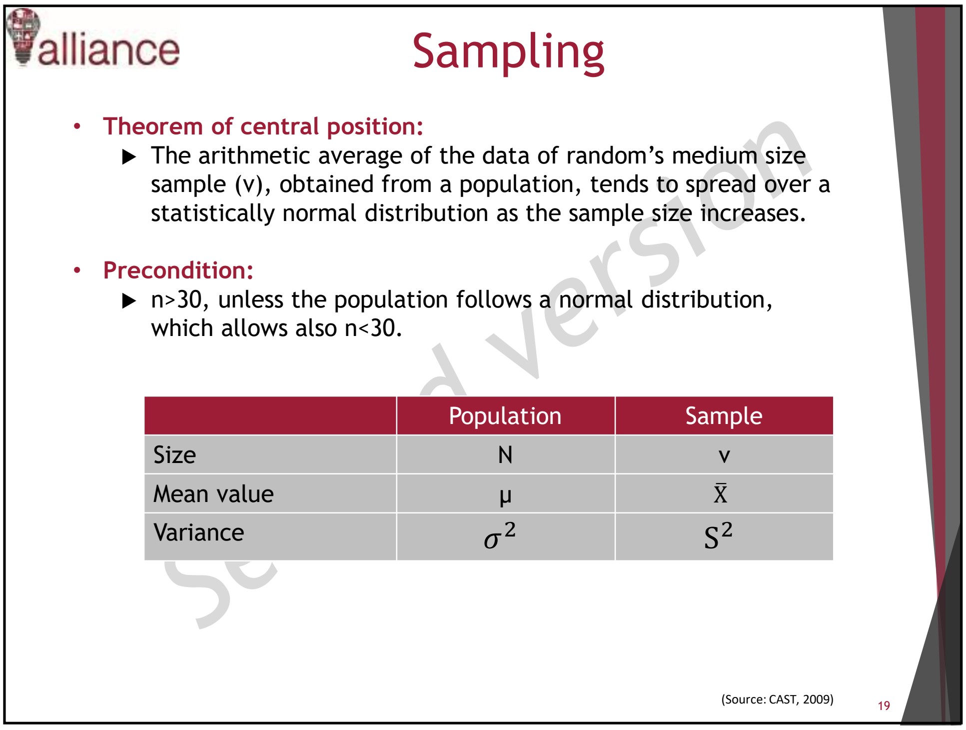


Sampling

- **Sampling Methods**
  - ▶ Sampling by groups
  - ▶ Sampling by layers
  - ▶ Sampling based on customers' choices
- **Confidence Intervals**
  - ▶ When collecting information from a sample we do not expect that the results of the analysis are identical to those that would be calculated if we had data from the entire population.
  - ▶ Using the variability of the sample data we can calculate the value range within which it is likely to be the population mean.
  - ▶ We can alter the value range of the spectrum depending on how confident we are that the range will include the true population mean (usually we consider a confidence level of 95%).

sample's mean value ± (confidence level factor * standard error)

(Source: CAST, 2009)



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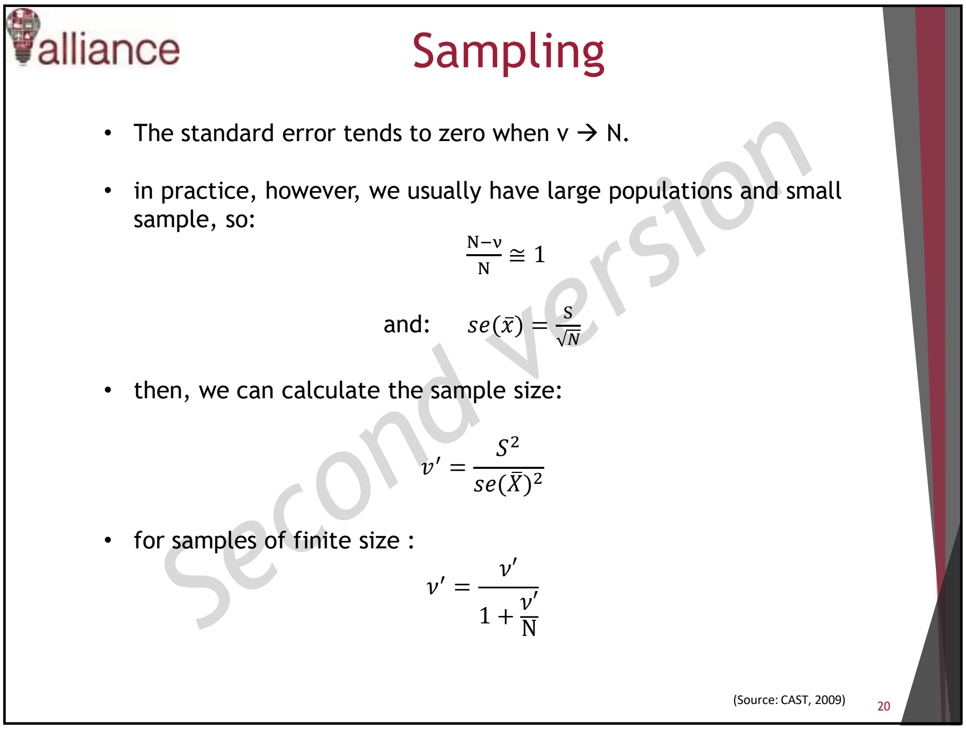
Sampling

- **Theorem of central position:**
  - ▶ The arithmetic average of the data of random's medium size sample (v), obtained from a population, tends to spread over a statistically normal distribution as the sample size increases.
- **Precondition:**
  - ▶ n>30, unless the population follows a normal distribution, which allows also n<30.

	Population	Sample
Size	N	v
Mean value	μ	$\bar{X}$
Variance	σ^2	S^2

(Source: CAST, 2009)



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Sampling

- The standard error tends to zero when v → N.
- in practice, however, we usually have large populations and small sample, so:

$$\frac{\mathrm{N}-\nu}{\mathrm{N}} \cong 1$$

and: $$se(\bar{x}) = \frac{S}{\sqrt{N}}$$

- then, we can calculate the sample size:

$$v' = \frac{S^2}{se(\bar{X})^2}$$

- for samples of finite size :

$$v' = \frac{v'}{1+\frac{v'}{\mathrm{N}}}$$

(Source: CAST, 2009)

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Data collection methods & techniques

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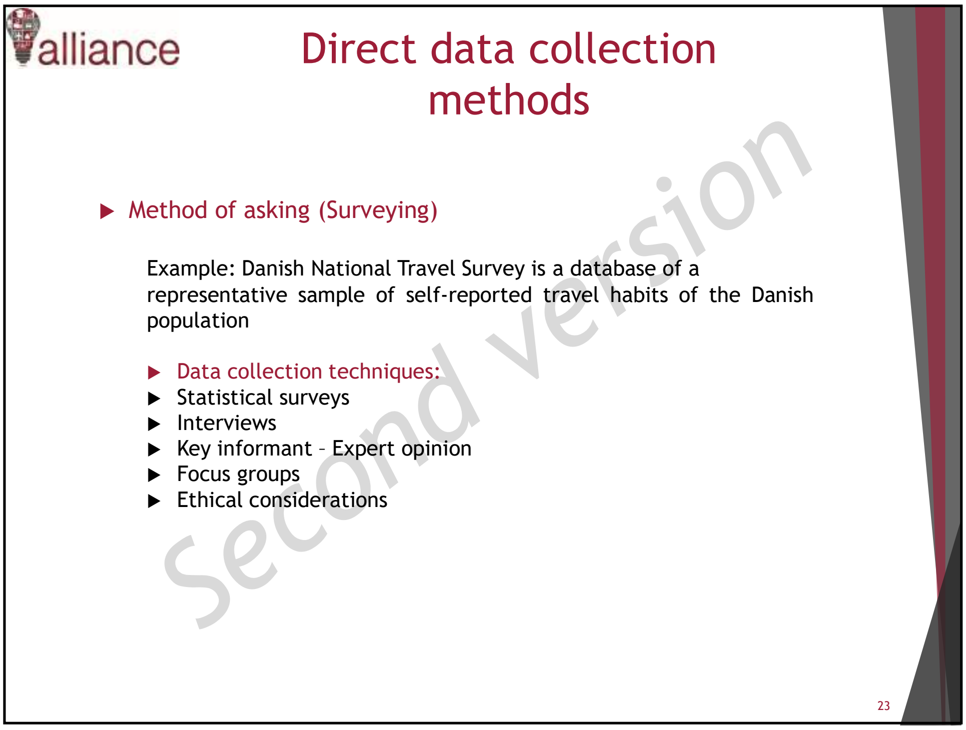
Data collection methods

Data collection method is the general orientation towards data collection. The chosen collection procedure depends on its strengths and weaknesses, costs, data availability, and convenience.

Data collection technique is more concrete than data collection method and specifically refers to the actual means / instruments / procedures for data collection

Data collection methods:

- Direct (obtrusive data collection)
  - subjects are aware of the fact that they are being studied
- Indirect (unobtrusive data collection)
  - subjects are not aware of the fact that they are being studied

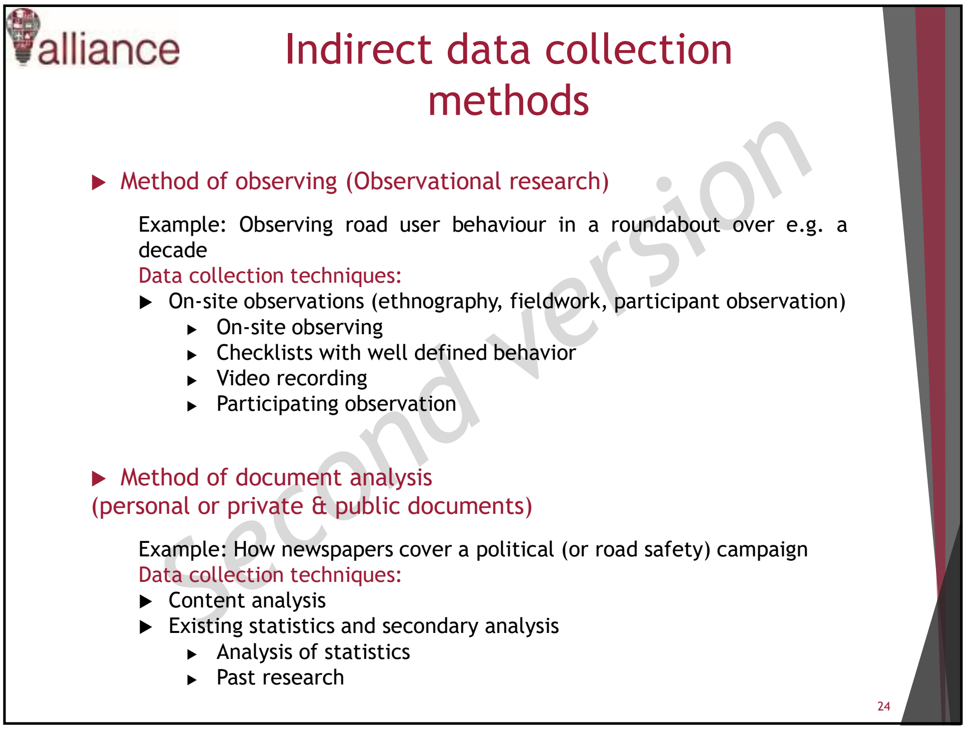


Direct data collection methods

- Method of asking (Surveying)

Example: Danish National Travel Survey is a database of a representative sample of self-reported travel habits of the Danish population

- Data collection techniques:
- Statistical surveys
- Interviews
- Key informant – Expert opinion
- Focus groups
- Ethical considerations



Indirect data collection methods

- Method of observing (Observational research)

Example: Observing road user behaviour in a roundabout over e.g. a decade

Data collection techniques:

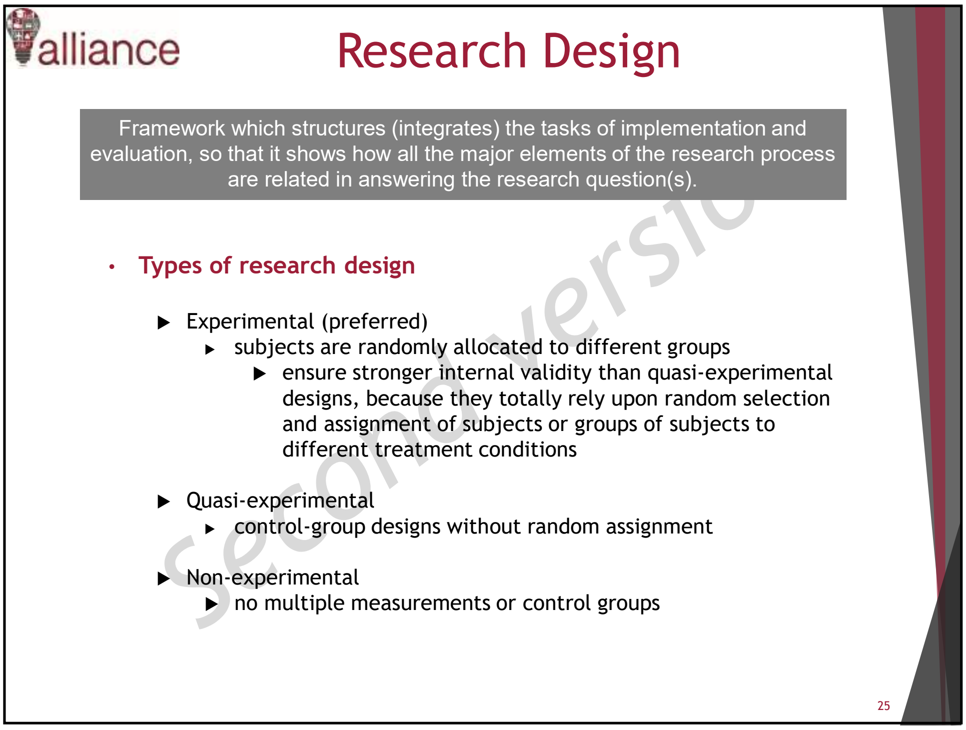
- On-site observations (ethnography, fieldwork, participant observation)
  - On-site observing
  - Checklists with well defined behavior
  - Video recording
  - Participating observation

- Method of document analysis
(personal or private & public documents)

Example: How newspapers cover a political (or road safety) campaign

Data collection techniques:

- Content analysis
- Existing statistics and secondary analysis
  - Analysis of statistics
  - Past research

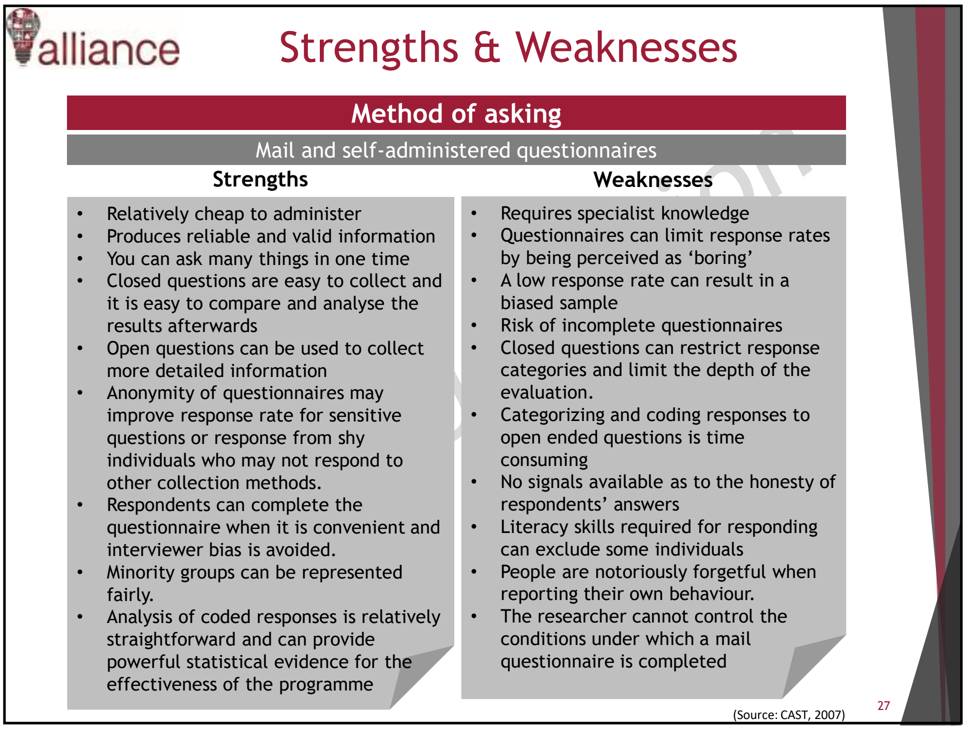


Research Design

Framework which structures (integrates) the tasks of implementation and evaluation, so that it shows how all the major elements of the research process are related in answering the research question(s).

- **Types of research design**
  - Experimental (preferred)
    - subjects are randomly allocated to different groups
      - ensure stronger internal validity than quasi-experimental designs, because they totally rely upon random selection and assignment of subjects or groups of subjects to different treatment conditions
  - Quasi-experimental
    - control-group designs without random assignment
  - Non-experimental
    - no multiple measurements or control groups

Strengths and weaknesses of each method



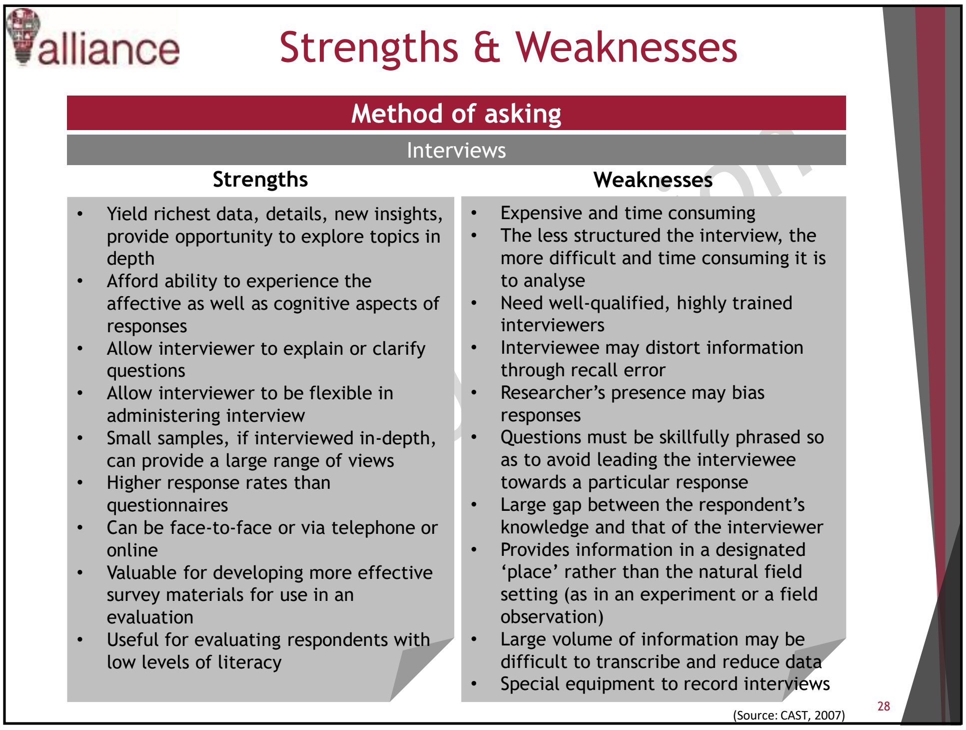
Strengths & Weaknesses

Method of asking

Mail and self-administered questionnaires

Strengths	Weaknesses
• Relatively cheap to administer • Produces reliable and valid information • You can ask many things in one time • Closed questions are easy to collect and it is easy to compare and analyse the results afterwards • Open questions can be used to collect more detailed information • Anonymity of questionnaires may improve response rate for sensitive questions or response from shy individuals who may not respond to other collection methods. • Respondents can complete the questionnaire when it is convenient and interviewer bias is avoided. • Minority groups can be represented fairly. • Analysis of coded responses is relatively straightforward and can provide powerful statistical evidence for the effectiveness of the programme	• Requires specialist knowledge • Questionnaires can limit response rates by being perceived as ‘boring’ • A low response rate can result in a biased sample • Risk of incomplete questionnaires • Closed questions can restrict response categories and limit the depth of the evaluation. • Categorizing and coding responses to open ended questions is time consuming • No signals available as to the honesty of respondents’ answers • Literacy skills required for responding can exclude some individuals • People are notoriously forgetful when reporting their own behaviour. • The researcher cannot control the conditions under which a mail questionnaire is completed

(Source: CAST, 2007)



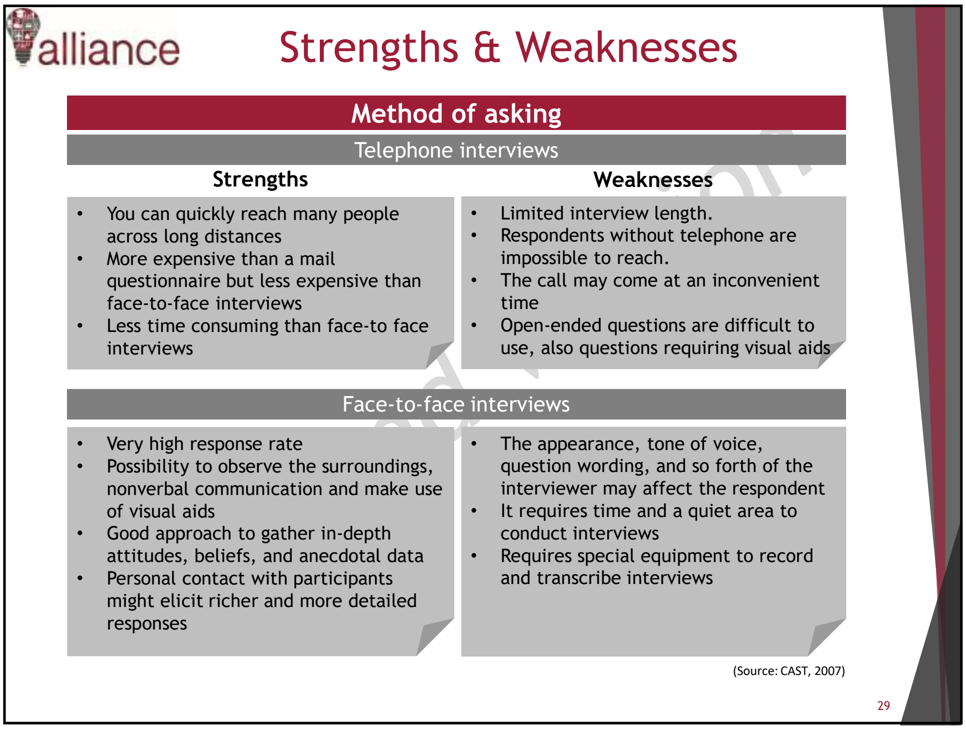
Strengths & Weaknesses

Method of asking

Interviews

Strengths	Weaknesses
• Yield richest data, details, new insights, provide opportunity to explore topics in depth • Afford ability to experience the affective as well as cognitive aspects of responses • Allow interviewer to explain or clarify questions • Allow interviewer to be flexible in administering interview • Small samples, if interviewed in-depth, can provide a large range of views • Higher response rates than questionnaires • Can be face-to-face or via telephone or online • Valuable for developing more effective survey materials for use in an evaluation • Useful for evaluating respondents with low levels of literacy	• Expensive and time consuming • The less structured the interview, the more difficult and time consuming it is to analyse • Need well-qualified, highly trained interviewers • Interviewee may distort information through recall error • Researcher’s presence may bias responses • Questions must be skillfully phrased so as to avoid leading the interviewee towards a particular response • Large gap between the respondent’s knowledge and that of the interviewer • Provides information in a designated ‘place’ rather than the natural field setting (as in an experiment or a field observation) • Large volume of information may be difficult to transcribe and reduce data • Special equipment to record interviews

(Source: CAST, 2007)



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Strengths & Weaknesses

Method of asking

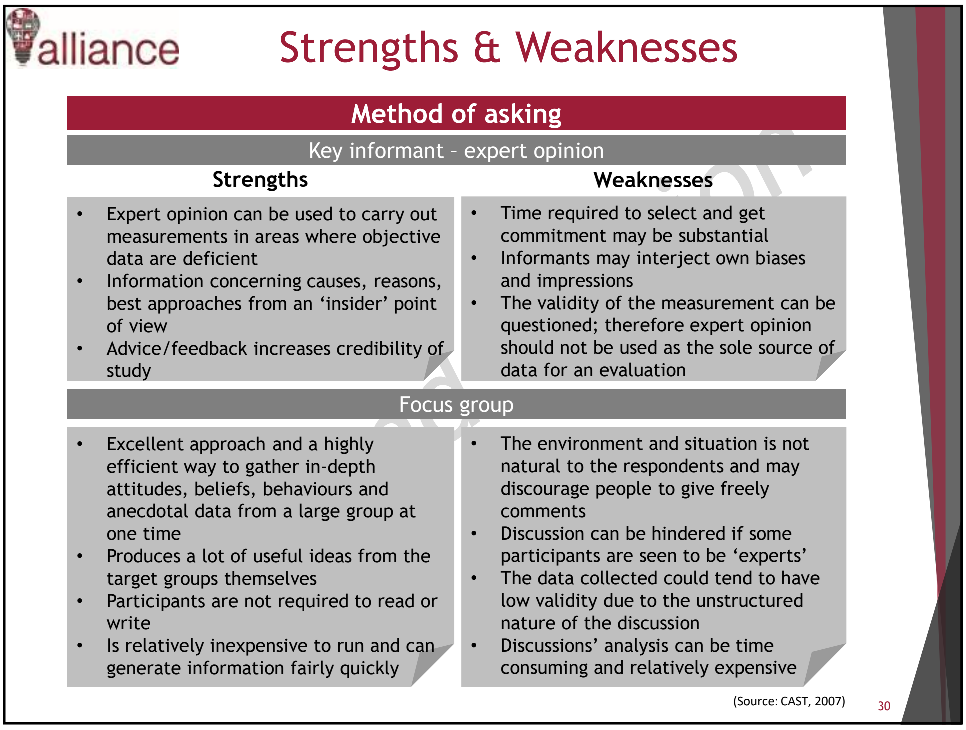
Telephone interviews

Strengths	Weaknesses
• You can quickly reach many people across long distances • More expensive than a mail questionnaire but less expensive than face-to-face interviews • Less time consuming than face-to face interviews	• Limited interview length. • Respondents without telephone are impossible to reach. • The call may come at an inconvenient time • Open-ended questions are difficult to use, also questions requiring visual aids

Face-to-face interviews

Strengths	Weaknesses
• Very high response rate • Possibility to observe the surroundings, nonverbal communication and make use of visual aids • Good approach to gather in-depth attitudes, beliefs, and anecdotal data • Personal contact with participants might elicit richer and more detailed responses	• The appearance, tone of voice, question wording, and so forth of the interviewer may affect the respondent • It requires time and a quiet area to conduct interviews • Requires special equipment to record and transcribe interviews

(Source: CAST, 2007)



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Strengths & Weaknesses

Method of asking

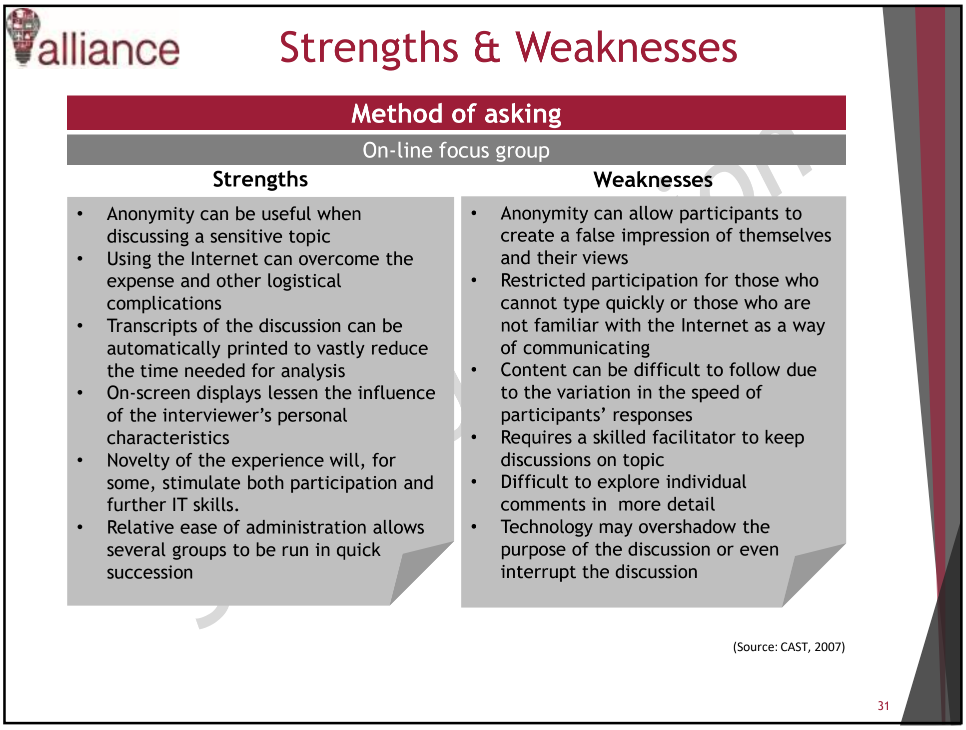
Key informant - expert opinion

Strengths	Weaknesses
• Expert opinion can be used to carry out measurements in areas where objective data are deficient • Information concerning causes, reasons, best approaches from an ‘insider’ point of view • Advice/feedback increases credibility of study	• Time required to select and get commitment may be substantial • Informants may interject own biases and impressions • The validity of the measurement can be questioned; therefore expert opinion should not be used as the sole source of data for an evaluation

Focus group

Strengths	Weaknesses
• Excellent approach and a highly efficient way to gather in-depth attitudes, beliefs, behaviours and anecdotal data from a large group at one time • Produces a lot of useful ideas from the target groups themselves • Participants are not required to read or write • Is relatively inexpensive to run and can generate information fairly quickly	• The environment and situation is not natural to the respondents and may discourage people to give freely comments • Discussion can be hindered if some participants are seen to be ‘experts’ • The data collected could tend to have low validity due to the unstructured nature of the discussion • Discussions’ analysis can be time consuming and relatively expensive

(Source: CAST, 2007)



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Strengths & Weaknesses

Method of asking

On-line focus group

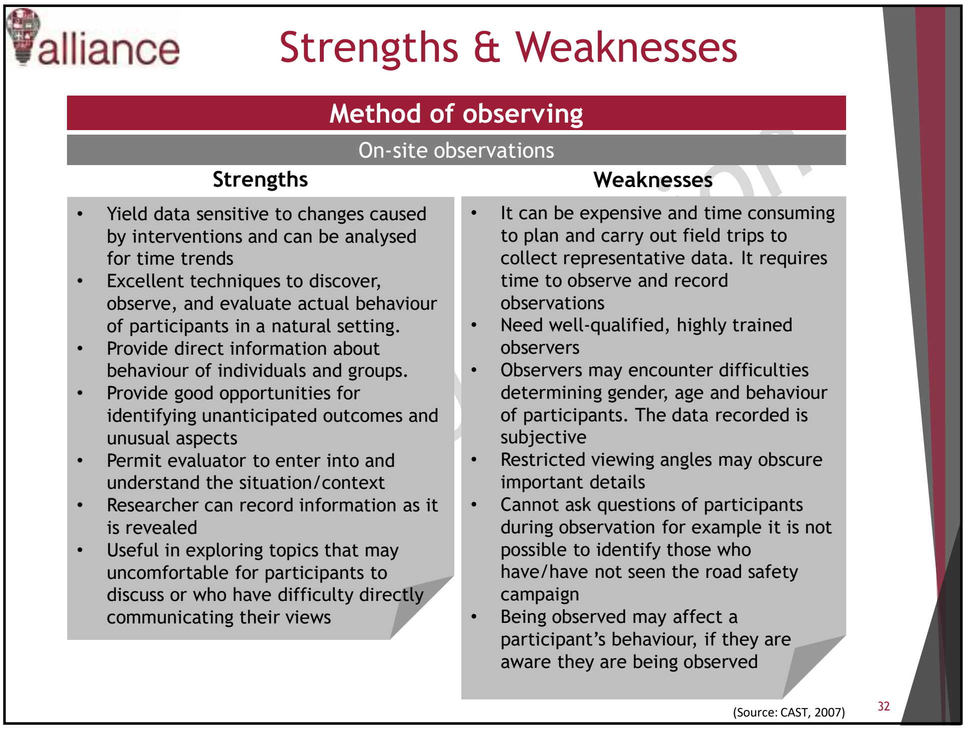
Strengths

- Anonymity can be useful when discussing a sensitive topic
- Using the Internet can overcome the expense and other logistical complications
- Transcripts of the discussion can be automatically printed to vastly reduce the time needed for analysis
- On-screen displays lessen the influence of the interviewer's personal characteristics
- Novelty of the experience will, for some, stimulate both participation and further IT skills.
- Relative ease of administration allows several groups to be run in quick succession

Weaknesses

- Anonymity can allow participants to create a false impression of themselves and their views
- Restricted participation for those who cannot type quickly or those who are not familiar with the Internet as a way of communicating
- Content can be difficult to follow due to the variation in the speed of participants' responses
- Requires a skilled facilitator to keep discussions on topic
- Difficult to explore individual comments in more detail
- Technology may overshadow the purpose of the discussion or even interrupt the discussion

(Source: CAST, 2007)



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Strengths & Weaknesses

Method of observing

On-site observations

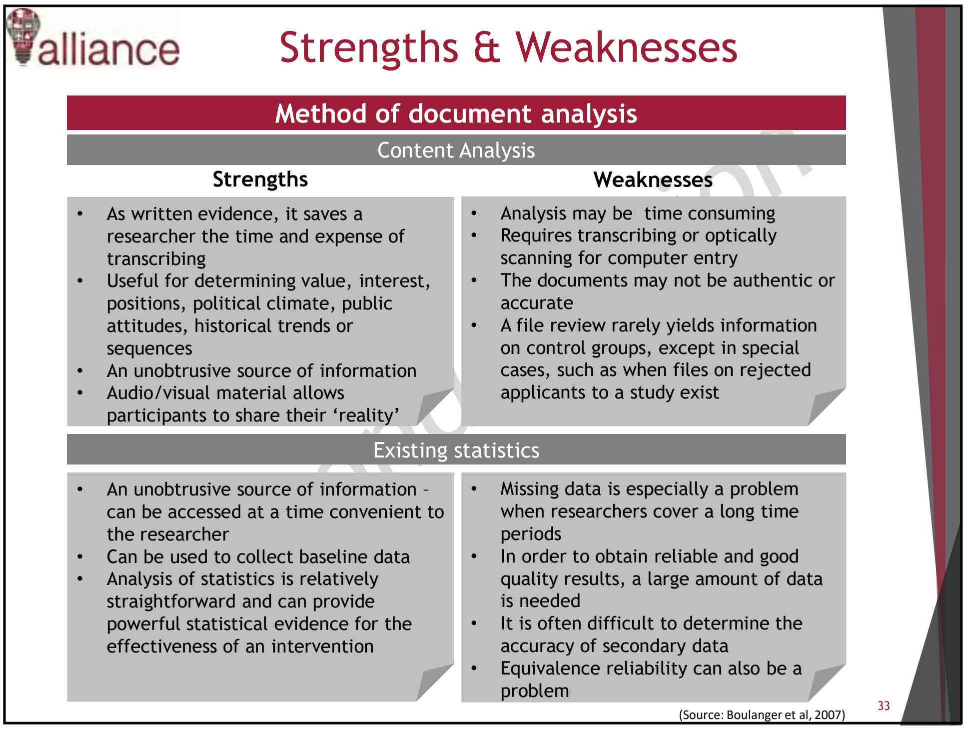
Strengths

- Yield data sensitive to changes caused by interventions and can be analysed for time trends
- Excellent techniques to discover, observe, and evaluate actual behaviour of participants in a natural setting.
- Provide direct information about behaviour of individuals and groups.
- Provide good opportunities for identifying unanticipated outcomes and unusual aspects
- Permit evaluator to enter into and understand the situation/context
- Researcher can record information as it is revealed
- Useful in exploring topics that may uncomfortable for participants to discuss or who have difficulty directly communicating their views

Weaknesses

- It can be expensive and time consuming to plan and carry out field trips to collect representative data. It requires time to observe and record observations
- Need well-qualified, highly trained observers
- Observers may encounter difficulties determining gender, age and behaviour of participants. The data recorded is subjective
- Restricted viewing angles may obscure important details
- Cannot ask questions of participants during observation for example it is not possible to identify those who have/have not seen the road safety campaign
- Being observed may affect a participant's behaviour, if they are aware they are being observed

(Source: CAST, 2007)

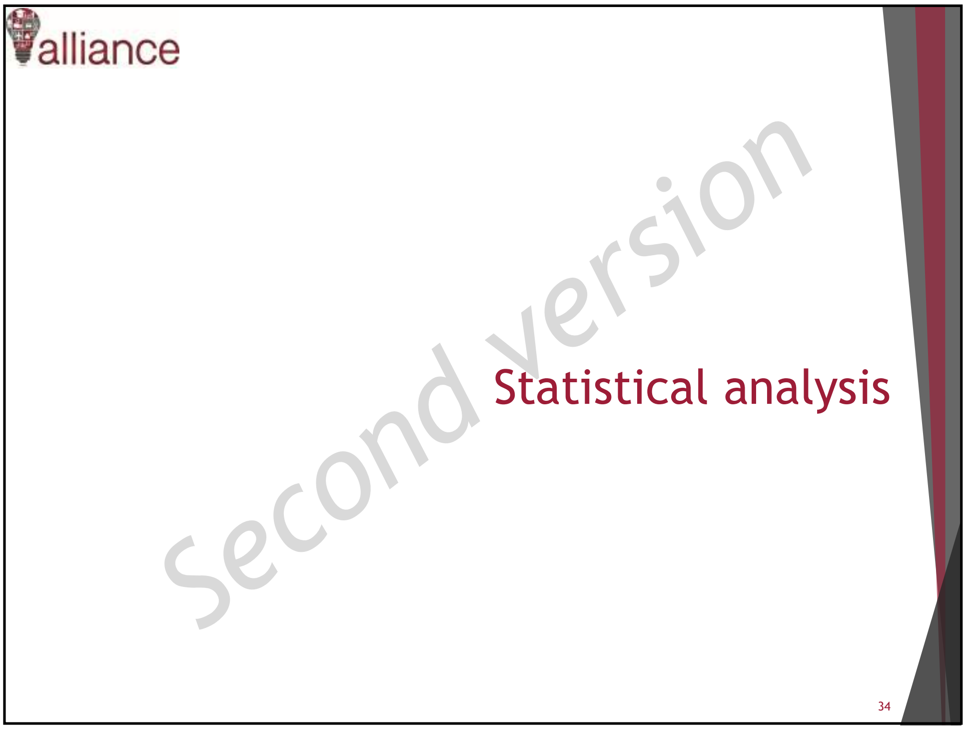


Strengths & Weaknesses

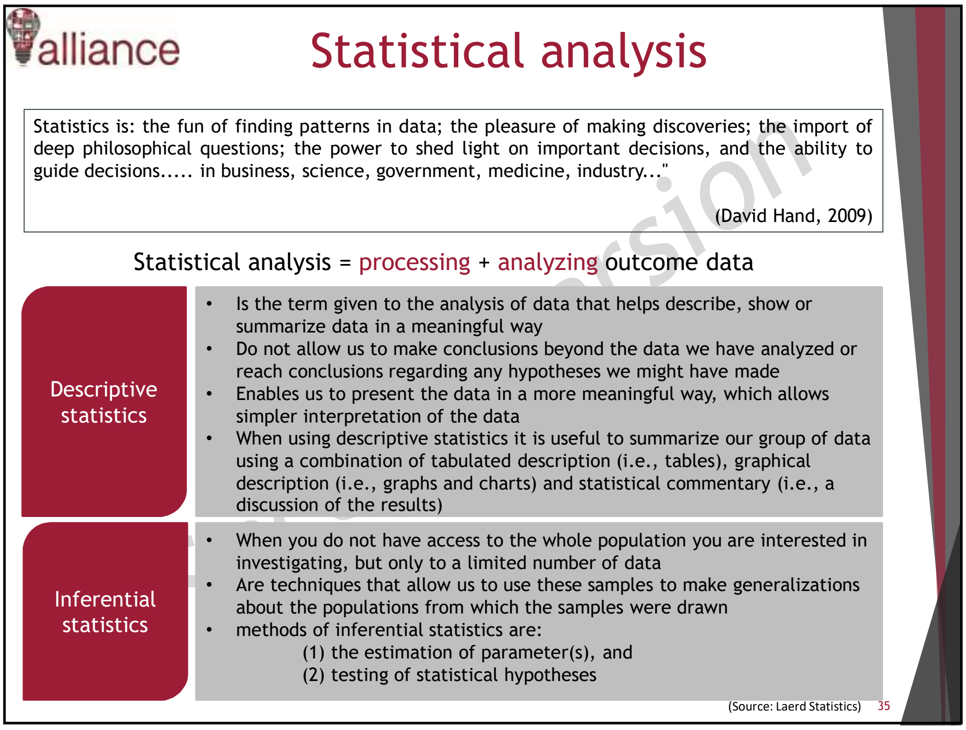
Method of document analysis

Strengths	Weaknesses
Content Analysis	
• As written evidence, it saves a researcher the time and expense of transcribing • Useful for determining value, interest, positions, political climate, public attitudes, historical trends or sequences • An unobtrusive source of information • Audio/visual material allows participants to share their 'reality'	• Analysis may be time consuming • Requires transcribing or optically scanning for computer entry • The documents may not be authentic or accurate • A file review rarely yields information on control groups, except in special cases, such as when files on rejected applicants to a study exist
Existing statistics	
• An unobtrusive source of information – can be accessed at a time convenient to the researcher • Can be used to collect baseline data • Analysis of statistics is relatively straightforward and can provide powerful statistical evidence for the effectiveness of an intervention	• Missing data is especially a problem when researchers cover a long time periods • In order to obtain reliable and good quality results, a large amount of data is needed • It is often difficult to determine the accuracy of secondary data • Equivalence reliability can also be a problem

(Source: Boulanger et al, 2007)



Statistical analysis



Statistical analysis

> Statistics is: the fun of finding patterns in data; the pleasure of making discoveries; the import of deep philosophical questions; the power to shed light on important decisions, and the ability to guide decisions..... in business, science, government, medicine, industry..."
>
> (David Hand, 2009)

Statistical analysis = processing + analyzing outcome data

Descriptive statistics

- Is the term given to the analysis of data that helps describe, show or summarize data in a meaningful way
- Do not allow us to make conclusions beyond the data we have analyzed or reach conclusions regarding any hypotheses we might have made
- Enables us to present the data in a more meaningful way, which allows simpler interpretation of the data
- When using descriptive statistics it is useful to summarize our group of data using a combination of tabulated description (i.e., tables), graphical description (i.e., graphs and charts) and statistical commentary (i.e., a discussion of the results)

Inferential statistics

- When you do not have access to the whole population you are interested in investigating, but only to a limited number of data
- Are techniques that allow us to use these samples to make generalizations about the populations from which the samples were drawn
- methods of inferential statistics are:
  - (1) the estimation of parameter(s), and
  - (2) testing of statistical hypotheses

(Source: Laerd Statistics)

Guidance to further knowledge acquisition

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Suggested literature

- Abdel-Aty M., (2003), “Hybrid Distribution and Response Techniques for an Origin-Destination Travel Survey”, ITE Journal, pp. 22-27.
- Amekudzi, A., Meyer, M., & Ross, C. (2011). Transportation planning for sustainability guidebook. Washington, D.C.: U.S. Federal Highway Administration.
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- Cascetta E., (1984), “Estimation of trip matrices from traffic counts and survey data: a generalized least squares estimator”, Trasportation research, Vol. B, pp. 289-299, USA.

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Suggested literature

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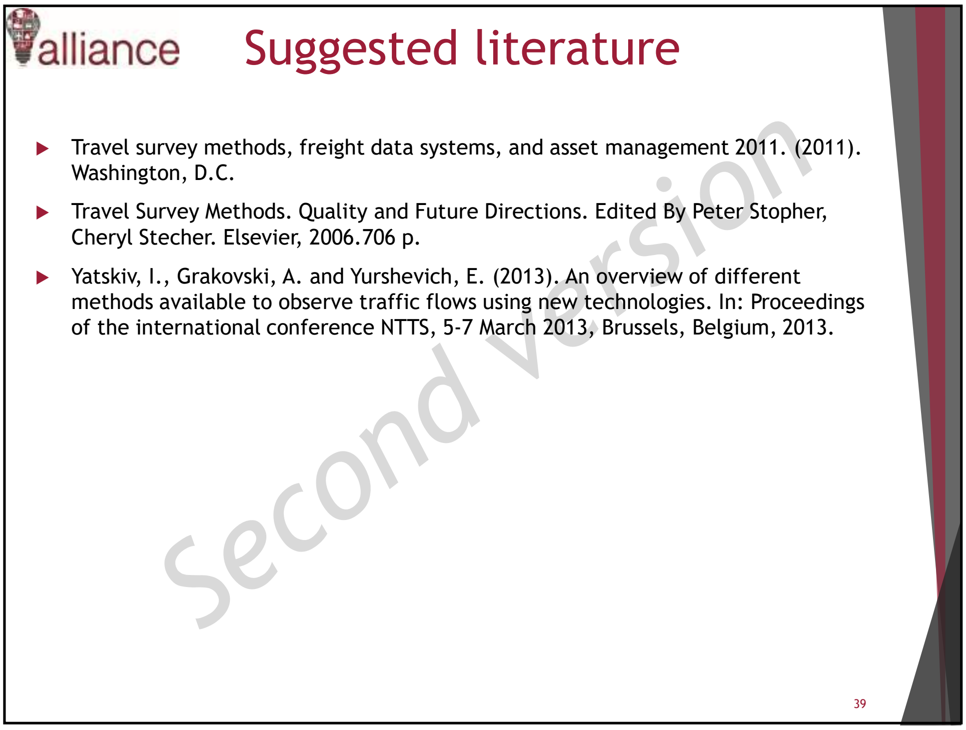
- Travel survey methods, freight data systems, and asset management 2011. (2011). Washington, D.C.



Suggested literature

- Travel survey methods, freight data systems, and asset management 2011. (2011). Washington, D.C.
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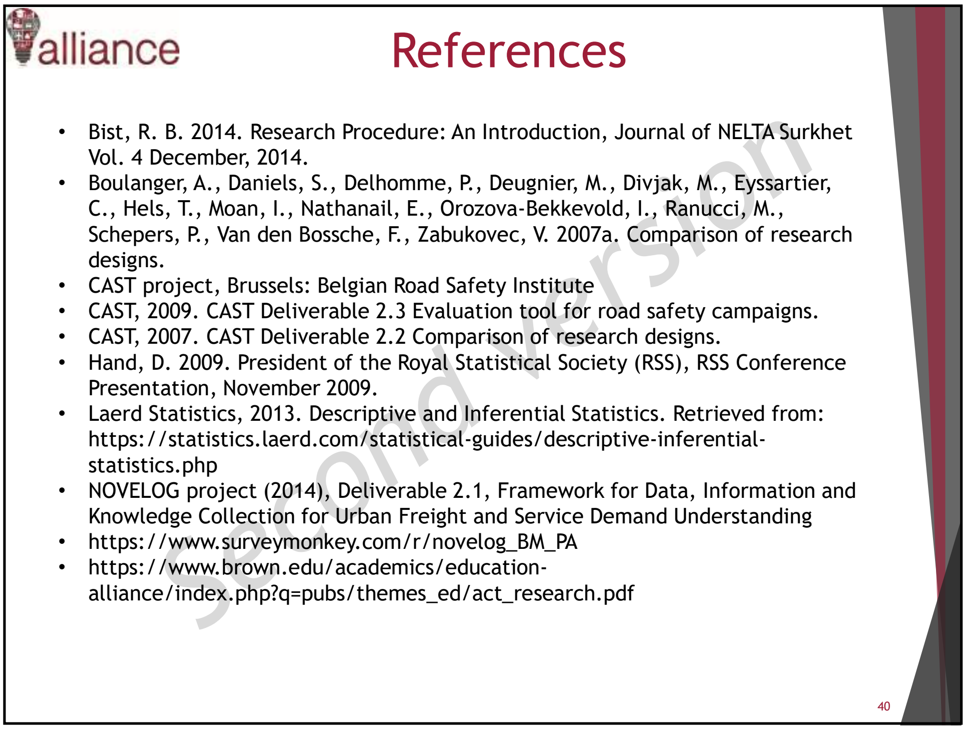

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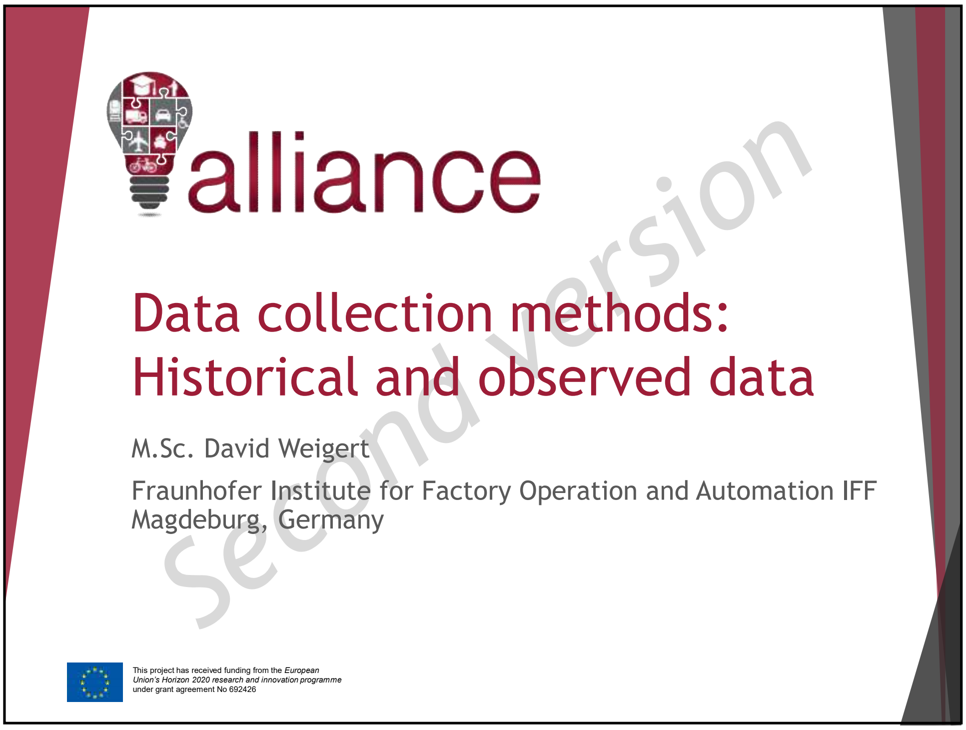
Thank you for your attention!

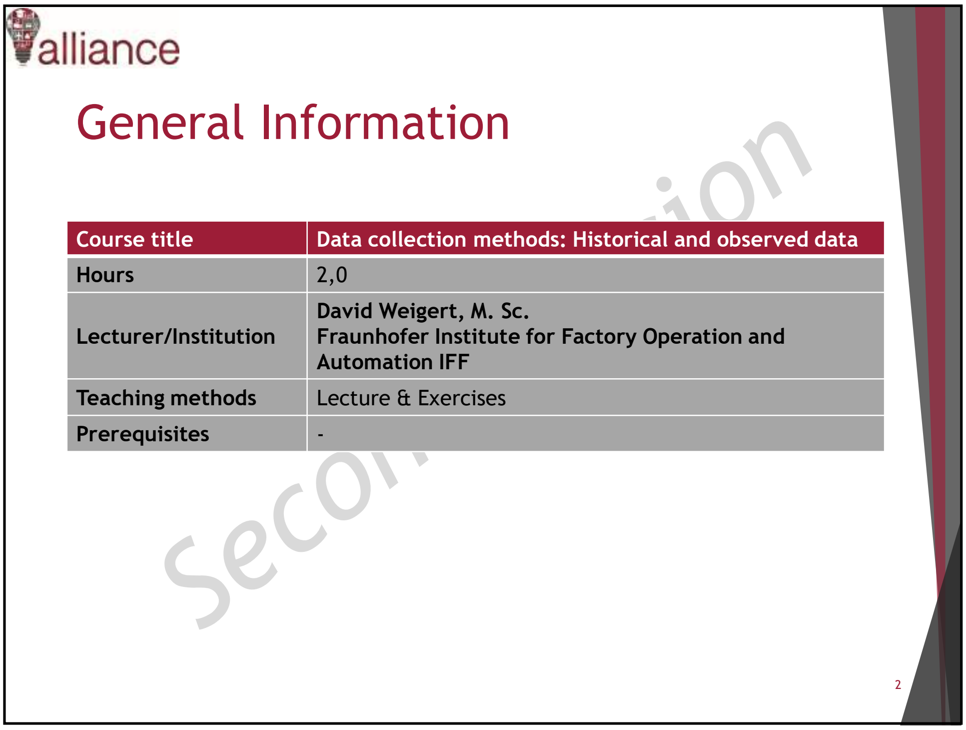


Data collection methods: Historical and observed data

M.Sc. David Weigert

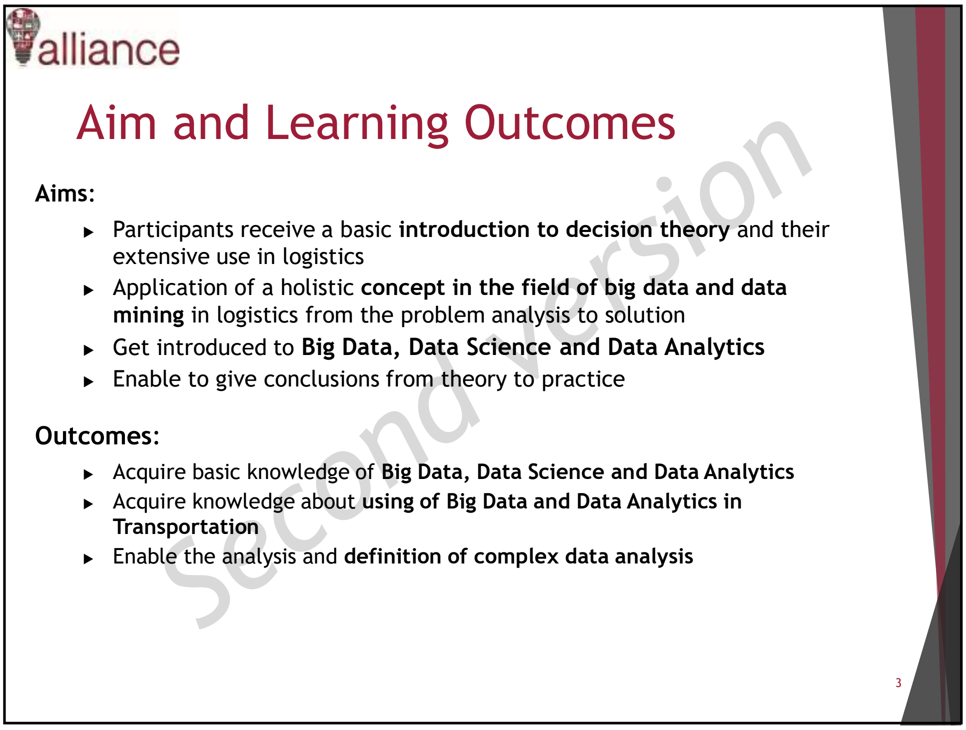
Fraunhofer Institute for Factory Operation and Automation IFF
Magdeburg, Germany

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



General Information

Course title	Data collection methods: Historical and observed data
Hours	2,0
Lecturer/Institution	**David Weigert, M. Sc. Fraunhofer Institute for Factory Operation and Automation IFF**
Teaching methods	Lecture & Exercises
Prerequisites	-



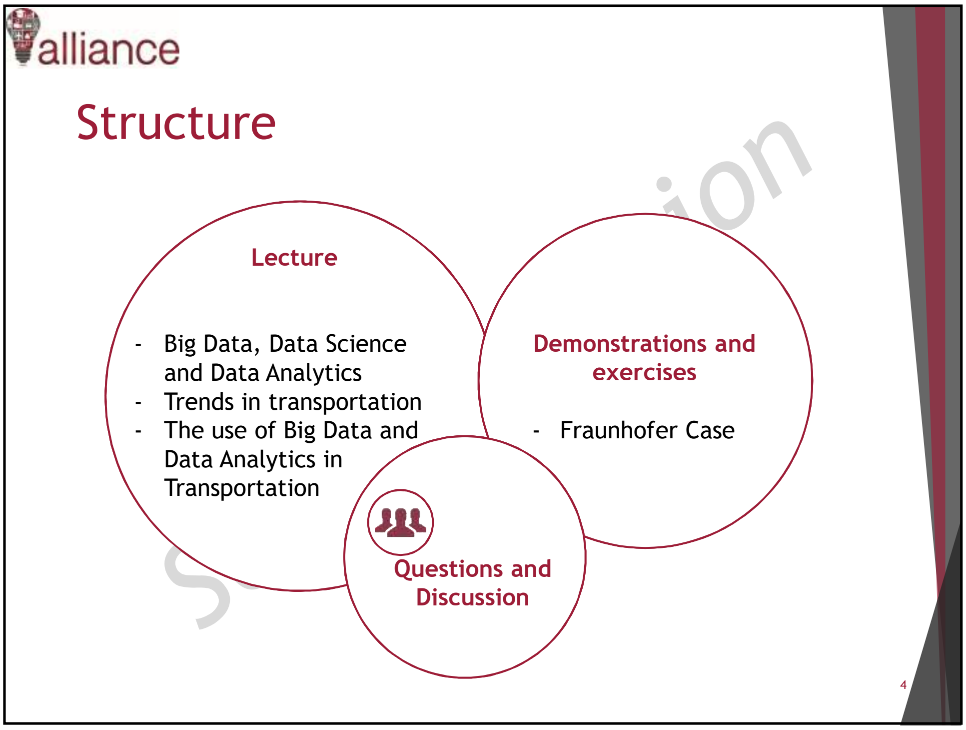
Aim and Learning Outcomes

Aims:

- Participants receive a basic **introduction to decision theory** and their extensive use in logistics
- Application of a holistic **concept in the field of big data and data mining** in logistics from the problem analysis to solution
- Get introduced to **Big Data, Data Science and Data Analytics**
- Enable to give conclusions from theory to practice

Outcomes:

- Acquire basic knowledge of **Big Data, Data Science and Data Analytics**
- Acquire knowledge about **using of Big Data and Data Analytics in Transportation**
- Enable the analysis and **definition of complex data analysis**



Structure

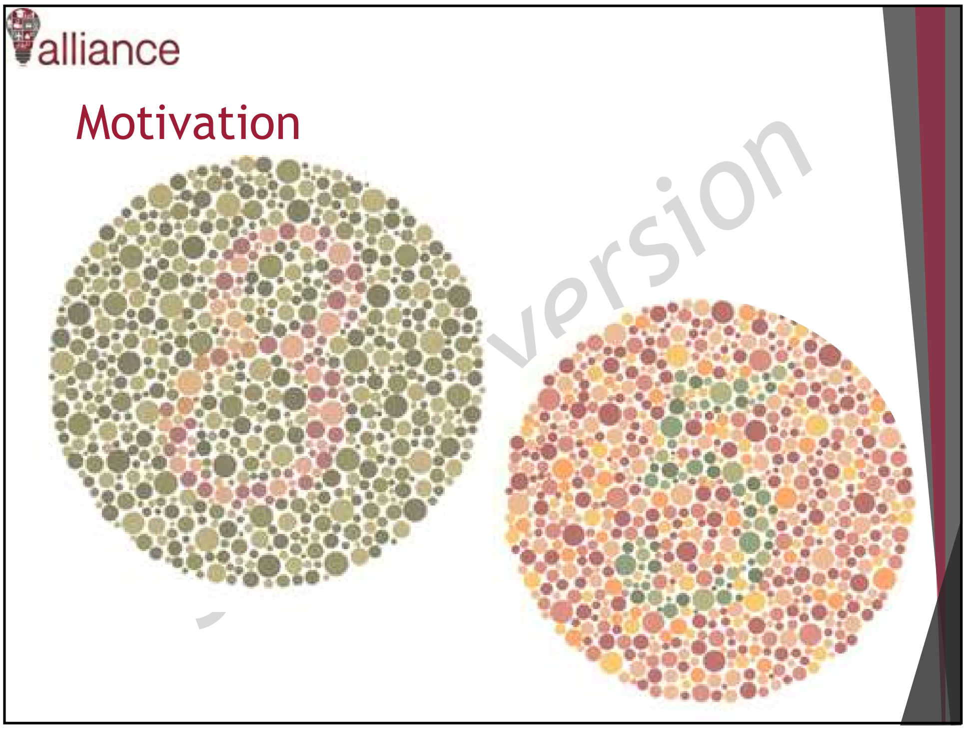
Lecture

- Big Data, Data Science and Data Analytics
- Trends in transportation
- The use of Big Data and Data Analytics in Transportation

Demonstrations and exercises

- Fraunhofer Case

Questions and Discussion



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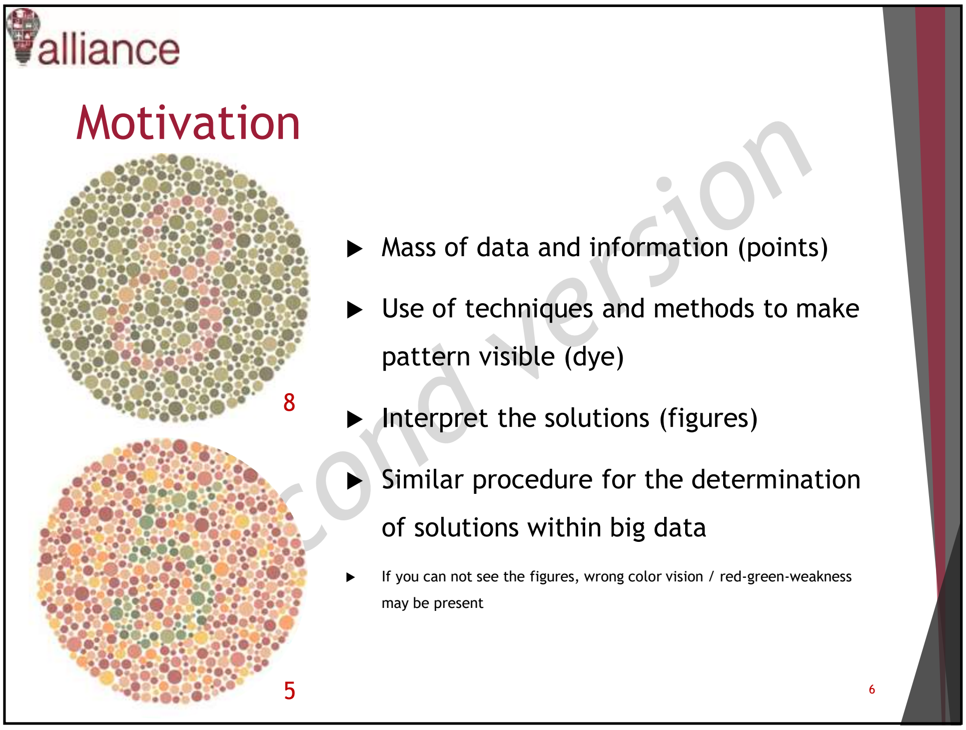
Motivation



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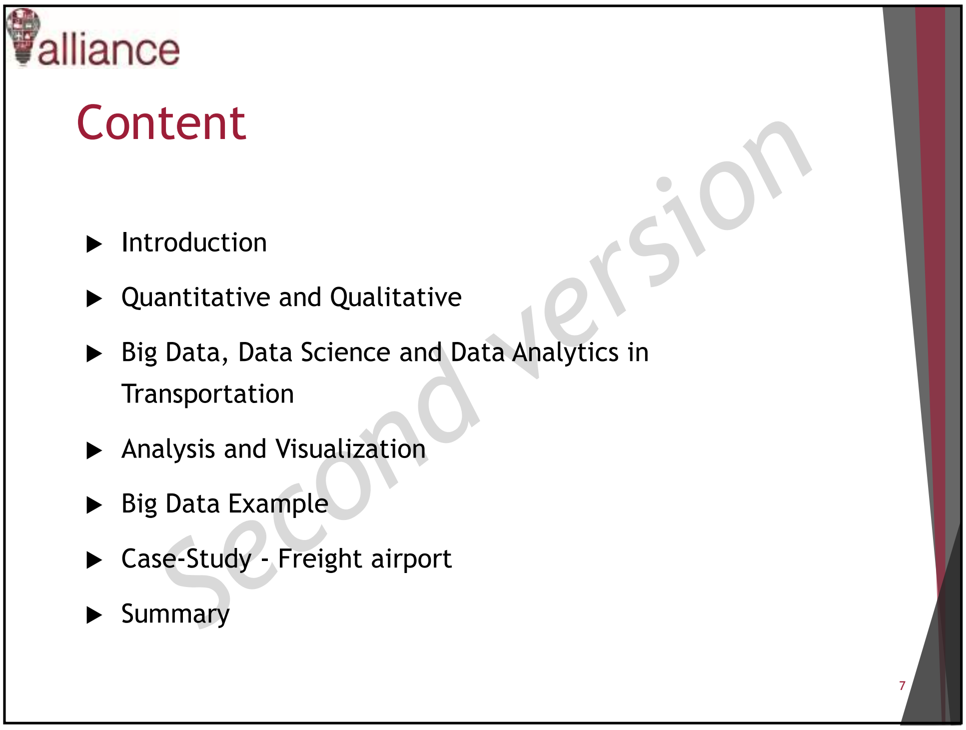
Motivation

- Mass of data and information (points)
- Use of techniques and methods to make pattern visible (dye)
- Interpret the solutions (figures)
- Similar procedure for the determination of solutions within big data
- If you can not see the figures, wrong color vision / red-green-weakness may be present



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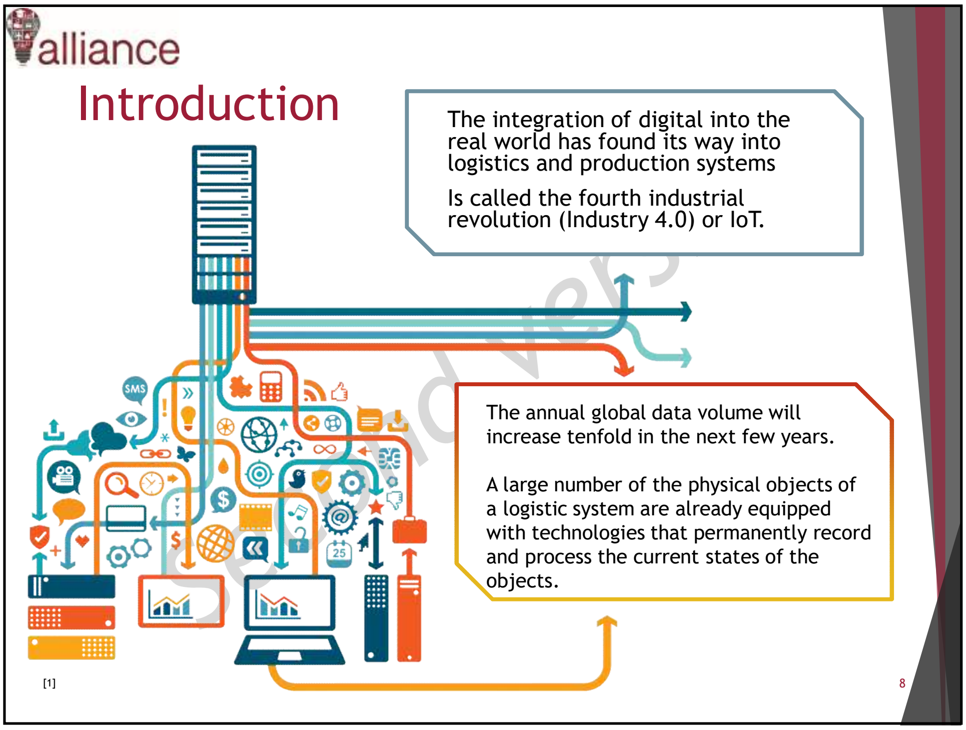
Content

- Introduction
- Quantitative and Qualitative
- Big Data, Data Science and Data Analytics in Transportation
- Analysis and Visualization
- Big Data Example
- Case-Study - Freight airport
- Summary



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Introduction

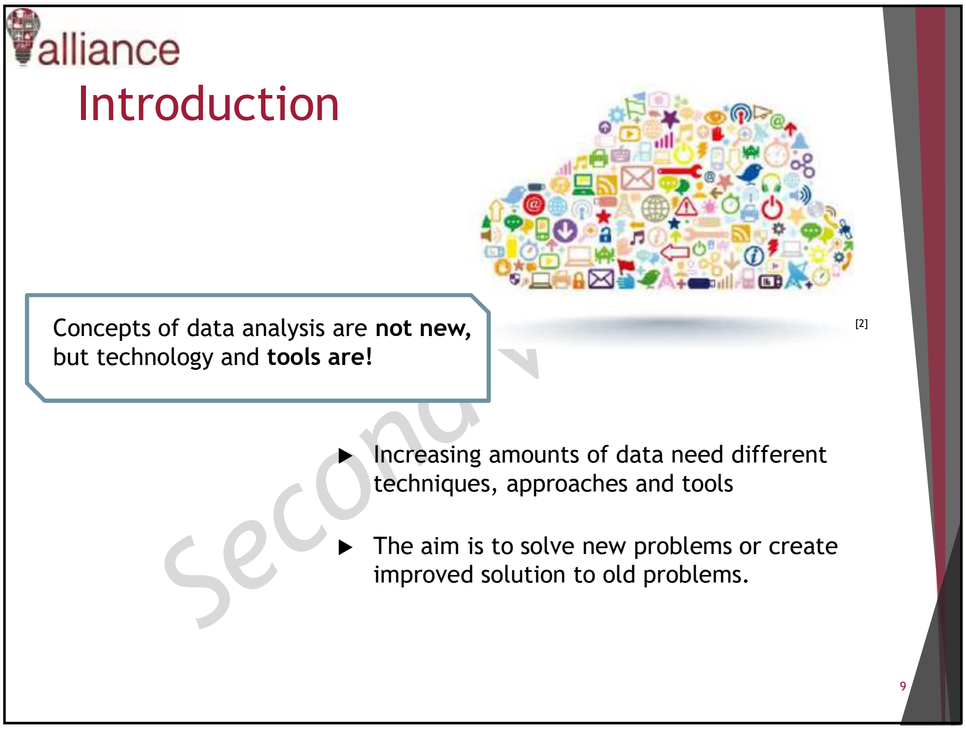
The integration of digital into the real world has found its way into logistics and production systems

Is called the fourth industrial revolution (Industry 4.0) or IoT.

The annual global data volume will increase tenfold in the next few years.

A large number of the physical objects of a logistic system are already equipped with technologies that permanently record and process the current states of the objects.

[1]

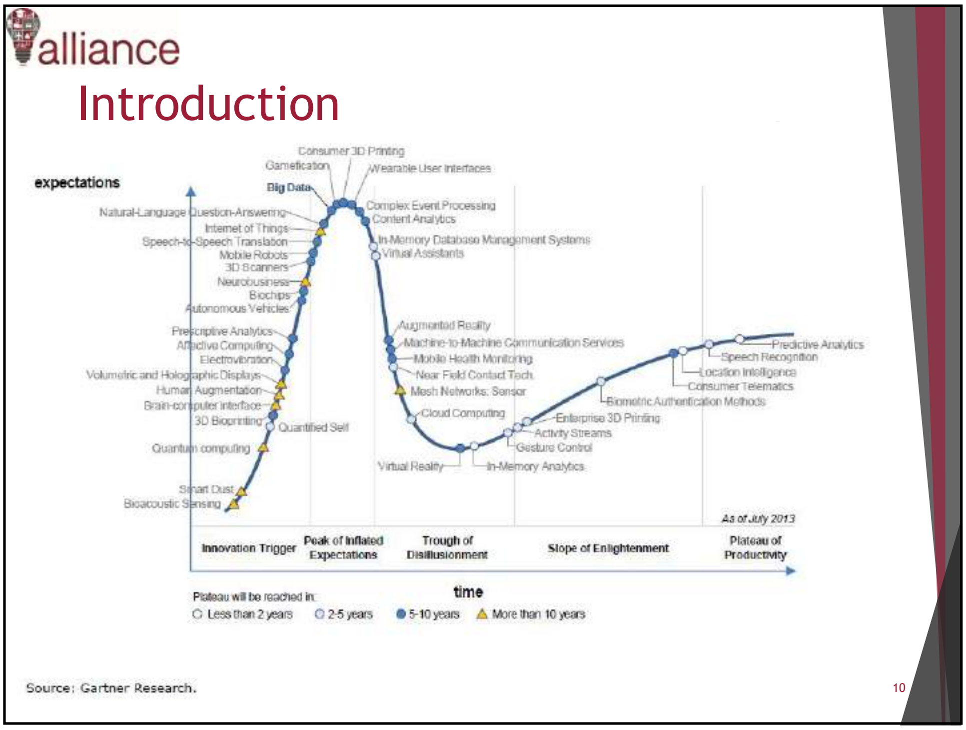


Introduction

Concepts of data analysis are **not new,** but technology and **tools are!**

[2]

- Increasing amounts of data need different techniques, approaches and tools
- The aim is to solve new problems or create improved solution to old problems.



Introduction

Source: Gartner Research.

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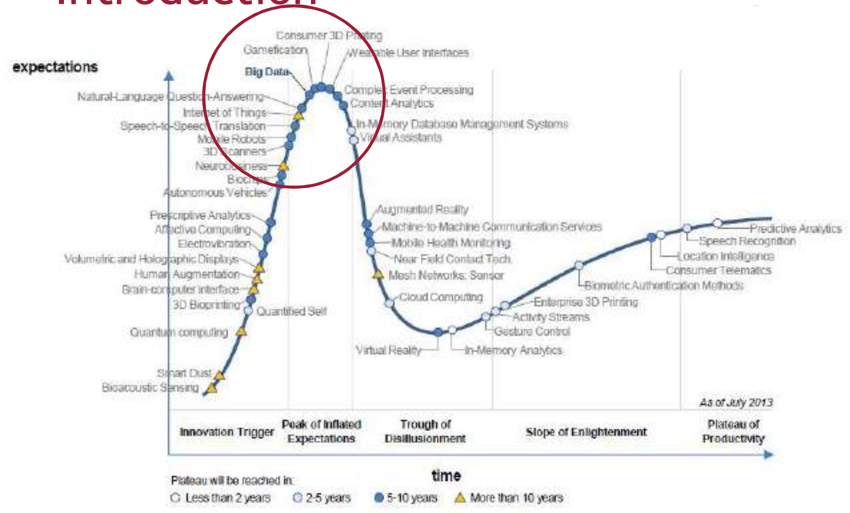
Introduction



Source: Gartner Research.

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Introduction

- logistics operations are carried out in time and space (in contrast to, manufacturing operations which are usually executed in time and place - fixed place)
- logistics operations are realized not only in one organization but also among the organization and its supply chain partners
- logistics operations and necessity to communicate and collaborate with other organizations

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Introduction

- logistics operations are carried out in time and space (in contrast to, manufacturing operations which are usually executed in time and place - fixed place)
- logistics operations are realized not only in one organization but also among the organization and its supply chain partners
- logistics operations and necessity to communicate and collaborate with other organizations

- higher complexity of some decision making situations
- increase level of uncertainty in decision making
- …

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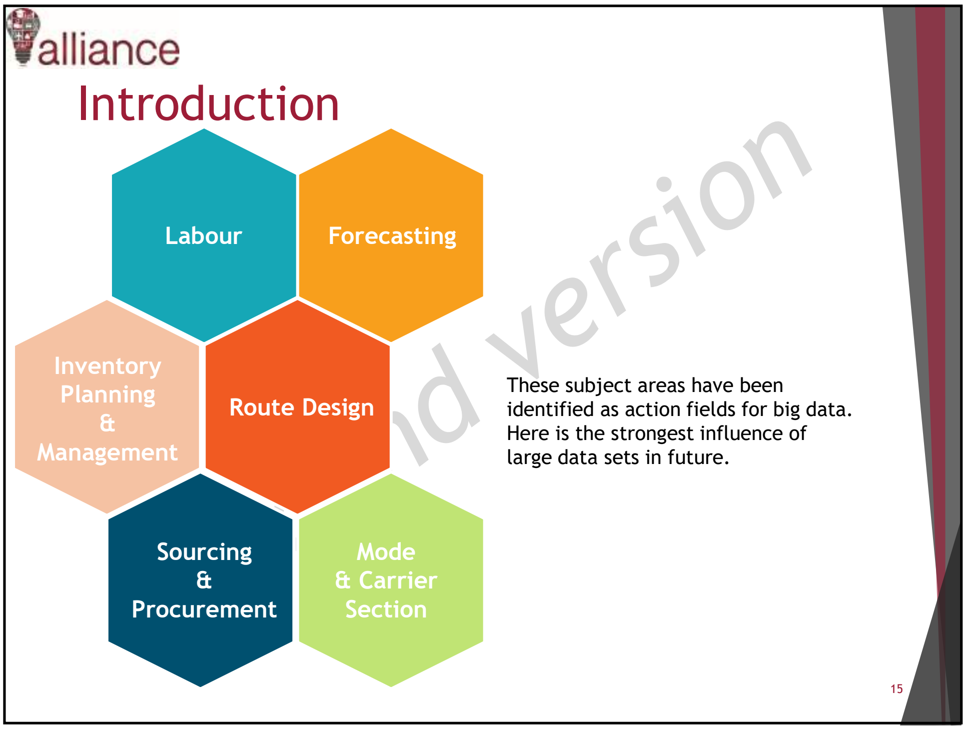
Introduction

[3]

- **Data Driven Decision Making**
  Correct analysis of the data and therefore support decision-making.

  That knowledge will translate to better business decisions. In practice, even if you have the best data in the world, decisions are sometimes made in spite of that data, or with what is often described as going with a good feeling.
- Nowadays, **decision problems are complex**, especially in global multi-echelon supply chains
- Technological advancements facilitate decision making because data and information is available accurate and in real time



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Introduction

Labour

Forecasting

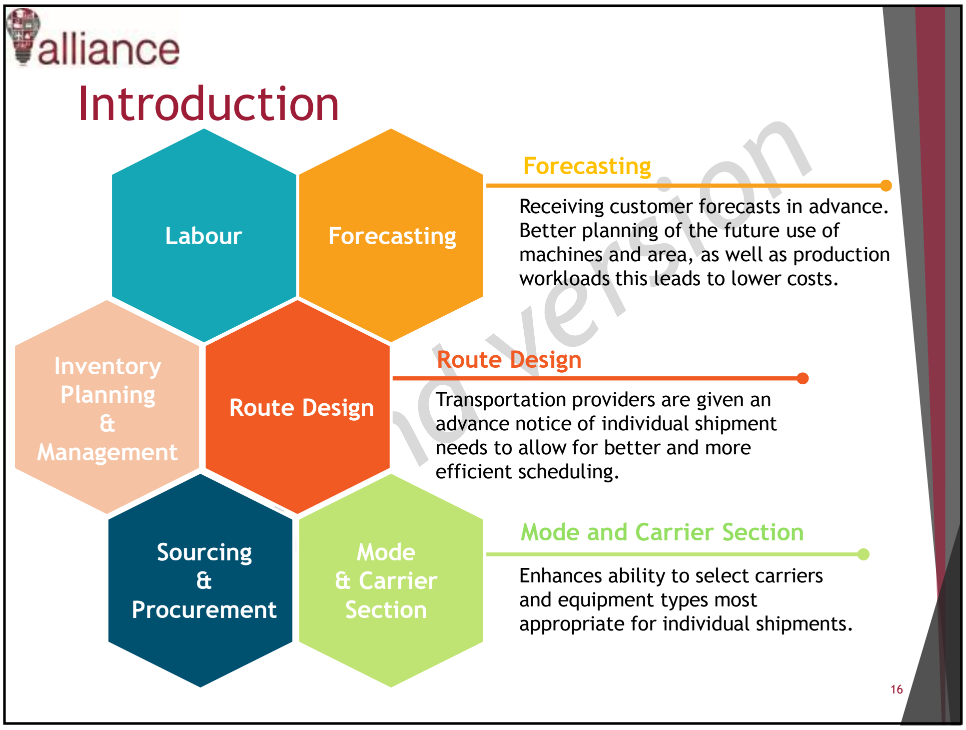
Inventory Planning & Management

Route Design

Sourcing & Procurement

Mode & Carrier Section

These subject areas have been identified as action fields for big data. Here is the strongest influence of large data sets in future.



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Introduction

Labour

Forecasting

Inventory Planning & Management

Route Design

Sourcing & Procurement

Mode & Carrier Section

Forecasting

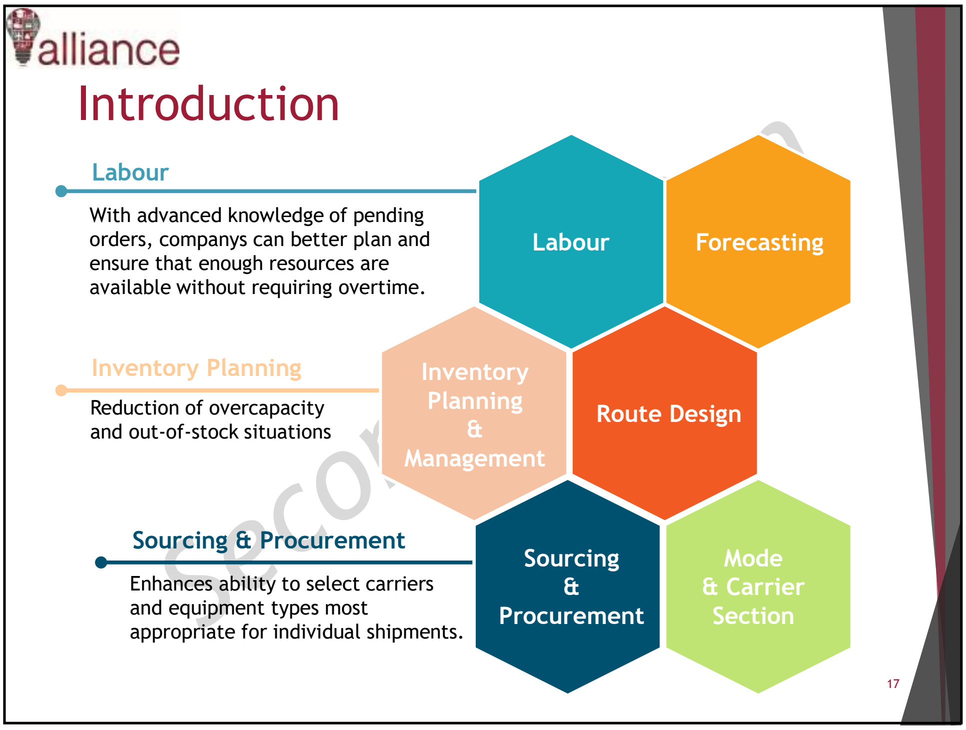
Receiving customer forecasts in advance. Better planning of the future use of machines and area, as well as production workloads this leads to lower costs.

Route Design

Transportation providers are given an advance notice of individual shipment needs to allow for better and more efficient scheduling.

Mode and Carrier Section

Enhances ability to select carriers and equipment types most appropriate for individual shipments.



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Introduction

Labour

With advanced knowledge of pending orders, companys can better plan and ensure that enough resources are available without requiring overtime.

Inventory Planning

Reduction of overcapacity and out-of-stock situations

Sourcing & Procurement

Enhances ability to select carriers and equipment types most appropriate for individual shipments.

Labour

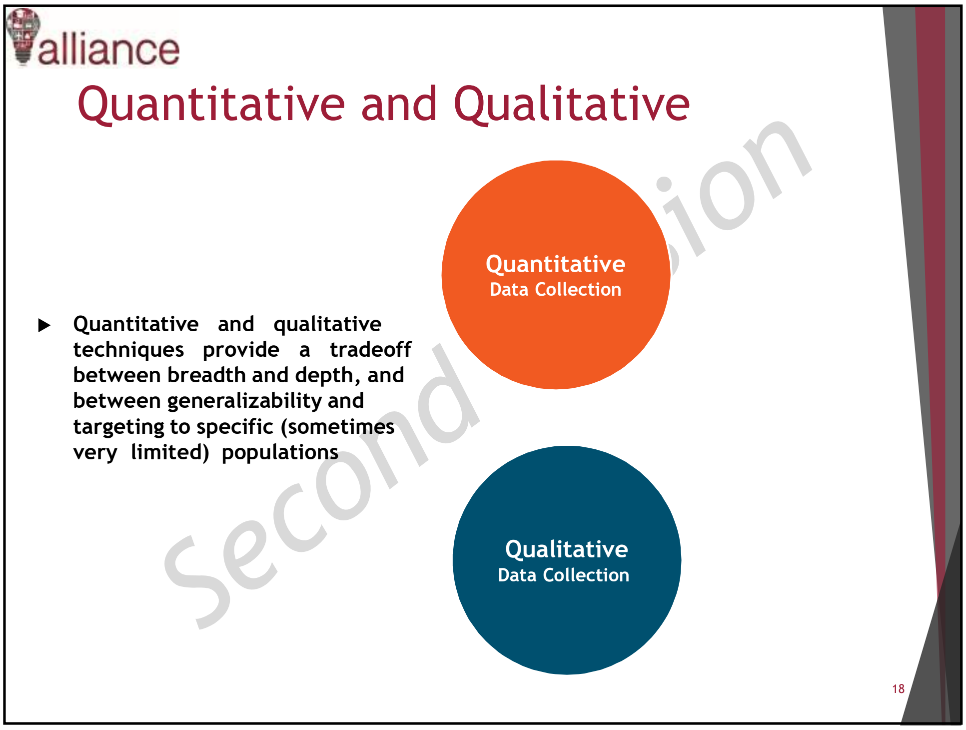
Forecasting

Inventory Planning & Management

Route Design

Sourcing & Procurement

Mode & Carrier Section



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Quantitative and Qualitative

- **Quantitative and qualitative techniques provide a tradeoff between breadth and depth, and between generalizability and targeting to specific (sometimes very limited) populations**

Quantitative
Data Collection

Qualitative
Data Collection

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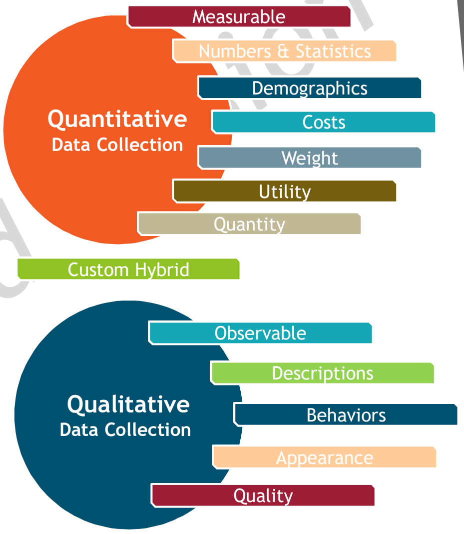
Quantitative and Qualitative

- Data collected through quantitative methods are often believed more objective and accurate information
- **Quantitative data** were collected using standardized methods, can be replicated
- **Qualitative data** can be analyzed using sophisticated statistical techniques



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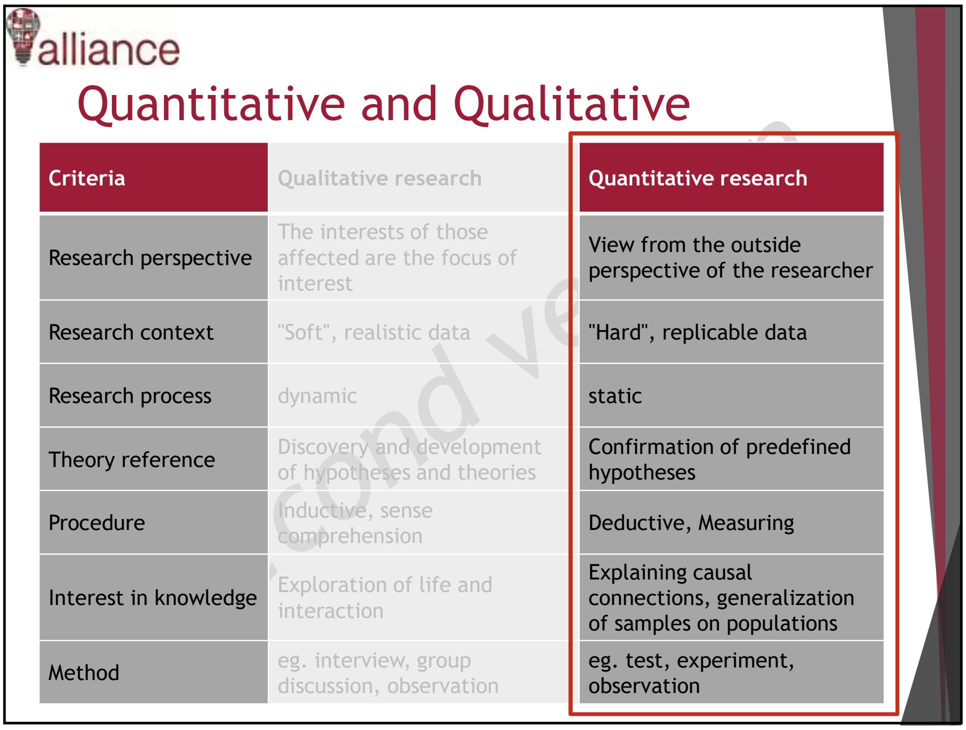
Quantitative and Qualitative

Criteria	Qualitative research	Quantitative research
Research perspective	The interests of those affected are the focus of interest	View from the outside perspective of the researcher
Research context	"Soft", realistic data	"Hard", replicable data
Research process	dynamic	static
Theory reference	Discovery and development of hypotheses and theories	Confirmation of predefined hypotheses
Procedure	Inductive, sense comprehension	Deductive, Measuring
Interest in knowledge	Exploration of life and interaction	Explaining causal connections, generalization of samples on populations
Method	eg. interview, group discussion, observation	eg. test, experiment, observation



Quantitative and Qualitative

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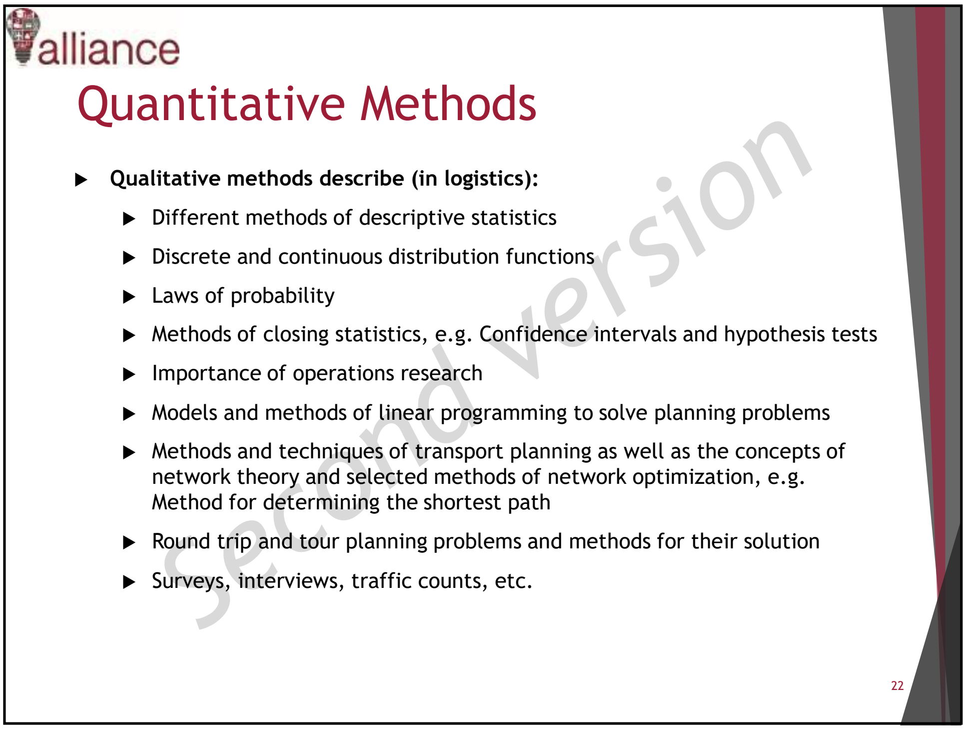
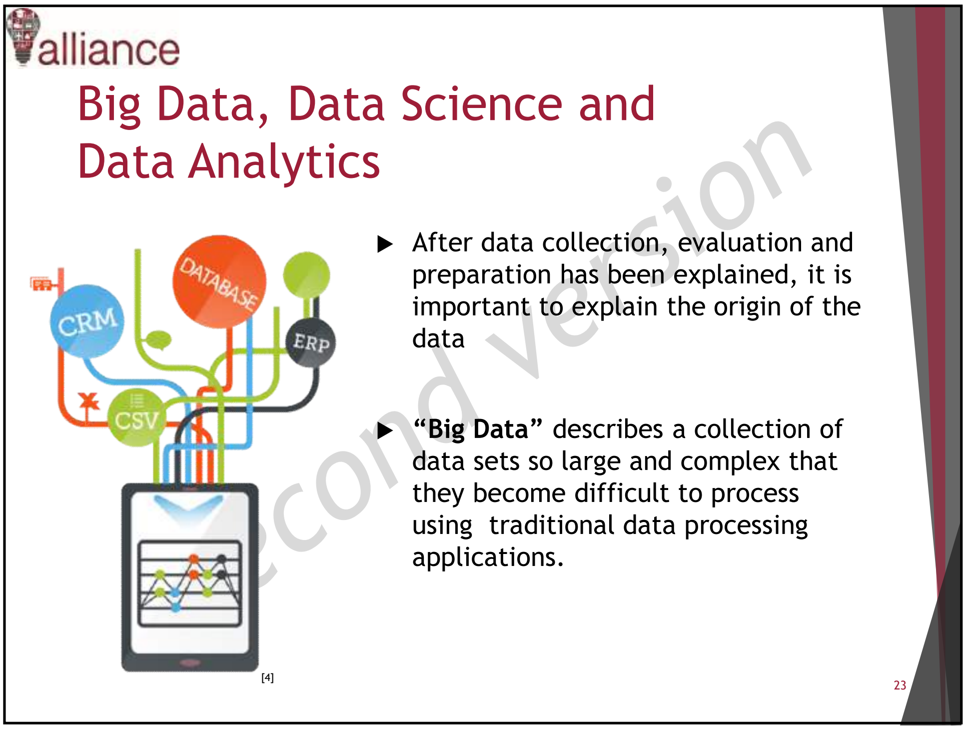


Quantitative Methods

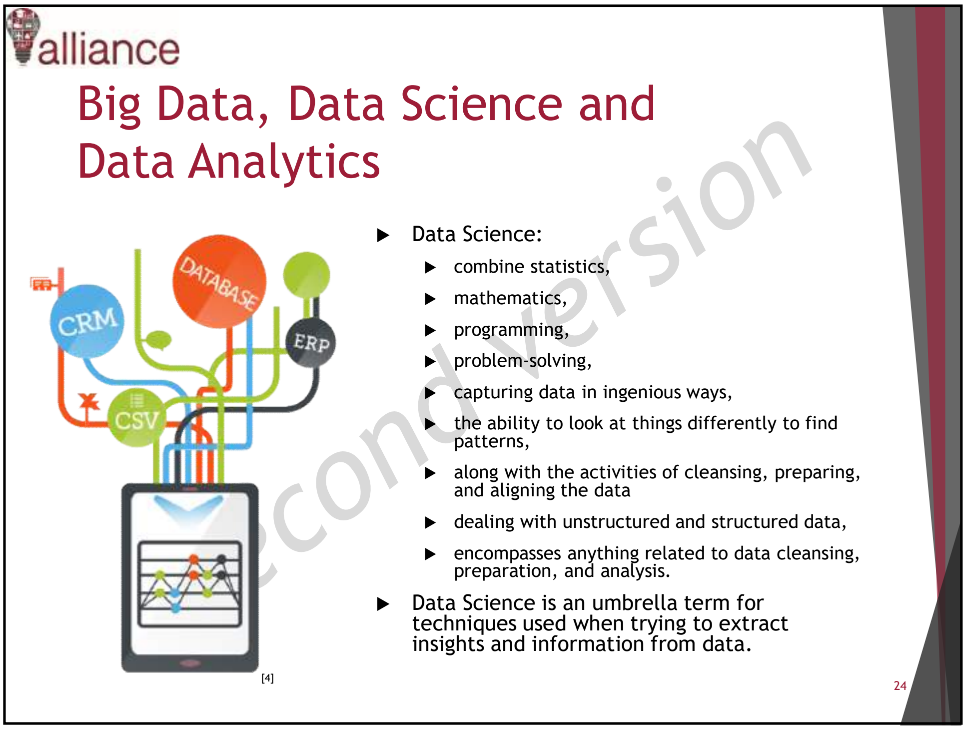
- **Qualitative methods describe (in logistics):**
    - Different methods of descriptive statistics
    - Discrete and continuous distribution functions
    - Laws of probability
    - Methods of closing statistics, e.g. Confidence intervals and hypothesis tests
    - Importance of operations research
    - Models and methods of linear programming to solve planning problems
    - Methods and techniques of transport planning as well as the concepts of network theory and selected methods of network optimization, e.g. Method for determining the shortest path
    - Round trip and tour planning problems and methods for their solution
    - Surveys, interviews, traffic counts, etc.



Big Data, Data Science and Data Analytics

- After data collection, evaluation and preparation has been explained, it is important to explain the origin of the data
- **"Big Data"** describes a collection of data sets so large and complex that they become difficult to process using traditional data processing applications.

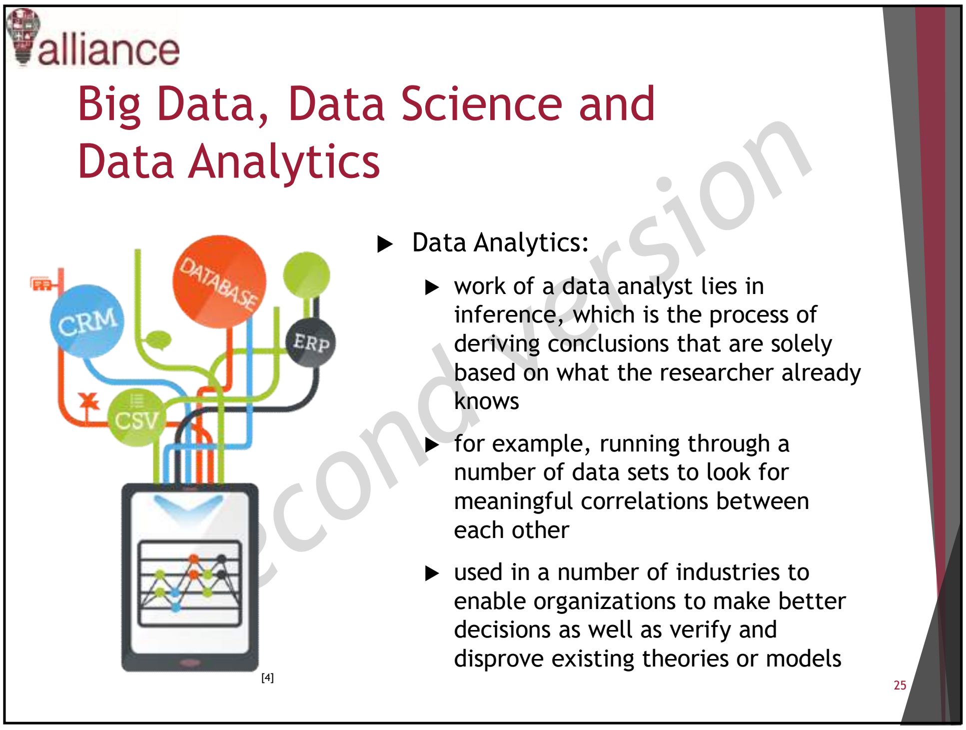
[4]



Big Data, Data Science and Data Analytics

- Data Science:
  - combine statistics,
  - mathematics,
  - programming,
  - problem-solving,
  - capturing data in ingenious ways,
  - the ability to look at things differently to find patterns,
  - along with the activities of cleansing, preparing, and aligning the data
  - dealing with unstructured and structured data,
  - encompasses anything related to data cleansing, preparation, and analysis.
- Data Science is an umbrella term for techniques used when trying to extract insights and information from data.

[4]



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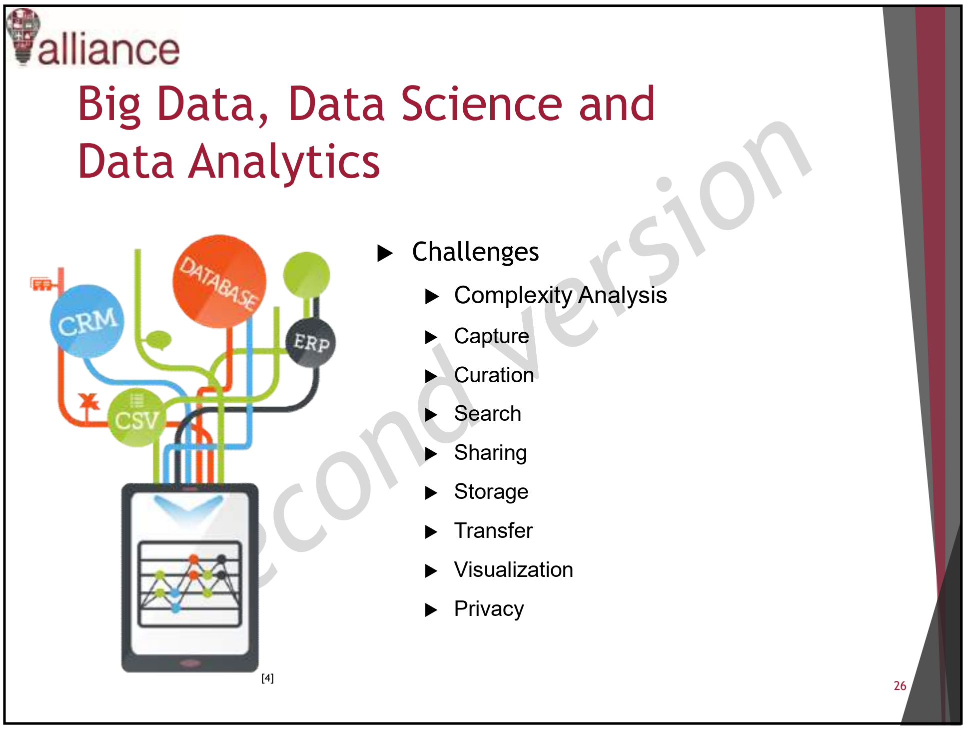
Big Data, Data Science and Data Analytics

- Data Analytics:
  - work of a data analyst lies in inference, which is the process of deriving conclusions that are solely based on what the researcher already knows
  - for example, running through a number of data sets to look for meaningful correlations between each other
  - used in a number of industries to enable organizations to make better decisions as well as verify and disprove existing theories or models

[4]



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Big Data, Data Science and Data Analytics

- Challenges
  - Complexity Analysis
  - Capture
  - Curation
  - Search
  - Sharing
  - Storage
  - Transfer
  - Visualization
  - Privacy

[4]

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Big Data, Data Science and Data Analytics

The Big Data Value Chain

- Big Data may be as important to business and society as the Internet since more data leads to more accurate analyses

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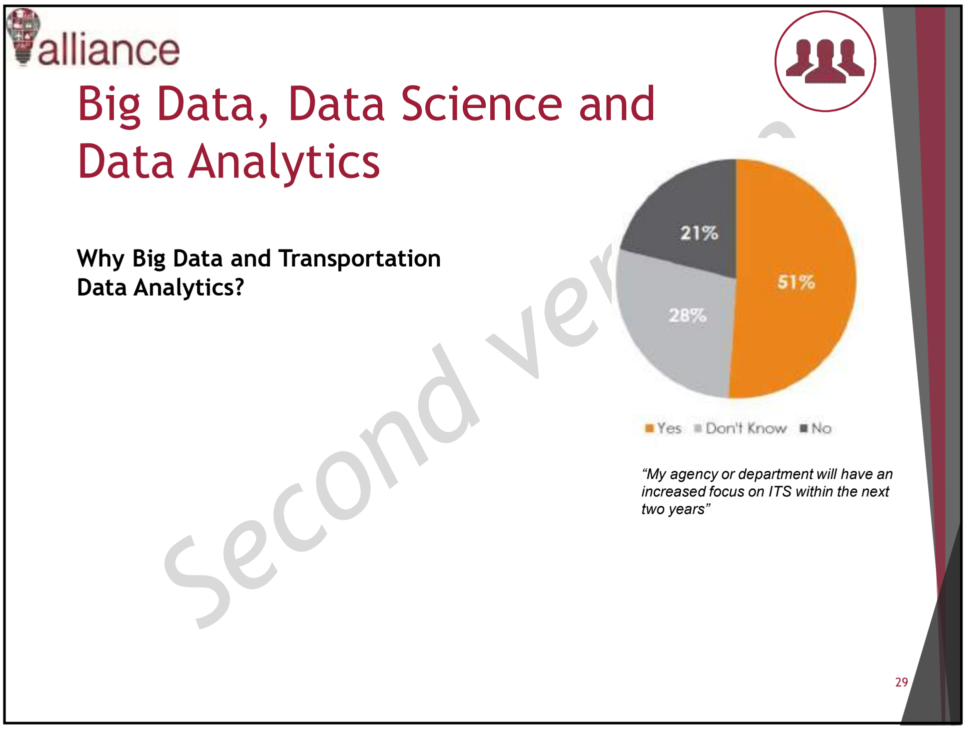
Big Data, Data Science and Data Analytics

NEW

- Economics: increased amounts of data you can afford to capture
- Tools: uncover insights from new data types to quickly find the signal in the noise
- Architecture Framework: a hybrid ecosystem that makes it easy to use both old and new tools on old and new data (i.e. use the right tool for the right job)
- New analytics on new, non relational data types (coupled with existing relational data) open up new possibilities for unique insights

NOT NEW

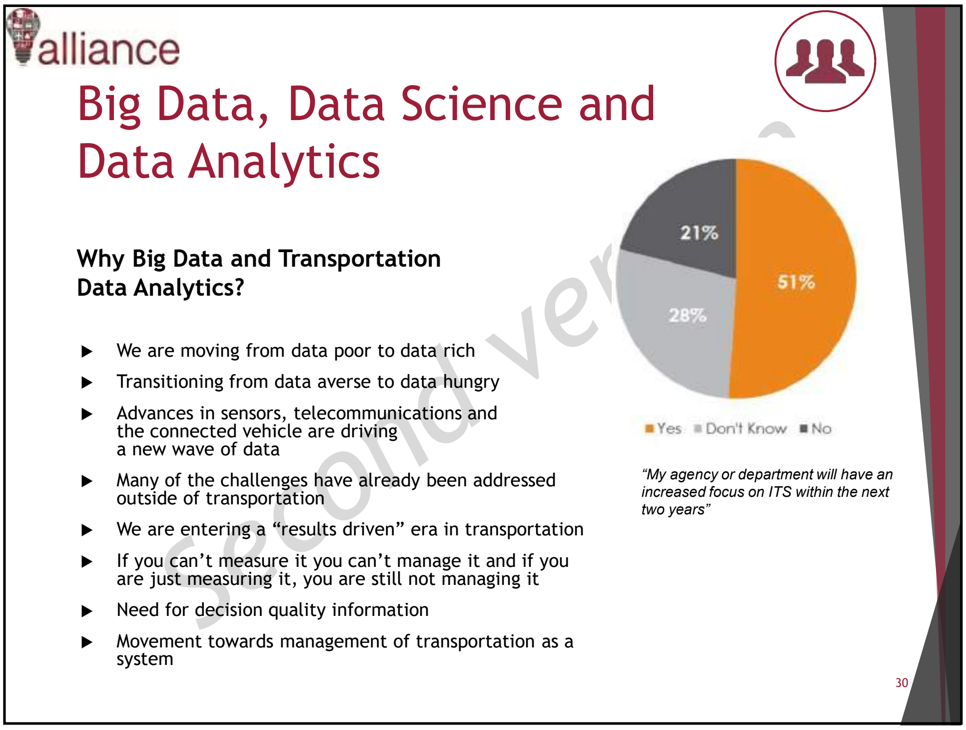
- Most big data Use Cases are variations on the same things organizations and government agencies have been doing for years



Big Data, Data Science and Data Analytics

Why Big Data and Transportation Data Analytics?

"My agency or department will have an increased focus on ITS within the next two years"



Big Data, Data Science and Data Analytics

Why Big Data and Transportation Data Analytics?

- We are moving from data poor to data rich
- Transitioning from data averse to data hungry
- Advances in sensors, telecommunications and the connected vehicle are driving a new wave of data
- Many of the challenges have already been addressed outside of transportation
- We are entering a "results driven" era in transportation
- If you can't measure it you can't manage it and if you are just measuring it, you are still not managing it
- Need for decision quality information
- Movement towards management of transportation as a system

"My agency or department will have an increased focus on ITS within the next two years"

Big Data, Data Science and Data Analytics

- How effective are our transportation investments? Are travelers getting a fair deal?
- Are our ITS investment programs results driven?
- Can we determine the status of our transportation networks and services at any given time?
- Do we understand the mechanisms and patterns that underlie transportation in our jurisdiction?
- Are we collecting data once and using it many times, or duplicating data collection efforts and submerging data in silos?
- Does our entire organization have easy access to information required to support work processes?
- Is our data collection and acquisition optimized?
- Do we understand public perception of transportation service delivery at any given time?

[5]

Big Data, Data Science and Data Analytics

- Big Data and analytics **techniques are proven and available now**
- We need to get **ready to be data hungry**
- There are trends and patterns to be **discovered through analysis of multiple data sets**
- We can monetize Big Data for transportation in terms of safety, efficiency and customer service in planning, design and operational management activities
- Harnessing the power of Big Data, Data Science and Transportation Data Analytics we can improve planning, design and service delivery for transportation

[6]

Analysis and Visualization

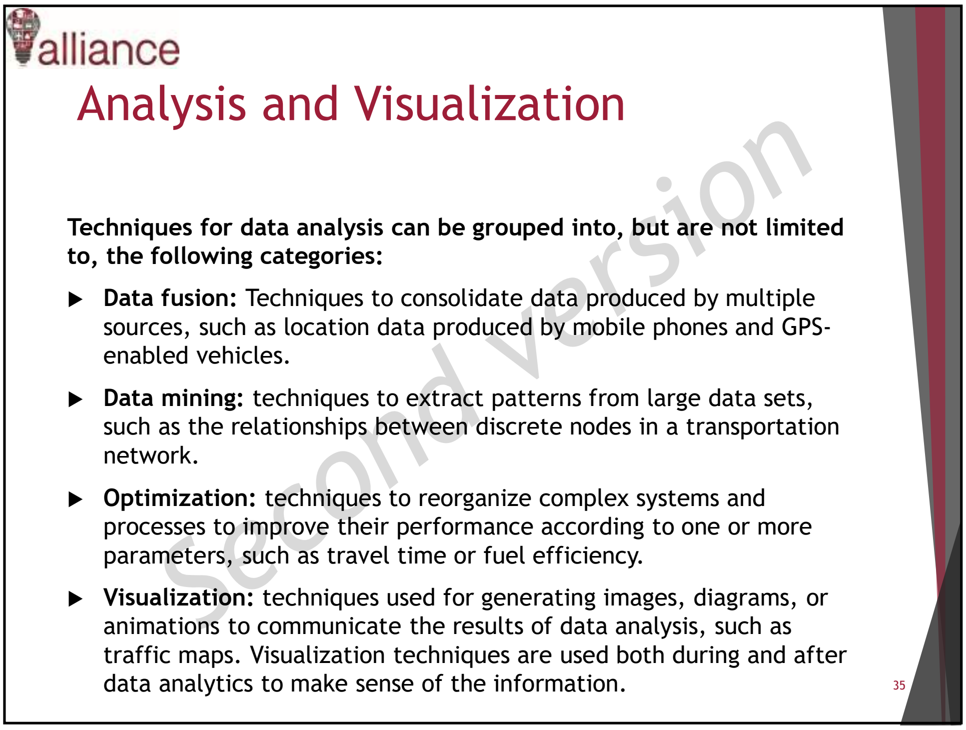
- An analysis of large amounts of data serves to recognize unknown connections or to confirm already known ones
- Computers made it possible to process large amounts of data at lightning-fast speeds
- Today, data visualization has become a rapidly evolving blend of science and art that is certain to change the corporate landscape over the next few years

[7]

Analysis and Visualization

- This area of data analysis is referred to by the terms Knowledge Discovery in Databases (KDD) and Data Mining
- As a common process model and typical representative, the **CR**oss Industry **S**tandard **P**rocess for Data Mining **CRISP-DM** is presented
- Afterwards, different process groups and algorithms of knowledge discovery in databases are explained and assigned to specific task classes.

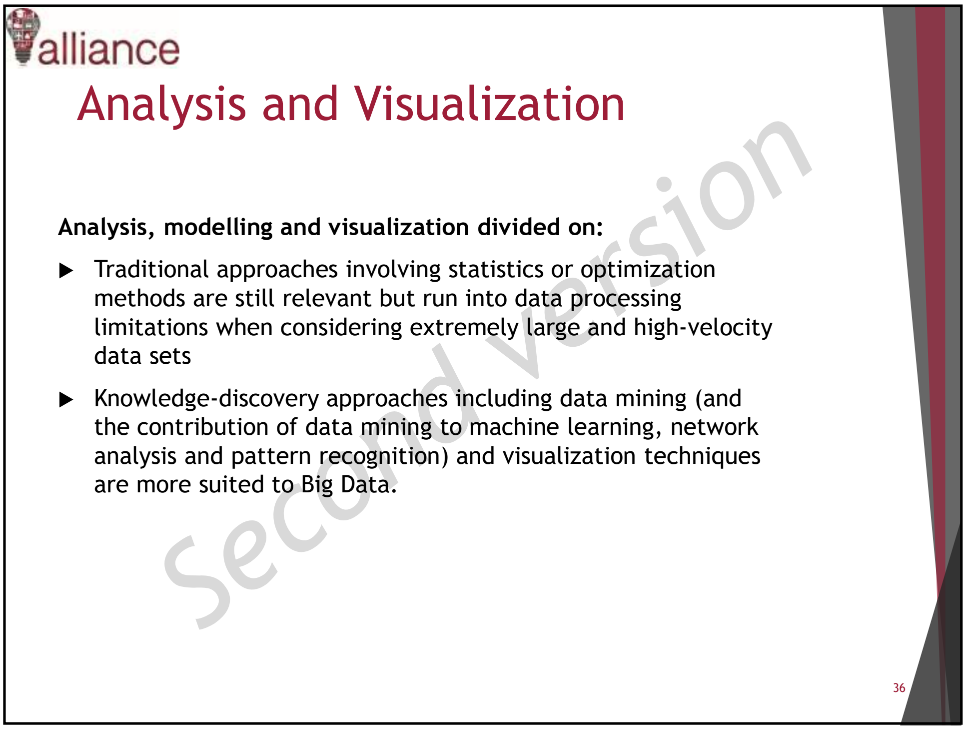
[7]



Analysis and Visualization

Techniques for data analysis can be grouped into, but are not limited to, the following categories:

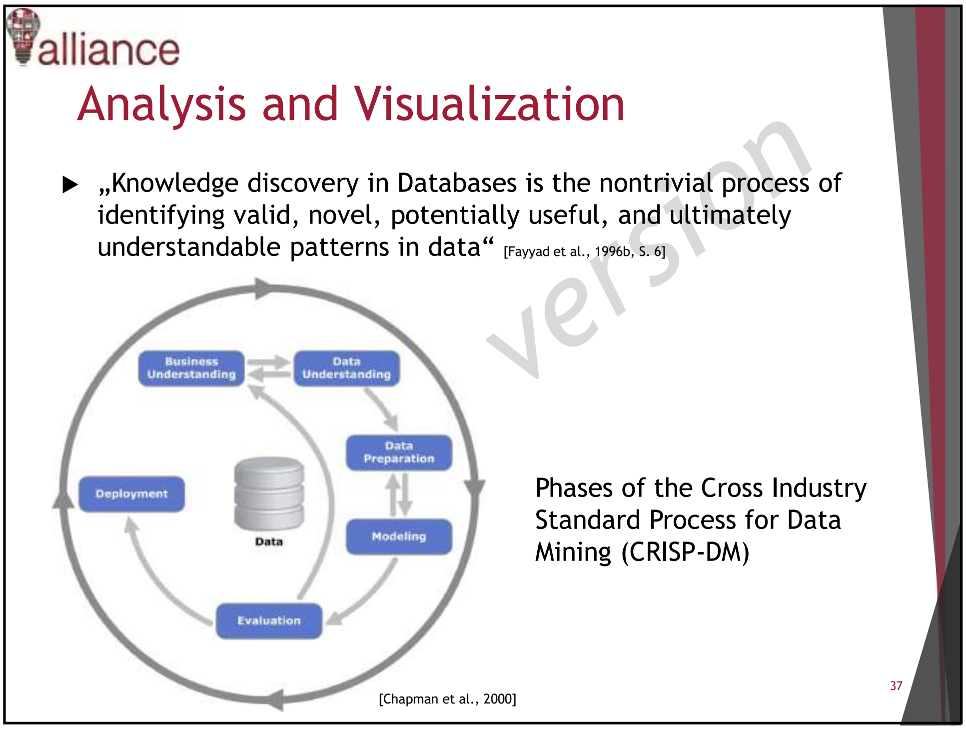
- **Data fusion:** Techniques to consolidate data produced by multiple sources, such as location data produced by mobile phones and GPS-enabled vehicles.
- **Data mining:** techniques to extract patterns from large data sets, such as the relationships between discrete nodes in a transportation network.
- **Optimization:** techniques to reorganize complex systems and processes to improve their performance according to one or more parameters, such as travel time or fuel efficiency.
- **Visualization:** techniques used for generating images, diagrams, or animations to communicate the results of data analysis, such as traffic maps. Visualization techniques are used both during and after data analytics to make sense of the information.



Analysis and Visualization

Analysis, modelling and visualization divided on:

- Traditional approaches involving statistics or optimization methods are still relevant but run into data processing limitations when considering extremely large and high-velocity data sets
- Knowledge-discovery approaches including data mining (and the contribution of data mining to machine learning, network analysis and pattern recognition) and visualization techniques are more suited to Big Data.



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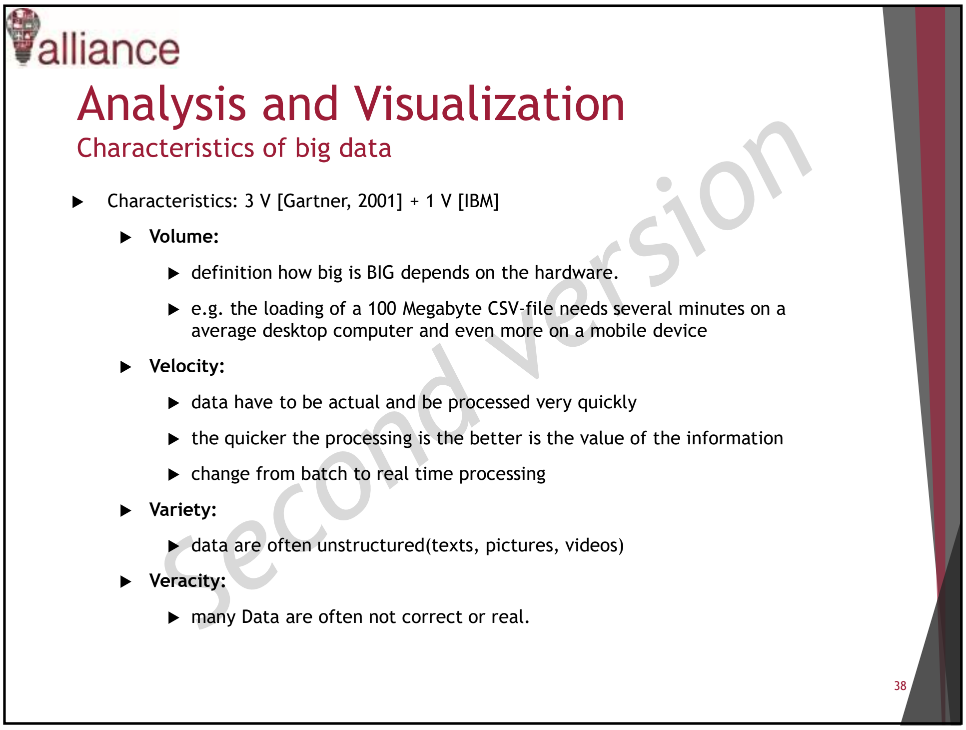
Analysis and Visualization

- „Knowledge discovery in Databases is the nontrivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data“ [Fayyad et al., 1996b, S. 6]

Phases of the Cross Industry Standard Process for Data Mining (CRISP-DM)

[Chapman et al., 2000]



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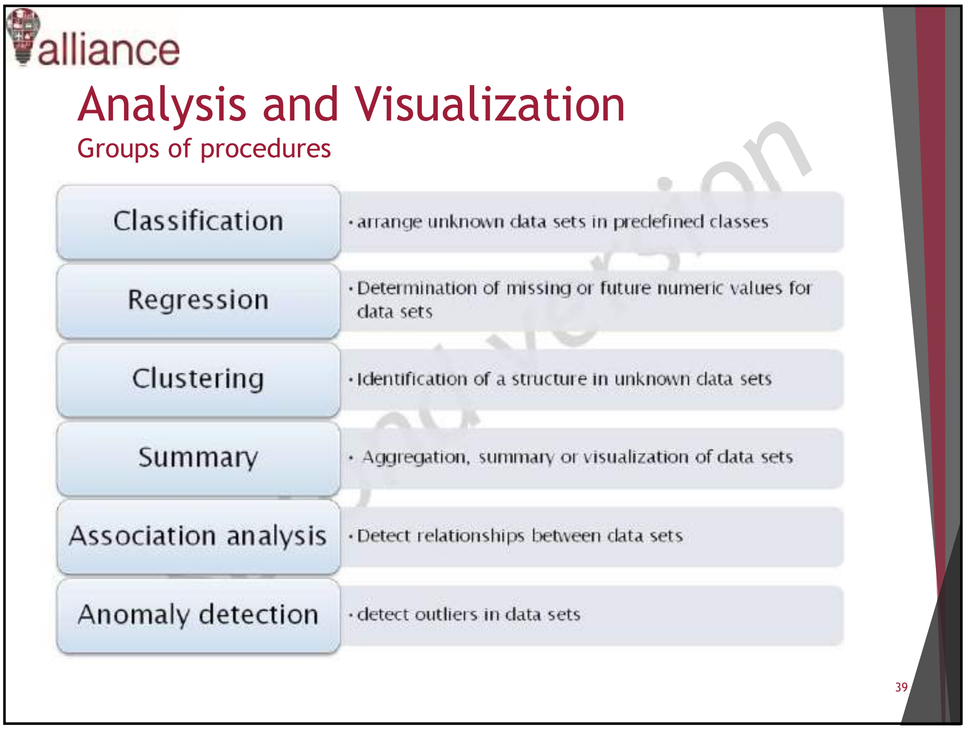
Analysis and Visualization

Characteristics of big data

- Characteristics: 3 V [Gartner, 2001] + 1 V [IBM]
  - **Volume:**
    - definition how big is BIG depends on the hardware.
    - e.g. the loading of a 100 Megabyte CSV-file needs several minutes on a average desktop computer and even more on a mobile device
  - **Velocity:**
    - data have to be actual and be processed very quickly
    - the quicker the processing is the better is the value of the information
    - change from batch to real time processing
  - **Variety:**
    - data are often unstructured(texts, pictures, videos)
  - **Veracity:**
    - many Data are often not correct or real.



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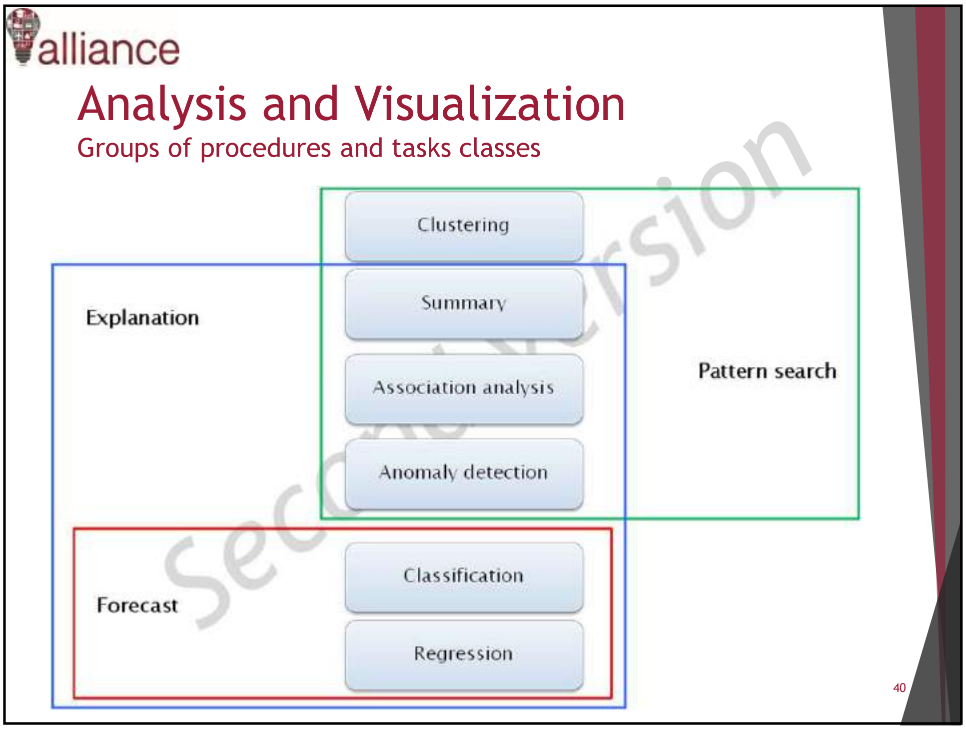
Analysis and Visualization

Groups of procedures

Classification	• arrange unknown data sets in predefined classes
Regression	• Determination of missing or future numeric values for data sets
Clustering	• Identification of a structure in unknown data sets
Summary	• Aggregation, summary or visualization of data sets
Association analysis	• Detect relationships between data sets
Anomaly detection	• detect outliers in data sets



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Analysis and Visualization

Groups of procedures and tasks classes

Pattern search

- Clustering
- Summary
- Association analysis
- Anomaly detection

Explanation

- Summary
- Association analysis
- Anomaly detection
- Classification
- Regression

Forecast

- Classification
- Regression

Analysis and Visualization

Development of the data volume

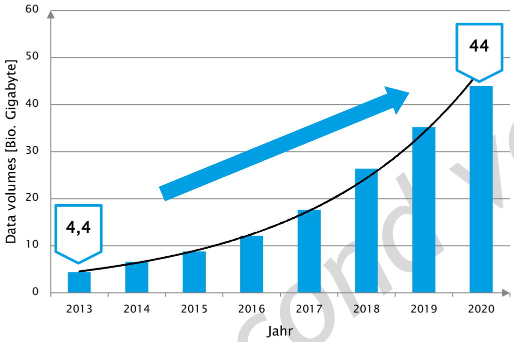

Abb. 1: development of data volume world wide, vgl. [Turner et al., 2014]

Drivers
- Auto-ID, localization and sensor technologies
- Industry 4.0

[Kagermann et al., 2013], [Turner et al., 2014]

In 2013:
- 80 % of data were managed by companies
- 22 % of data were suitable for analyses

[Turner et al., 2014]

Great potential to extract new information about the behavior of real systems

Only 1% of data were used for analyses by companies!

[Turner et al., 2014]

Analysis and Visualization

Data visualization

Bing Geoflow Excel tool – This is a sample of what one could do with Microsoft's Geoflow visualization tool for Excel 2013. Geoflow helps users map and explore both geographic and chronological data.

[8]

Popularity of Facebook usage – Instead of showing tables of data, the author created a visual image showing the usage pattern of Facebook. The intensity of the light indicates the popularity of the Facebook usage.

Analysis and Visualization

Data visualization

The next generation of visualization tools:

- Geo-spatial: plotting data on customizable maps with additional geographical information
- Time resolution: observing hourly, daily, weekly etc. patterns by easily switching between different time resolutions
- 3D: data depicted as 3D objects on a 3D globe for an immersive experience
- Animation: free navigation to different periods of time in the data and comparison capabilities
- Interaction: ability to pan or zoom to particular points and interact with them to display additional information

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Big Data Example

Google flue trends

- **Goal:** early detection of flue outbreaks
- **Assumption:** people with a flue are searching for the word flue on google more often than healthy persons
- **Data basis:** all search requests to google with a time stamp and a localization (IP-address)
- **Learning system:** comparison of the 50 million most common search phrases of the last 5 years with the flue data of the US Centers for Disease Control and Prevention
- **Result:** flue trends on a daily basis for more than 25 countries

```
Google Flu Trends - Germany
Copyright 2015 Google Inc.

Exported data may be used for any purpose,
If you choose to use the data, please attrib

Each week begins on the Sunday (Pacific Time
Data for the current week will be updated ea
Note: To open these files in a spreadsheet a
For more information, please visit http://ww

Date,Germany,Baden-Württemberg,Bayern,Berlin,
2003-09-28,839,,,,,,,,,,876,,,,,,
2003-10-05,1040,1207,1306,,,,,1296,,,995,,,,
2003-10-12,1171,1407,1432,,,,,1293,,946,1248,
2003-10-19,1310,1579,1562,1013,,,972,1238,,1
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2003-11-02,1055,1214,1112,1087,,,1152,1136,,
2003-11-09,1103,1241,1284,1034,,,1138,1233,,
2003-11-16,1142,1230,1326,1024,,,1074,1150,,
2003-11-23,991,1199,970,959,,,1132,1220,,105
2003-11-30,1071,1083,1108,924,939,,1134,1153,
2003-12-07,1287,1345,1398,1108,912,,1163,128
```

Big Data Example

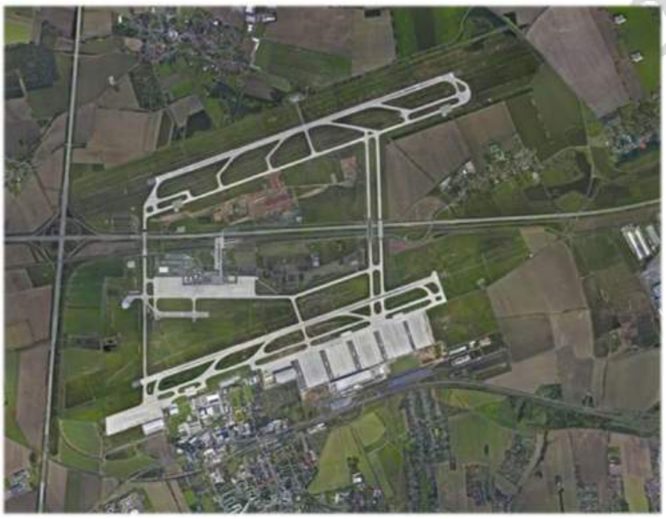
WATSON cognitive computing

- **Goal:** automated answering of questions in natural language
- **Data basis:** 200 Million book pages (Wikipedia, Bible, New York Times (10 years)
- **Method:** 2880 logical processor cores,

  15 terabyte memory
  - natural language processing,
  - machine learning,
  - logic,
  - search engine (full text search, semantic requests etc.)
  - miscellaneous heuristics
  - categorization
- **Result:** Watson won Jeopardy in 2011 against two human champions

Case-Study

Freight airport



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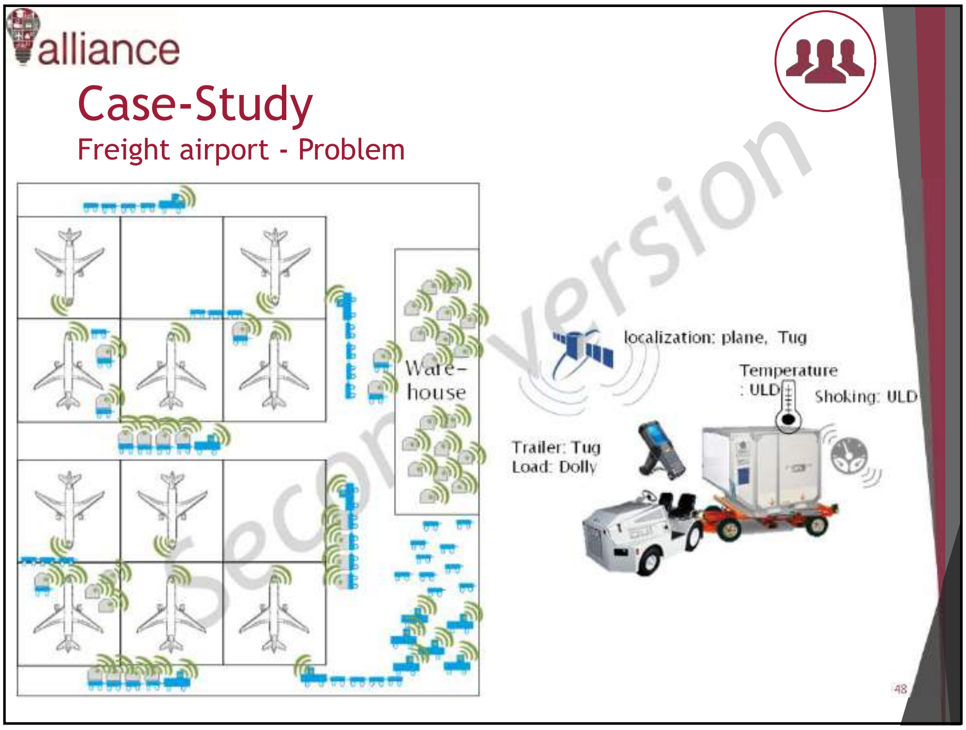
Case-Study

Freight airport

- In this first example of application, a simplified model of a real German freight airport is used as a logistical system. At the airport, aircraft containers are unloaded from the arriving aircraft, stored in the warehouse and subsequently loaded into the departing aircraft. The containers in question are partly refrigerated containers and contain fragile goods. It is assumed that all logistic objects of the cargo bay are equipped with auto-ID, localization and sensor technologies and thus state data are available for the monitoring the system.

- *What are the objective criteria according to which the system will be investigated?*
- *What methods can be used for data analysis?*
- *What are the possibilities of representation of error factors on the transport can be designed?*
- *What are applicable, future solutions?*



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Case-Study

Freight airport - Problem

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Case-Study

Freight airport – What is known?

- Type of objects
  - Means of transport:
    - Aircraft
    - Tug (as load suspension means, carrying the container)
    - Dolly (transport)
  - Loading unit:
    - Container → unit load device
  - What do we know about the container?
    - Localization: (aircraft, tug, warehouse)
    - Temperature: (cooling, not cooling)
    - Status (probably unharmed, broken)

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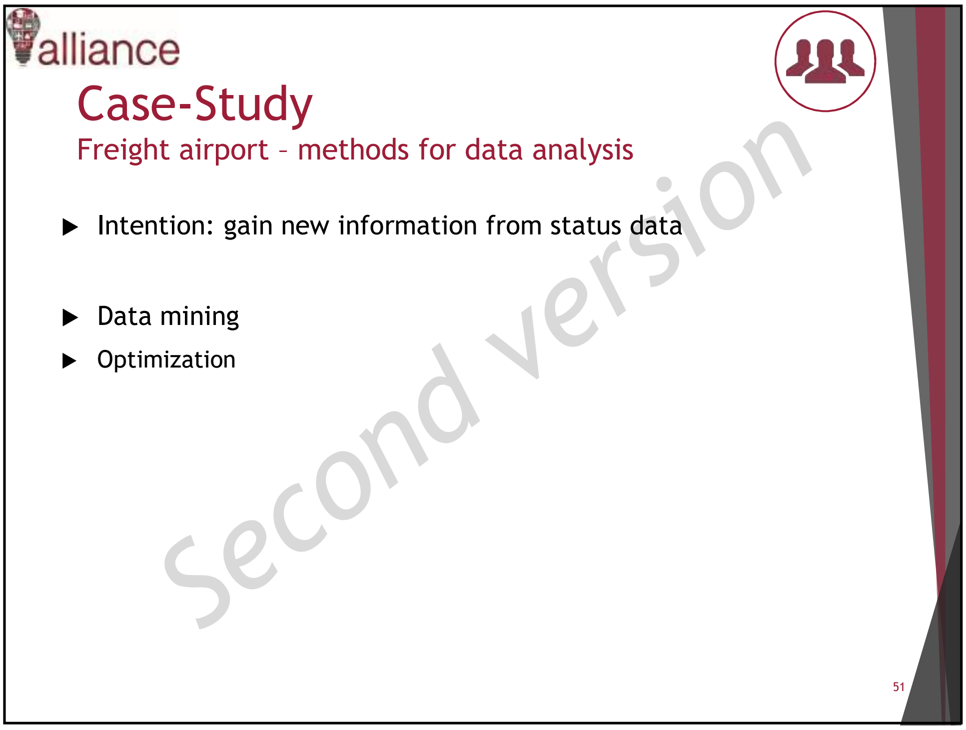
Case-Study

Freight airport – objective criteria

- Objective criteria for day-to-day business

- The 6 rights of logistics
  - The right product → the right container
  - In the right quantity → one per plane
  - In the right condition → right temperature and undamaged
  - To the right place → the right plane
  - At the right time → before departure
  - For the right cost → within the budget

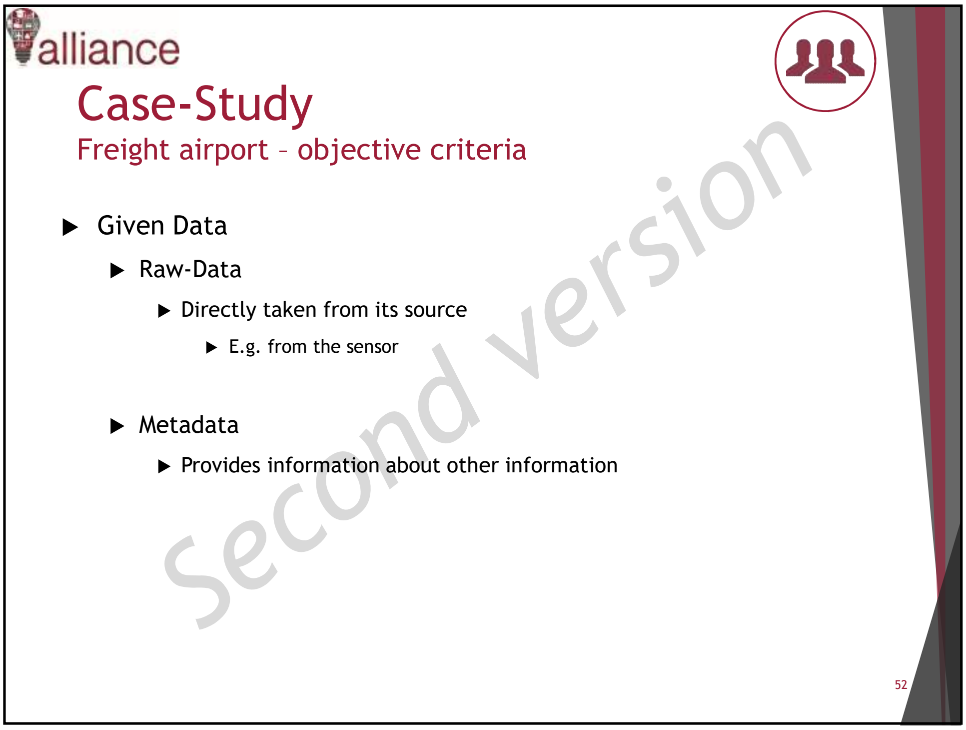


Case-Study

Freight airport – methods for data analysis

- Intention: gain new information from status data

- Data mining
- Optimization



Case-Study

Freight airport – objective criteria

- Given Data
  - Raw-Data
    - Directly taken from its source
      - E.g. from the sensor

  - Metadata
    - Provides information about other information

Case-Study

Freight airport - Raw data

No	Mandant	Device	ID	Time	Done	Batch	TimeStamp
50	1	61	74657874616720540002EEF7	2012-11-22 17:29:02.000	-1	3	0x000000000000D34C
61	1	62	74657874616720530006D761	2012-12-07 11:36:04.000	-1	3	0x0000000000751B06
62	1	62	74657874616720530006D77D	2012-12-07 11:36:04.000	-1	3	0x0000000000751B07
63	1	62	74657874616720530006A952	2012-12-07 11:37:27.000	-1	3	0x0000000000751B08
64	1	62	74657874616720530006A952	2012-12-07 11:38:10.000	-1	3	0x0000000000751B09
65	1	62	74657874616720530006A987	2012-12-07 11:38:18.000	-1	3	0x0000000000751B0A
66	1	62	74657874616720530006A984	2012-12-07 11:38:25.000	-1	3	0x0000000000751B0B
67	1	62	74657874616720540002EEF7	2012-12-07 11:38:33.000	-1	3	0x0000000000751B0C
68	1	62	74657874616720540002EF09	2012-12-07 11:38:37.000	-1	3	0x0000000000751B0D
69	1	62	74657874616720530006A99F	2012-12-07 11:38:42.000	-1	3	0x0000000000751B0E
70	1	62	74657874616720540002EF4E	2012-12-07 11:38:48.000	-1	3	0x0000000000751B0F
71	1	62	74657874616720540002EEF2	2012-12-07 11:38:53.000	-1	3	0x0000000000751B10
72	1	62	74657874616720540002EEF5	2012-12-07 11:38:59.000	-1	3	0x0000000000751B11
73	1	62	74657874616720530006D77E	2012-12-07 11:39:03.000	-1	3	0x0000000000751B12
74	1	62	74657874616720530006A986	2012-12-07 11:39:10.0			000000000751B13
75	1	62	74657874616720530006A9A0	2012-12-07 11:39:16.0			000000000751B14
76	1	62	74657874616720530006A989	2012-12-07 11:39:24.0			000000000751B15
77	1	62	74657874616720530006A988	2012-12-07 11:39:35.0			000000000751B16
78	1	62	74657874616720530006D758	2012-12-07 11:39:42.0			000000751B17
79	1	62	74657874616720530006D728	2012-12-07 11:39:43.000			000000751B18
80	1	62	74657874616720530006D760	2012-12-07 11:40:02.000	-1	3	0x0000000000751B19
81	1	62	74657874616720530006D777	2012-12-07 11:40:09.000	-1	3	0x0000000000751B1A
82	1	62	74657874616720530006D76C	2012-12-07 11:40:20.000	-1	3	0x0000000000751B1B
83	1	62	74657874616720530006D74D	2012-12-07 11:40:29.000	-1	3	0x0000000000751B1C
84	1	62	74657874616720530006D76B	2012-12-07 11:40:38.000	-1	3	0x0000000000751B1D
85	1	62	74657874616720530006D75B	2012-12-07 11:40:49.000	-1	3	0x0000000000751B1E
86	1	62	74657874616720530006D782	2012-12-07 11:40:59.000	-1	3	0x0000000000751B1F

> 50 data sets per minute

BIG DATA

Case-Study

Freight airport - Data protocol – structure of meta data

ULD	plane	Dolly	Tug	Ware–house	Stand	Transport route	Pool
ID	ID	ID	ID	ID	ID	ID	ID
time	time	time	time	time	time	time	time
localization	localization	localization	localization	content	content	content	content
status	status	status	status	–	–	–	–
shock	content	content	trailer	–			
cooling	–	–	–	–	–	–	–

Aggregation of the raw data of the acceleration sensor

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Case-Study

Freight airport - Data protocol – structure of meta data

ULD
- ID
- time
- localization
- status
- shock
- cooling

ID	time	place	status	shock	cooling
ULD033	23:47:00	Dolly17	Transport	0	1
ULD041	23:47:03	warehouse	storage	0	0
ULD035	23:47:33	Dolly18	Transport	0	0
ULD043	23:49:33	warehouse	storage	0	0
ULD053	23:50:00	Dolly27	Transport	0	0
ULD045	23:50:03	warehouse	storage	0	0
ULD047	23:50:33	warehouse	storage	0	0
ULD055	23:51:00	Dolly28	Transport	0	0
ULD049	23:51:03	warehouse	storage	0	0
ULD043	23:51:33	Dolly22	Transport	0	0
ULD057	23:52:00	Dolly29	Transport	0	0
ULD051	23:52:00	Dolly26	Transport	1	0
ULD053	23:52:00	Dolly27	Transport	1	0
ULD055	23:52:00	Dolly28	Transport	1	0
ULD057	23:52:00	Dolly29	Transport	1	0
ULD045	23:52:03	Dolly23	Transport	0	0
ULD047	23:52:33	Dolly24	Transport	0	0

Pool
- ID
- time
- content
- –
- –

data of
nsor

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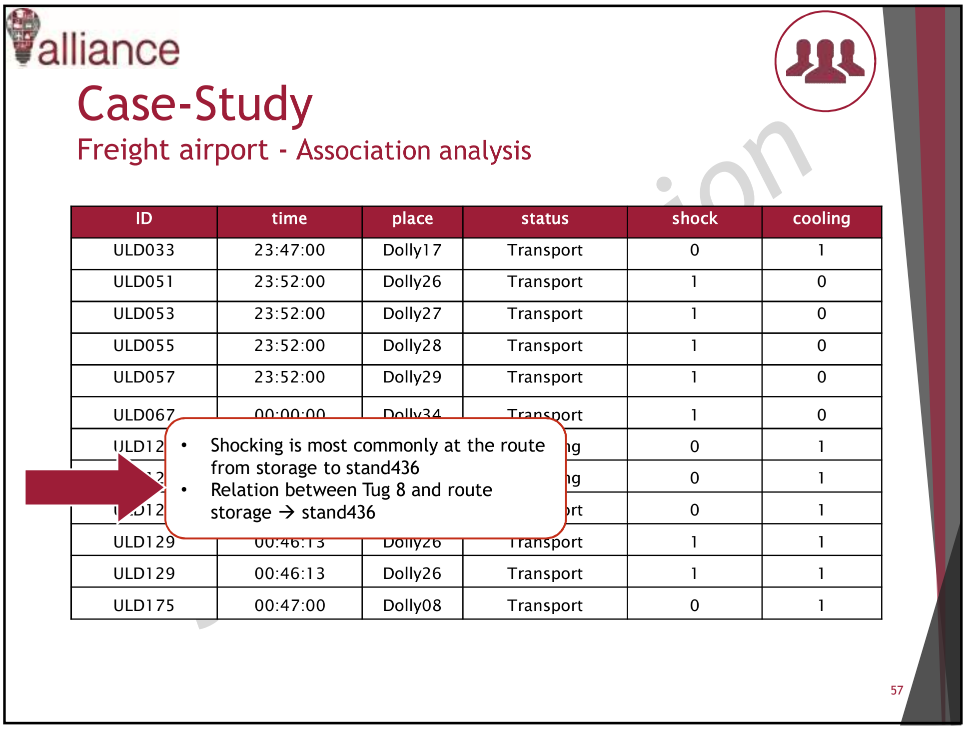
Case-Study

Freight airport – methods for data analysis – data mining

- Data mining: extract patterns
- Dependence analysis
  - Find dependences within data
    - No hierarchic ranking possible → data is a list of moments and the state of the container at this moment
    - Find connections within data → association analysis
      - Find rules with association analysis
        - E.g. shaken ULD → broken content
      - Find typical procedure for container handling



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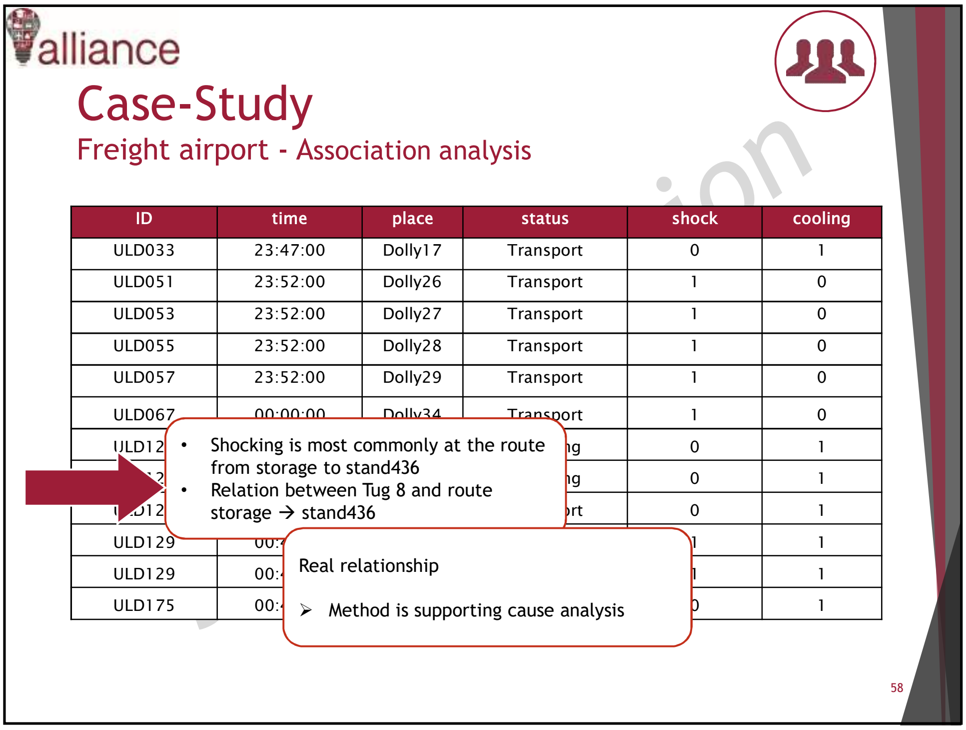
Case-Study

Freight airport - Association analysis

ID	time	place	status	shock	cooling
ULD033	23:47:00	Dolly17	Transport	0	1
ULD051	23:52:00	Dolly26	Transport	1	0
ULD053	23:52:00	Dolly27	Transport	1	0
ULD055	23:52:00	Dolly28	Transport	1	0
ULD057	23:52:00	Dolly29	Transport	1	0
ULD067	00:00:00	Dolly34	Transport	1	0
ULD12			ng	0	1
2			ng	0	1
D12			rt	0	1
ULD129	00:46:13	Dolly26	Transport	1	1
ULD129	00:46:13	Dolly26	Transport	1	1
ULD175	00:47:00	Dolly08	Transport	0	1

- Shocking is most commonly at the route from storage to stand436
- Relation between Tug 8 and route storage → stand436



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Case-Study

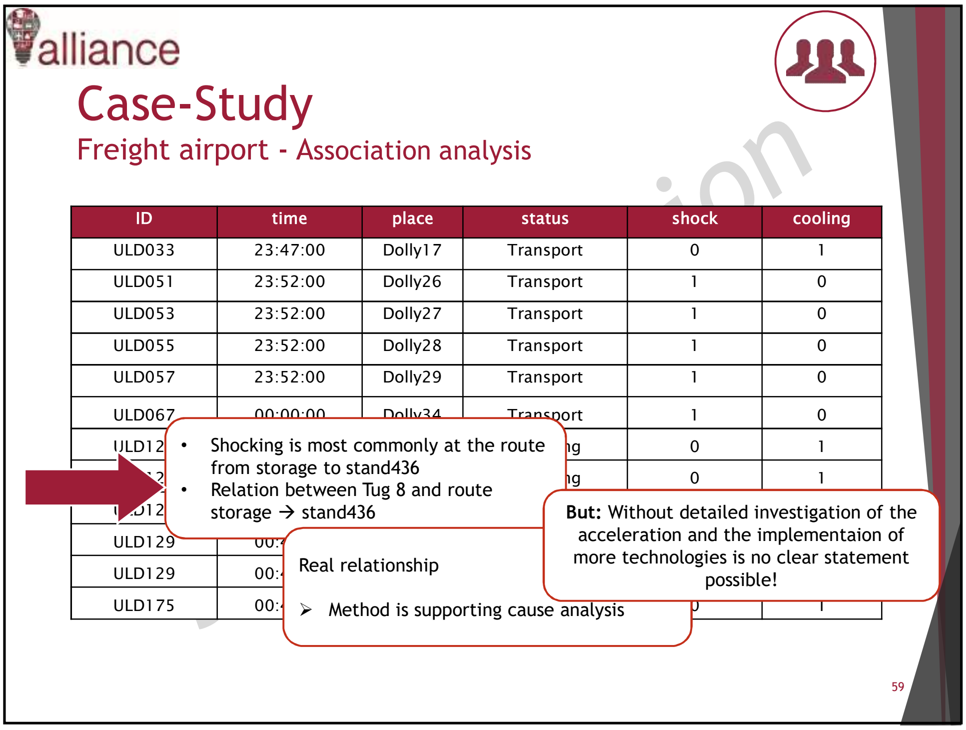
Freight airport - Association analysis

ID	time	place	status	shock	cooling
ULD033	23:47:00	Dolly17	Transport	0	1
ULD051	23:52:00	Dolly26	Transport	1	0
ULD053	23:52:00	Dolly27	Transport	1	0
ULD055	23:52:00	Dolly28	Transport	1	0
ULD057	23:52:00	Dolly29	Transport	1	0
ULD067	00:00:00	Dolly34	Transport	1	0
ULD12			ng	0	1
2			ng	0	1
D12			rt	0	1
ULD129	00:			1	1
ULD129	00:			1	1
ULD175	00:			0	1

- Shocking is most commonly at the route from storage to stand436
- Relation between Tug 8 and route storage → stand436

Real relationship

- Method is supporting cause analysis



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Case-Study

Freight airport - Association analysis

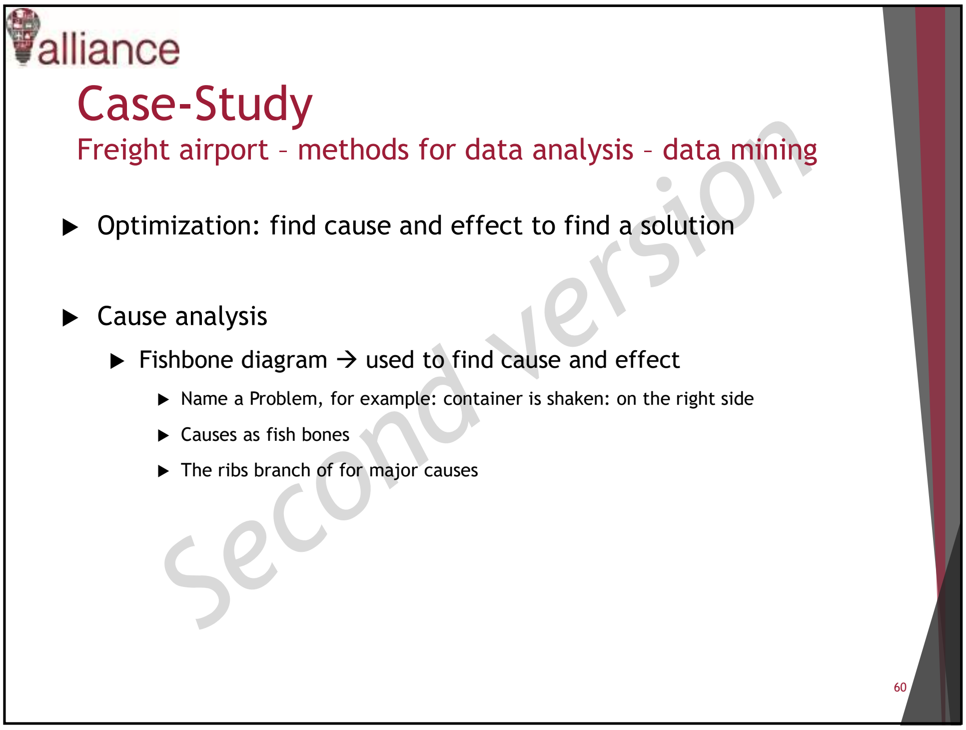
ID	time	place	status	shock	cooling
ULD033	23:47:00	Dolly17	Transport	0	1
ULD051	23:52:00	Dolly26	Transport	1	0
ULD053	23:52:00	Dolly27	Transport	1	0
ULD055	23:52:00	Dolly28	Transport	1	0
ULD057	23:52:00	Dolly29	Transport	1	0
ULD067	00:00:00	Dolly34	Transport	1	0
ULD12			ng	0	1
2			ng	0	1
D12					
ULD129	00:				
ULD129	00:				
ULD175	00:			0	1

- Shocking is most commonly at the route from storage to stand436
- Relation between Tug 8 and route storage → stand436

Real relationship

➢ Method is supporting cause analysis

But: Without detailed investigation of the acceleration and the implementaion of more technologies is no clear statement possible!



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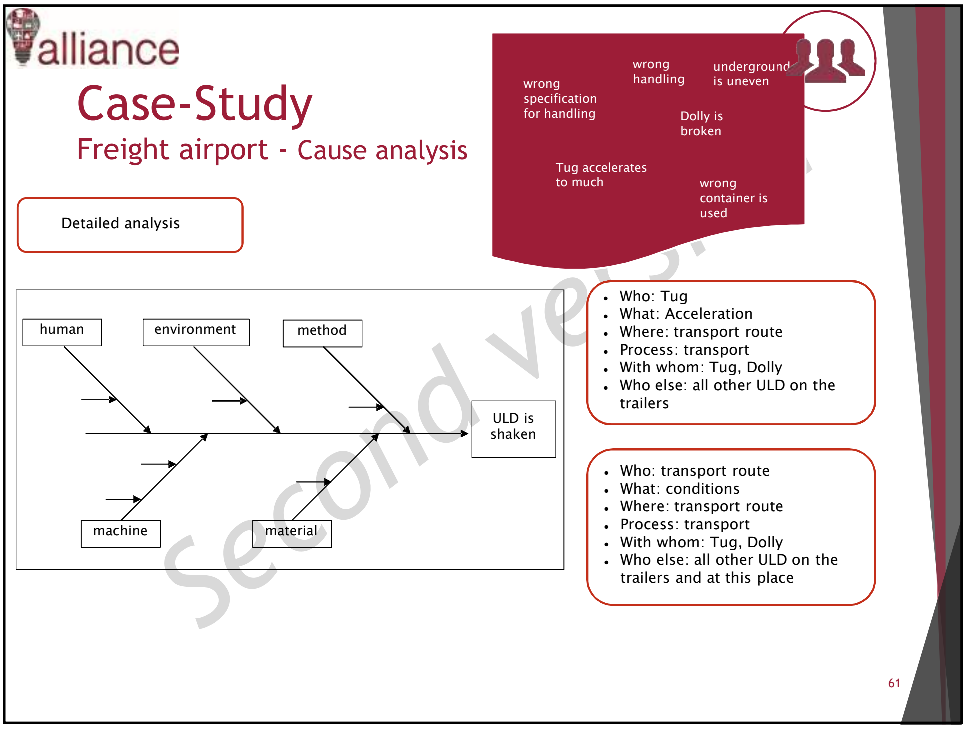
Case-Study

Freight airport – methods for data analysis – data mining

- Optimization: find cause and effect to find a solution
- Cause analysis
  - Fishbone diagram → used to find cause and effect
    - Name a Problem, for example: container is shaken: on the right side
    - Causes as fish bones
    - The ribs branch of for major causes



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Case-Study

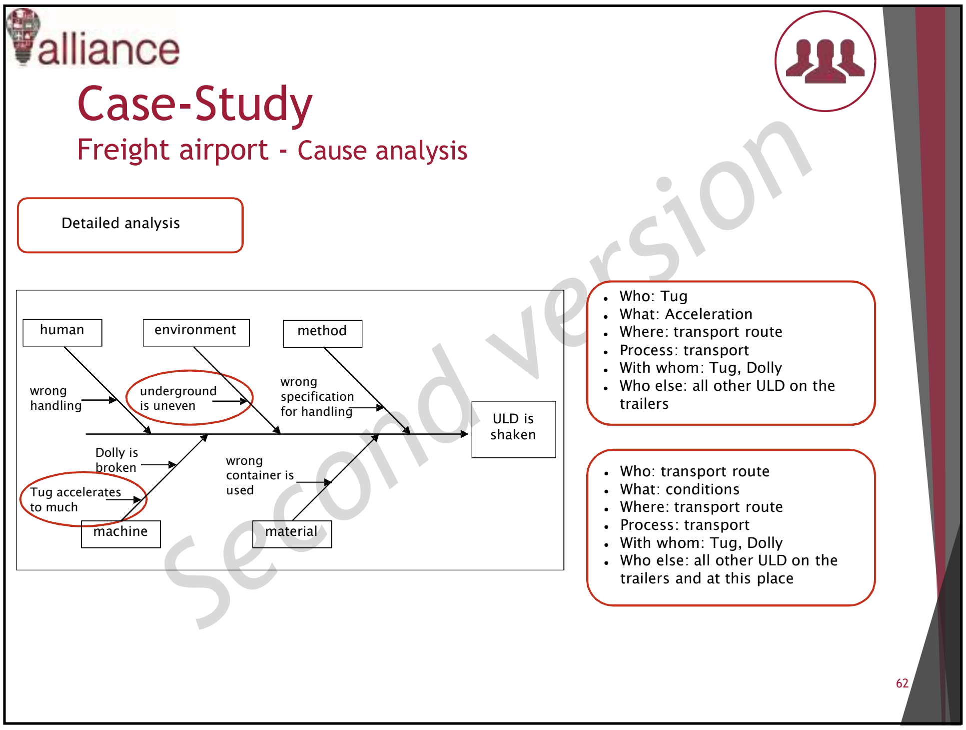
Freight airport - Cause analysis

Detailed analysis

wrong specification for handling
wrong handling
underground is uneven
Dolly is broken
Tug accelerates to much
wrong container is used

- Who: Tug
- What: Acceleration
- Where: transport route
- Process: transport
- With whom: Tug, Dolly
- Who else: all other ULD on the trailers

- Who: transport route
- What: conditions
- Where: transport route
- Process: transport
- With whom: Tug, Dolly
- Who else: all other ULD on the trailers and at this place



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Case-Study

Freight airport - Cause analysis

Detailed analysis

- Who: Tug
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- Who: transport route
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- Where: transport route
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- With whom: Tug, Dolly
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Case-Study

Freight airport – future solutions

- Underground is uneven
  - New asphalt application with better fundament
- Tug accelerates to much
  - Mayhap already solved with new underground
  - Slower acceleration over longer period of time

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Case-Study

Summary

Results obtained by the use of:

- **Data fusion**
  (consolidate data produced by multiple sources)
- **Data mining**
  (techniques to extract patterns from large data sets)
- **Visualization**
  (techniques used for generating diagrams or animations to communicate the results of data analysis)
- **Optimization**
  (techniques to reorganize complex systems and processes to improve their performance)

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Case-Study

Summary

Results provide us information about:

- **Origin of the data sets / volume**
- **Identification of interference and influences**
- **Cause-effect studies**
- **Derivation of recommendations**

- Only a small extract could be viewed. Large amounts of data are useful, but the analyzes have to be more accurate. This may result in overload and misdirection.

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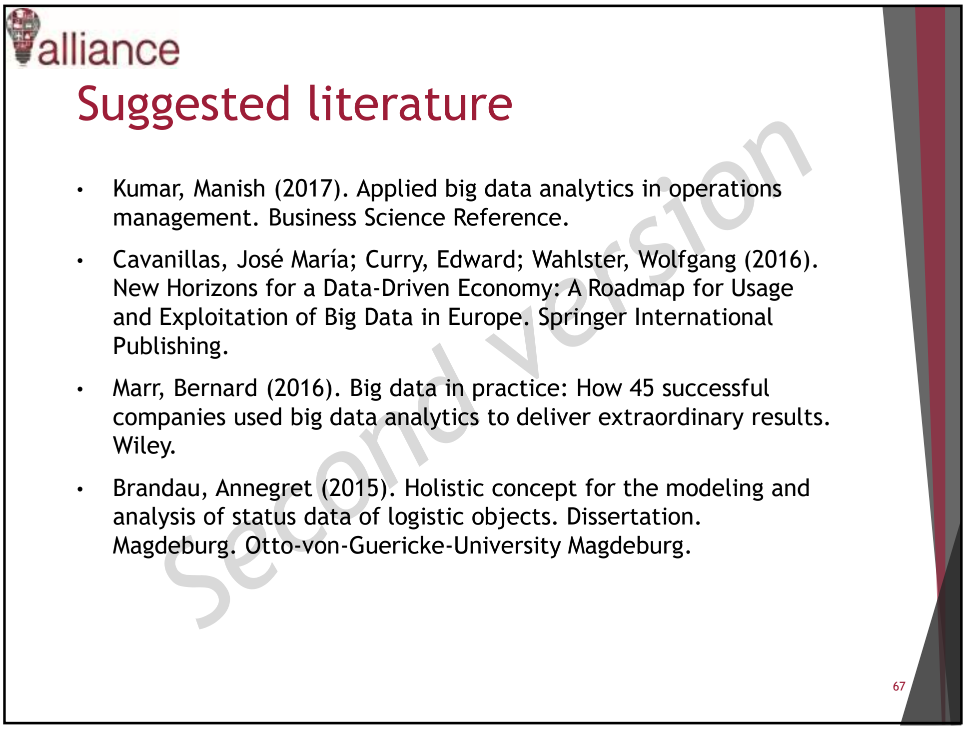
Thanks for your attention!

David Weigert, M. Sc.
Fraunhofer Institute for Factory Operation and Automation IFF Magdeburg
david.weigert@iff.fraunhofer.de

Sandtorstraße 22
39106 Magdeburg



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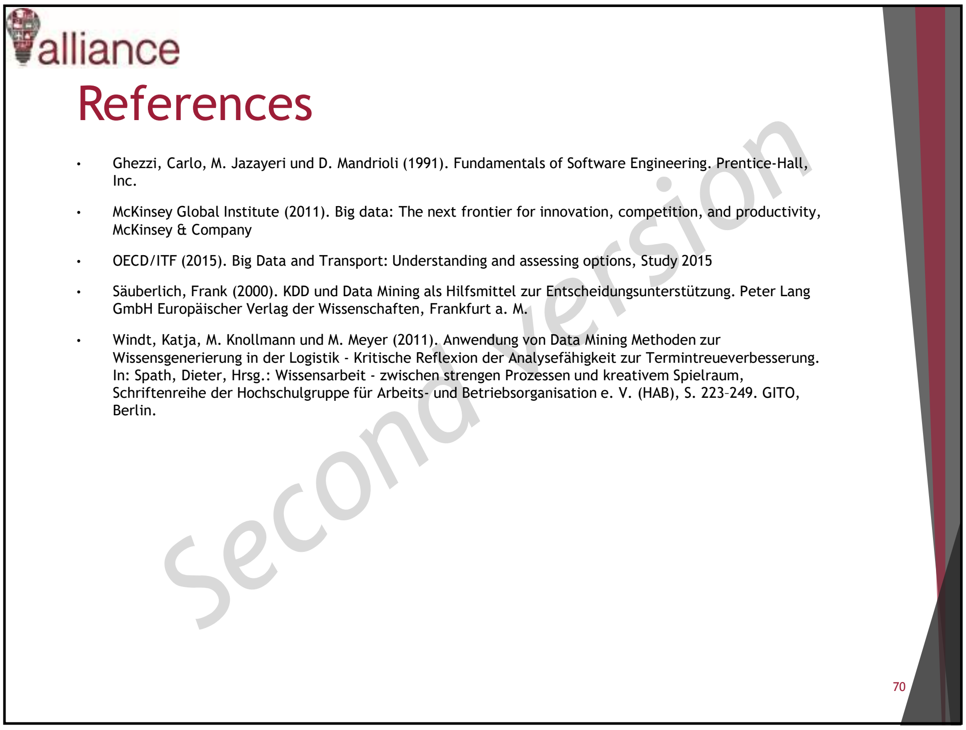

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Thank you for your kind attention!

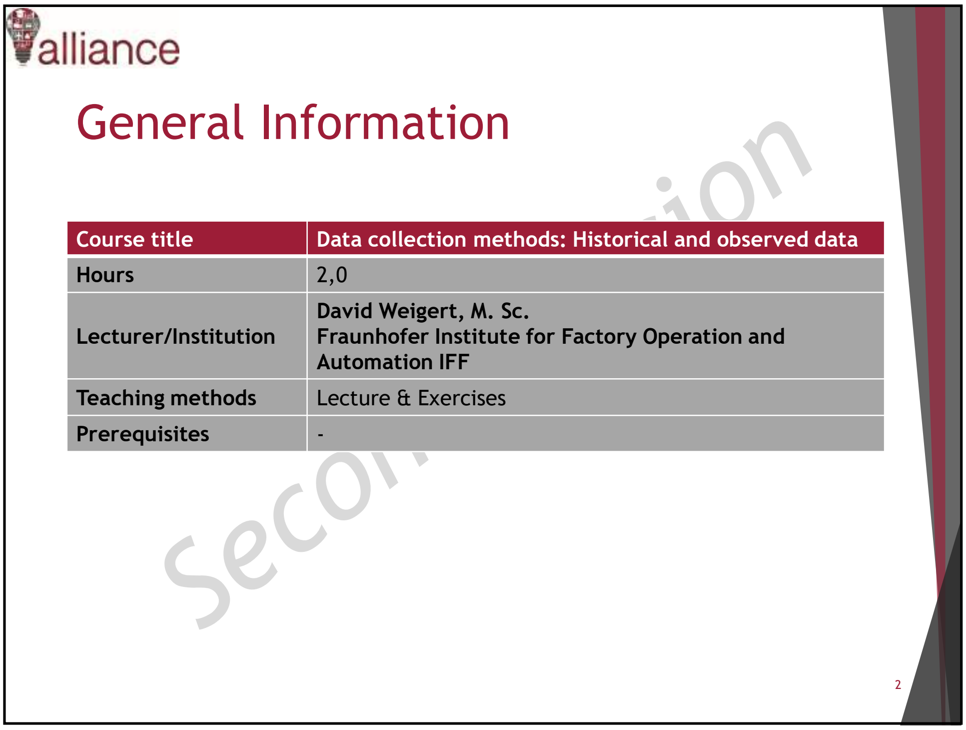
Data collection methods: Historical and observed data

Passenger Transport

M.Sc. David Weigert

Fraunhofer Institute for Factory Operation and Automation IFF
Magdeburg, Germany

This project has received funding from the *European Union's Horizon 2020 research and innovation programme* under grant agreement No 692426



General Information

Course title	Data collection methods: Historical and observed data
Hours	2,0
Lecturer/Institution	**David Weigert, M. Sc.** **Fraunhofer Institute for Factory Operation and Automation IFF**
Teaching methods	Lecture & Exercises
Prerequisites	-

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Aim and Learning Outcomes

Aims:

- Participants receive a basic introduction how real-time data and technological advancements facilitate decision making in passenger transport
- Overview of quantitative methods in data collection for passenger transport
- Get introduced to Big Data, Data Science and Data Analytics
- Enable to give conclusions from theory to practice in case of passenger transport

Outcomes:

- Acquire basic knowledge of **Big Data, Data Science and Data Analytics**
- Acquire knowledge about **using of Big Data and Data Analytics in passenger transportation**
- Enable the analysis and **definition of complex data analysis**

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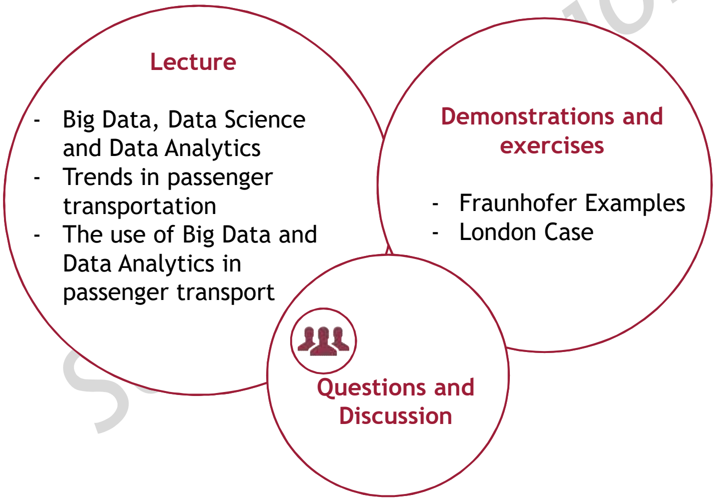
Structure



Lecture

- Big Data, Data Science and Data Analytics
- Trends in passenger transportation
- The use of Big Data and Data Analytics in passenger transport

Demonstrations and exercises

- Fraunhofer Examples
- London Case

Questions and Discussion

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Content

- Introduction
- Quantitative and Qualitative
- Big Data, Data Science and Data Analytics in passenger transport
- Analysis and Visualization
- Big Data Example
- Case-Study - London
- Summary

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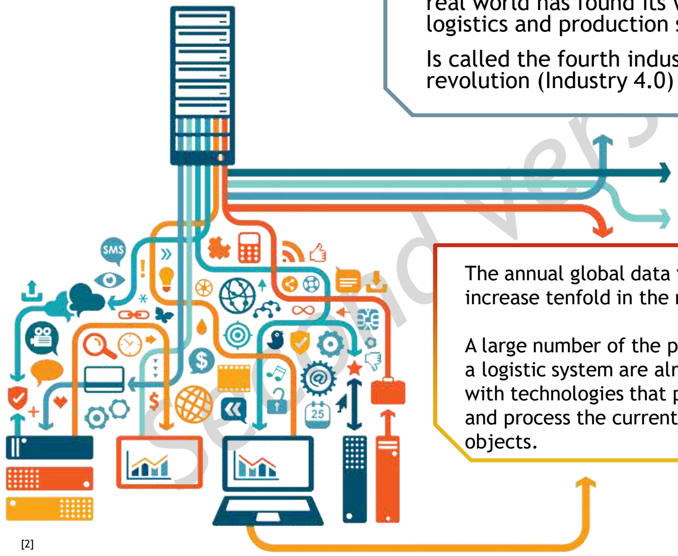
Introduction

The integration of digital into the real world has found its way into logistics and production systems

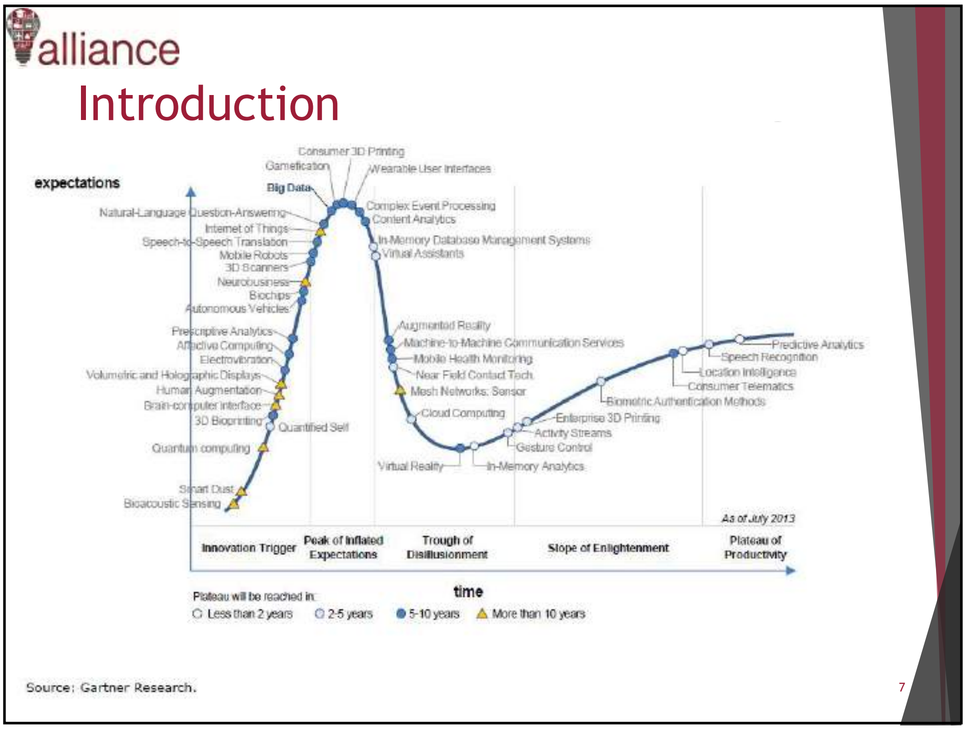
Is called the fourth industrial revolution (Industry 4.0) or IoT.



The annual global data volume will increase tenfold in the next few years.

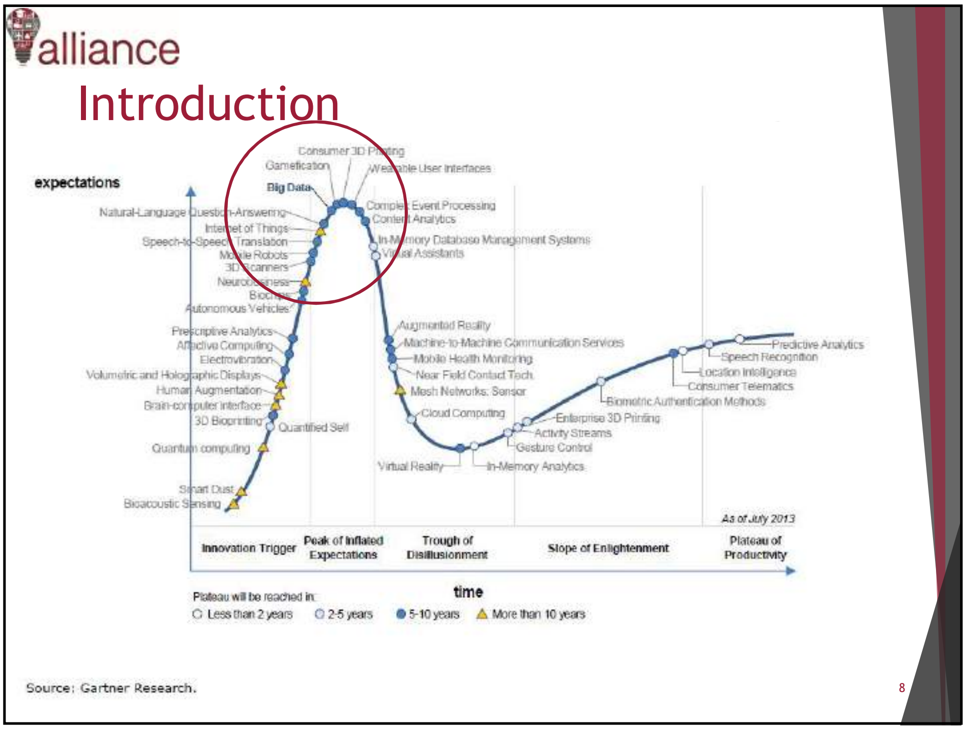
A large number of the physical objects of a logistic system are already equipped with technologies that permanently record and process the current states of the objects.

[2]



Introduction

Source: Gartner Research.



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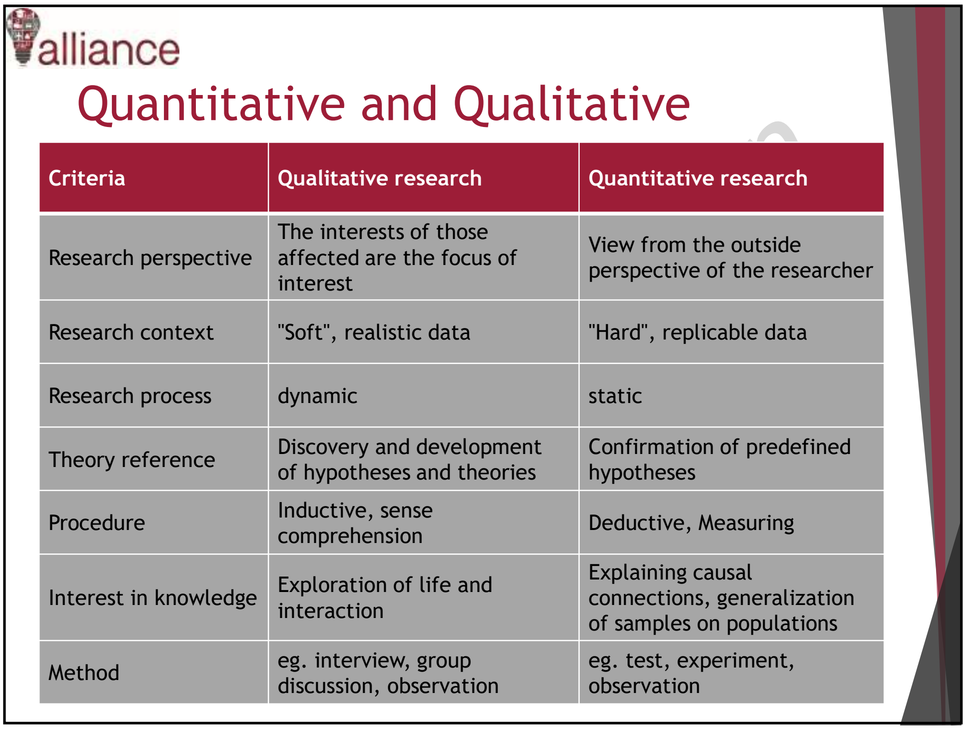

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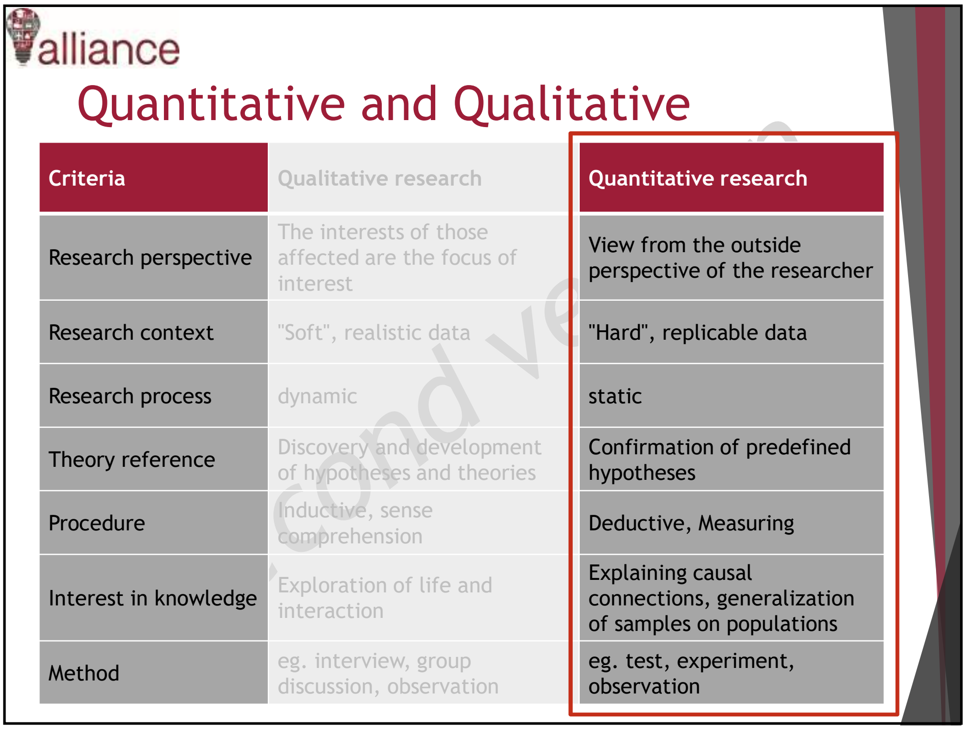
Quantitative and Qualitative

Criteria	Qualitative research	Quantitative research
Research perspective	The interests of those affected are the focus of interest	View from the outside perspective of the researcher
Research context	"Soft", realistic data	"Hard", replicable data
Research process	dynamic	static
Theory reference	Discovery and development of hypotheses and theories	Confirmation of predefined hypotheses
Procedure	Inductive, sense comprehension	Deductive, Measuring
Interest in knowledge	Exploration of life and interaction	Explaining causal connections, generalization of samples on populations
Method	eg. interview, group discussion, observation	eg. test, experiment, observation



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Quantitative Methods

- **Quantitative methods describe (for passenger transport):**
  - Different methods of descriptive statistics
  - Discrete and continuous distribution functions
  - Laws of probability
  - Methods of closing statistics, e.g. Confidence intervals and hypothesis tests
  - Importance of operations research
  - Models and methods of linear programming to solve planning problems
  - Methods and techniques of transport planning as well as the concepts of network theory and selected methods of network optimization, e.g. Method for determining the shortest path
  - Round trip and tour planning problems and methods for their solution
  - Surveys, interviews, traffic counts, etc.

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Big Data, Data Science and Data Analytics

[4]

Big Data, Data Science and Data Analytics

The Big Data Value Chain

- Big Data may be as important to business and society as the Internet since more data leads to more accurate analyses

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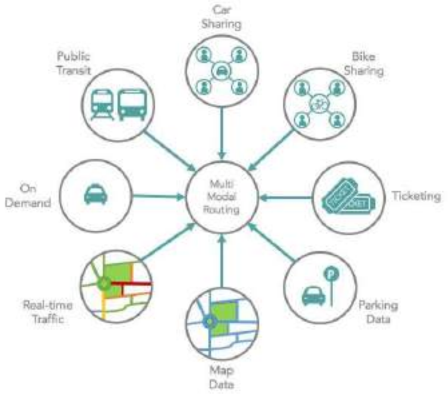
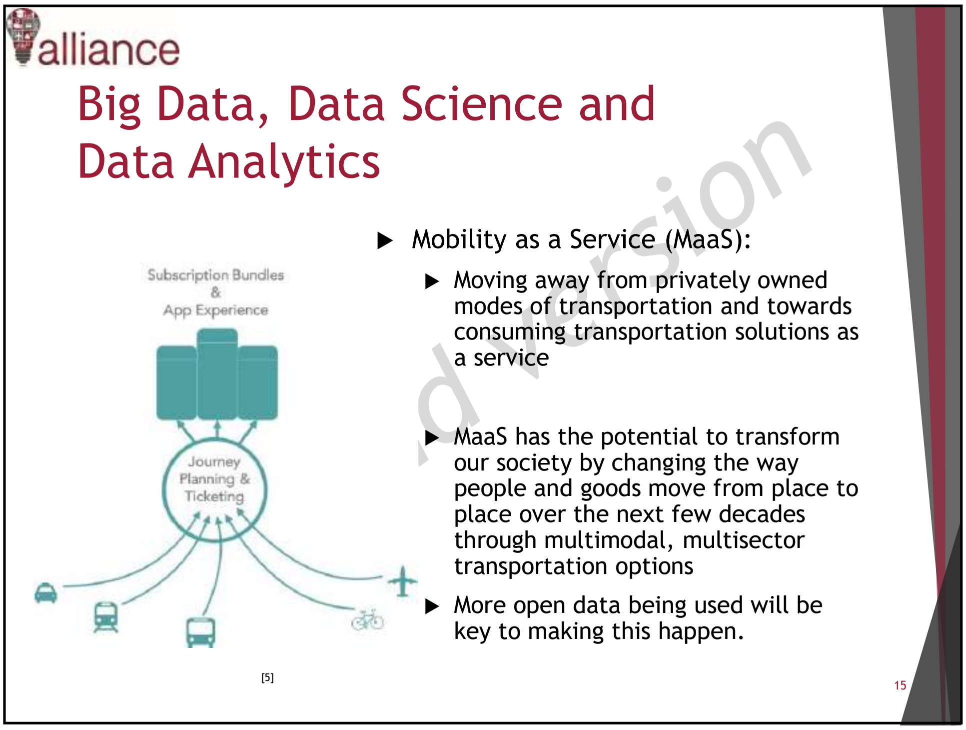
Big Data, Data Science and Data Analytics



- Personal data collection
- Transport-related data collection



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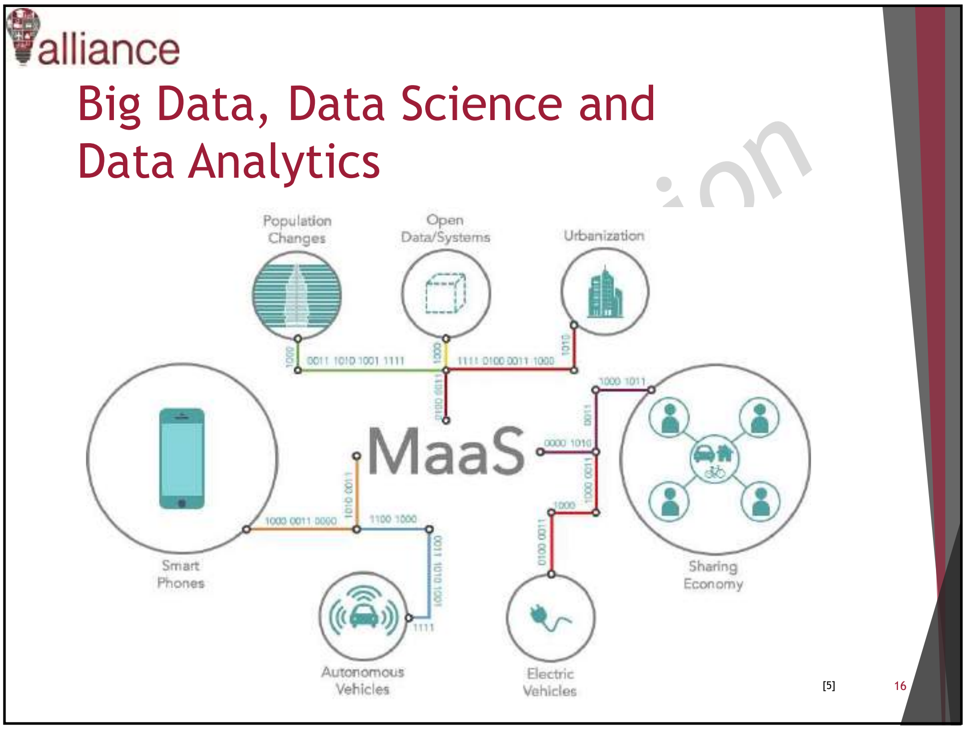
Big Data, Data Science and Data Analytics

- Mobility as a Service (MaaS):
  - Moving away from privately owned modes of transportation and towards consuming transportation solutions as a service
  - MaaS has the potential to transform our society by changing the way people and goods move from place to place over the next few decades through multimodal, multisector transportation options
  - More open data being used will be key to making this happen.

[5]



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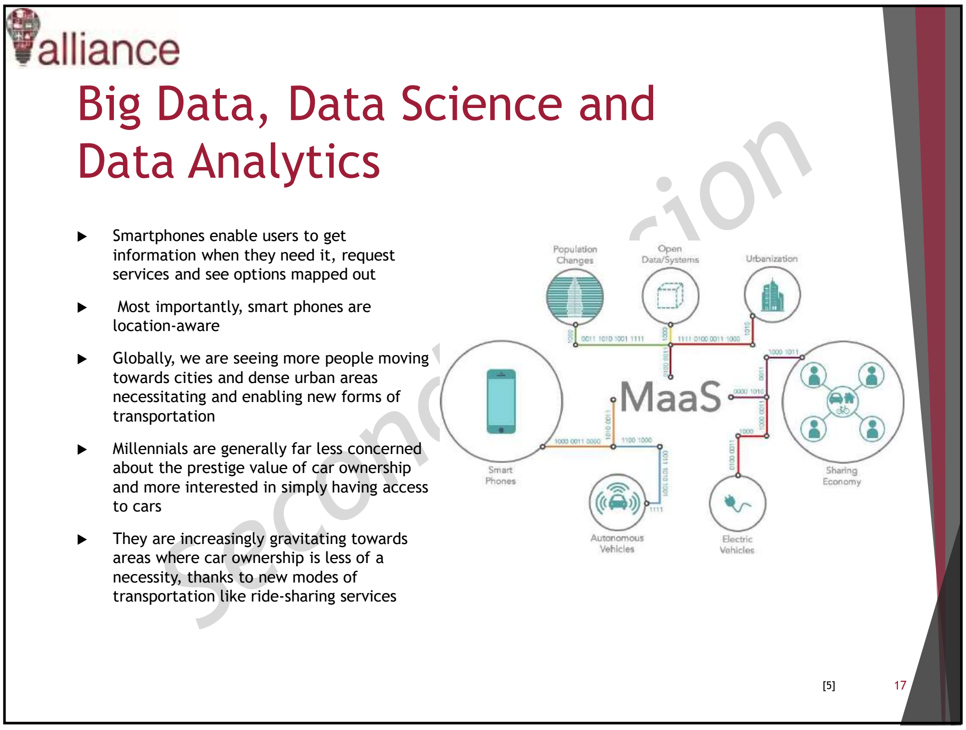
Big Data, Data Science and Data Analytics

[5]



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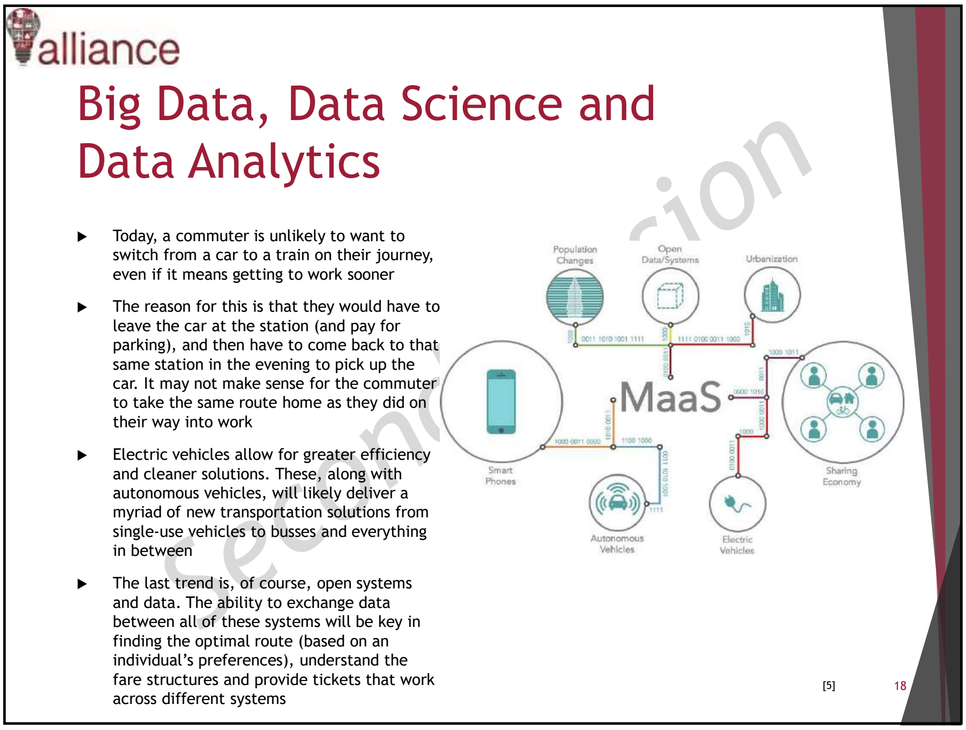
Big Data, Data Science and Data Analytics

- Smartphones enable users to get information when they need it, request services and see options mapped out
- Most importantly, smart phones are location-aware
- Globally, we are seeing more people moving towards cities and dense urban areas necessitating and enabling new forms of transportation
- Millennials are generally far less concerned about the prestige value of car ownership and more interested in simply having access to cars
- They are increasingly gravitating towards areas where car ownership is less of a necessity, thanks to new modes of transportation like ride-sharing services

[5]



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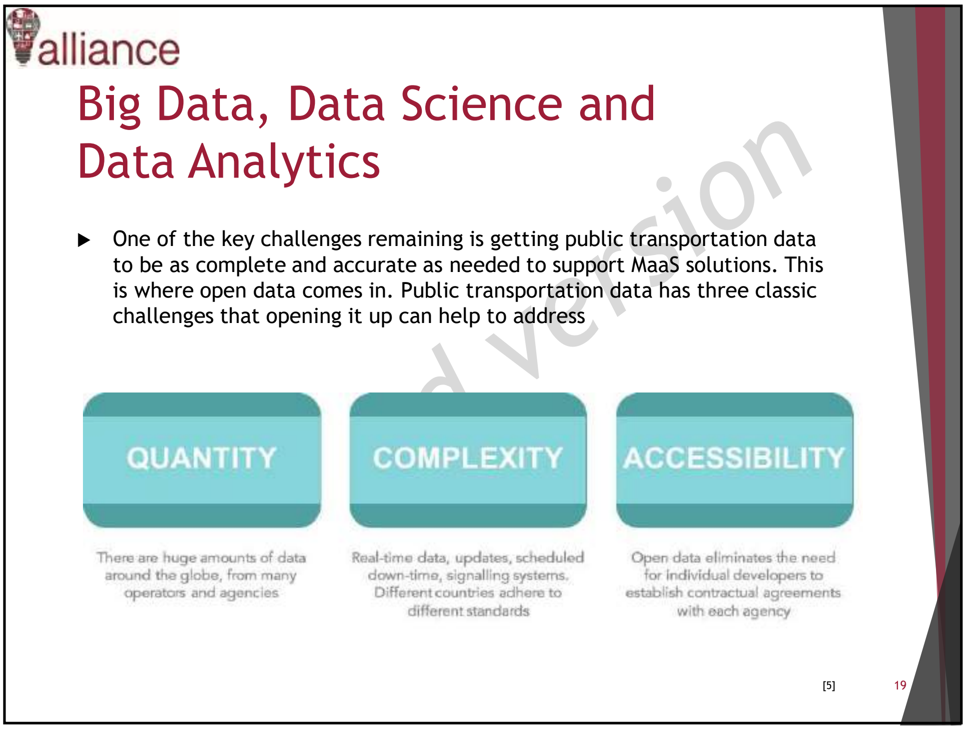
Big Data, Data Science and Data Analytics

- Today, a commuter is unlikely to want to switch from a car to a train on their journey, even if it means getting to work sooner
- The reason for this is that they would have to leave the car at the station (and pay for parking), and then have to come back to that same station in the evening to pick up the car. It may not make sense for the commuter to take the same route home as they did on their way into work
- Electric vehicles allow for greater efficiency and cleaner solutions. These, along with autonomous vehicles, will likely deliver a myriad of new transportation solutions from single-use vehicles to busses and everything in between
- The last trend is, of course, open systems and data. The ability to exchange data between all of these systems will be key in finding the optimal route (based on an individual's preferences), understand the fare structures and provide tickets that work across different systems

[5]



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Big Data, Data Science and Data Analytics

- One of the key challenges remaining is getting public transportation data to be as complete and accurate as needed to support MaaS solutions. This is where open data comes in. Public transportation data has three classic challenges that opening it up can help to address

QUANTITY

There are huge amounts of data around the globe, from many operators and agencies

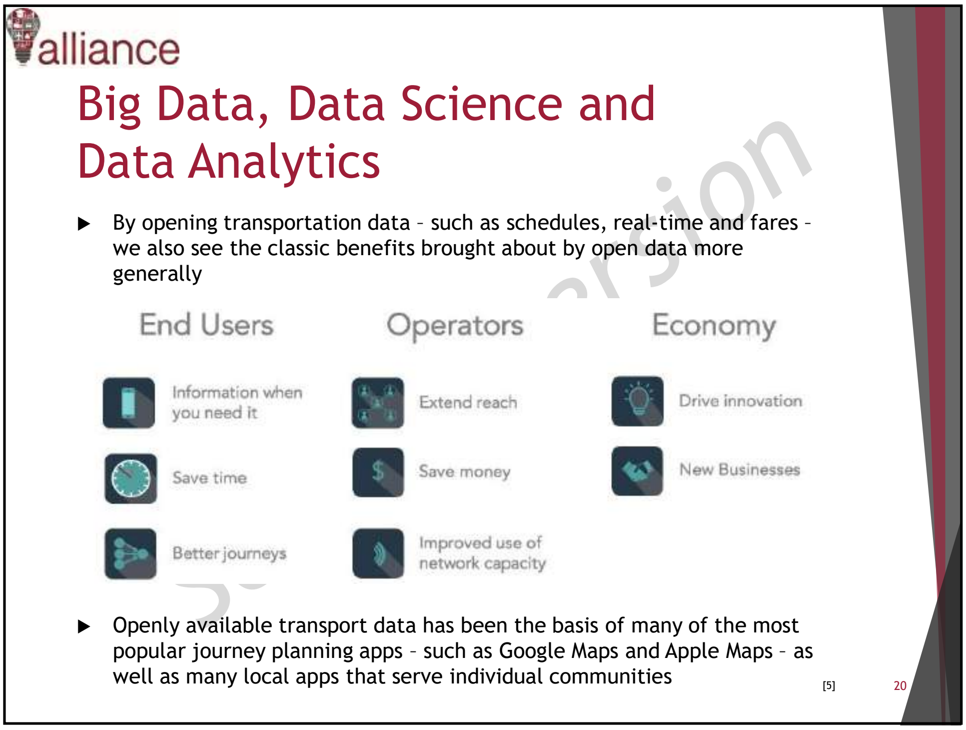
COMPLEXITY

Real-time data, updates, scheduled down-time, signalling systems. Different countries adhere to different standards

ACCESSIBILITY

Open data eliminates the need for individual developers to establish contractual agreements with each agency

[5] 19



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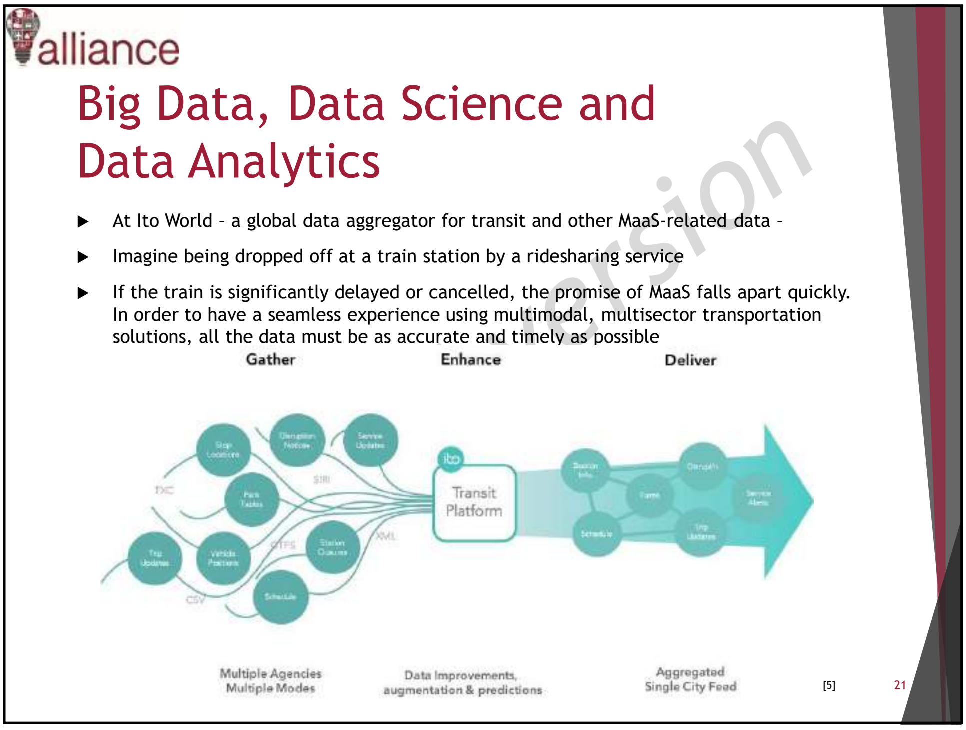
Big Data, Data Science and Data Analytics

- By opening transportation data – such as schedules, real-time and fares – we also see the classic benefits brought about by open data more generally

End Users	Operators	Economy
Information when you need it	Extend reach	Drive innovation
Save time	Save money	New Businesses
Better journeys	Improved use of network capacity	

- Openly available transport data has been the basis of many of the most popular journey planning apps – such as Google Maps and Apple Maps – as well as many local apps that serve individual communities

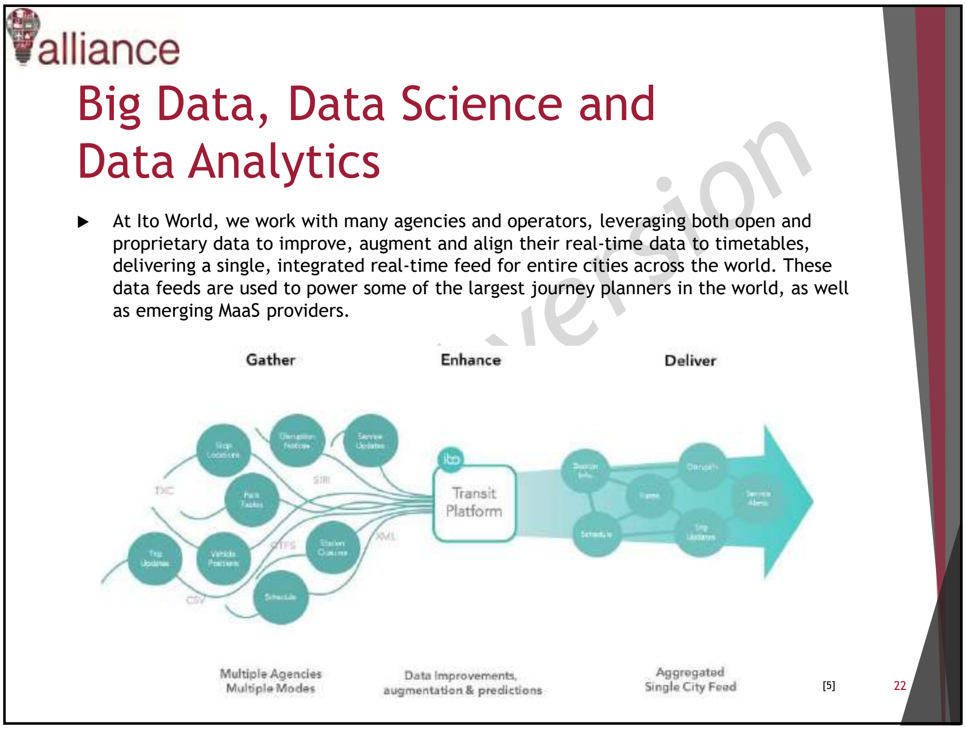
[5] 20



Big Data, Data Science and Data Analytics

- At Ito World – a global data aggregator for transit and other MaaS-related data –
- Imagine being dropped off at a train station by a ridesharing service
- If the train is significantly delayed or cancelled, the promise of MaaS falls apart quickly. In order to have a seamless experience using multimodal, multisector transportation solutions, all the data must be as accurate and timely as possible

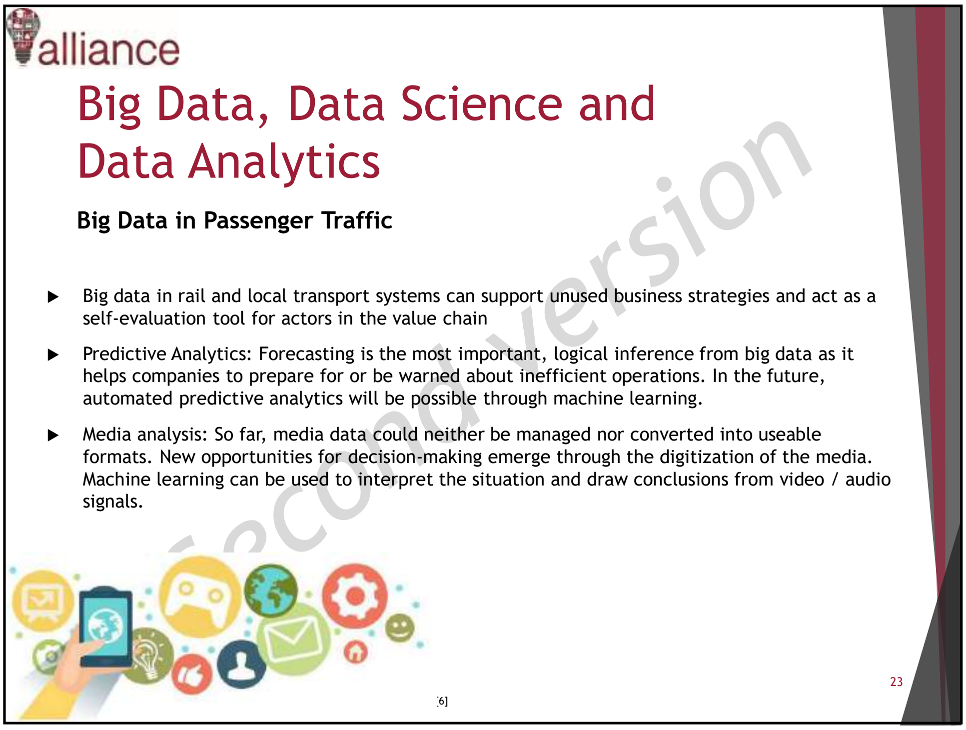
[5]



Big Data, Data Science and Data Analytics

- At Ito World, we work with many agencies and operators, leveraging both open and proprietary data to improve, augment and align their real-time data to timetables, delivering a single, integrated real-time feed for entire cities across the world. These data feeds are used to power some of the largest journey planners in the world, as well as emerging MaaS providers.

[5]



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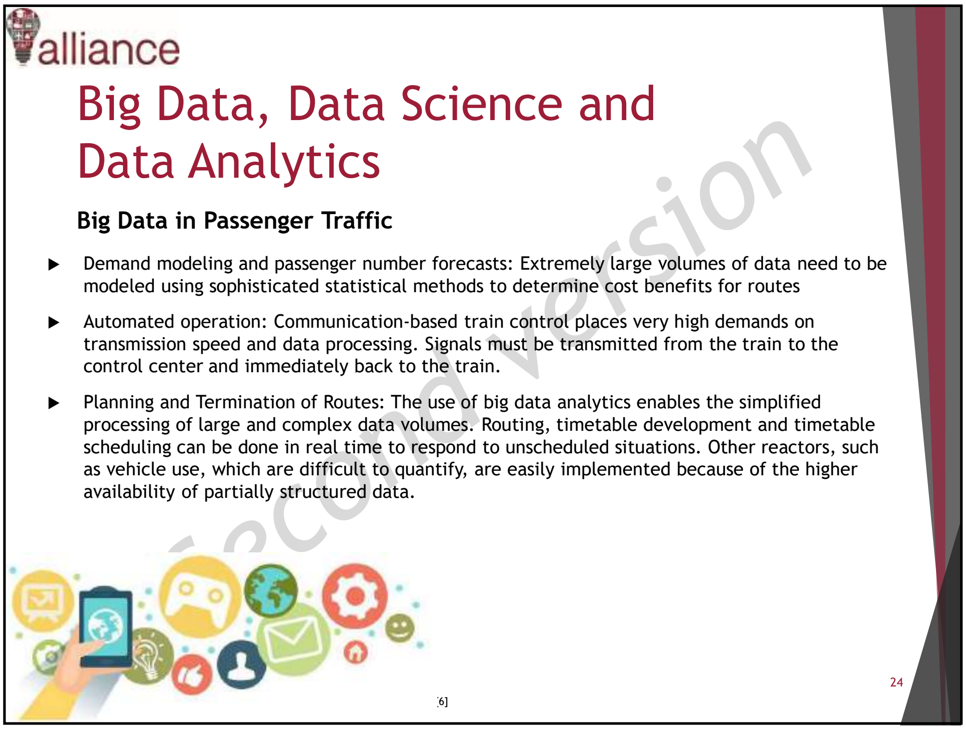
Big Data, Data Science and Data Analytics

Big Data in Passenger Traffic

- Big data in rail and local transport systems can support unused business strategies and act as a self-evaluation tool for actors in the value chain
- Predictive Analytics: Forecasting is the most important, logical inference from big data as it helps companies to prepare for or be warned about inefficient operations. In the future, automated predictive analytics will be possible through machine learning.
- Media analysis: So far, media data could neither be managed nor converted into useable formats. New opportunities for decision-making emerge through the digitization of the media. Machine learning can be used to interpret the situation and draw conclusions from video / audio signals.

[6]



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Big Data, Data Science and Data Analytics

Big Data in Passenger Traffic

- Demand modeling and passenger number forecasts: Extremely large volumes of data need to be modeled using sophisticated statistical methods to determine cost benefits for routes
- Automated operation: Communication-based train control places very high demands on transmission speed and data processing. Signals must be transmitted from the train to the control center and immediately back to the train.
- Planning and Termination of Routes: The use of big data analytics enables the simplified processing of large and complex data volumes. Routing, timetable development and timetable scheduling can be done in real time to respond to unscheduled situations. Other reactors, such as vehicle use, which are difficult to quantify, are easily implemented because of the higher availability of partially structured data.

[6]

Big Data, Data Science and Data Analytics

Big Data in Passenger Traffic

- Automatic vehicle tracking: changing service offerings based on real-time demand analytics, integration of passenger information systems and social media customer mood analysis
- Automated payment systems: Data collection is the core task of automated payment systems. In a much used transportation system, over one million transactions per day could take place. In previous ticketing systems, sales data was available only at the point of purchase. In the case of automated payment systems, data is now monitored and marked at the point of sale, at the point of discharge when entering the transport system and when leaving the transport system. Customer behavior can be monitored through social media tracking. Complaints and issues can already be taken into account as events evolve. Big Data in automated passenger counting systems is useful for estimating trends in passenger numbers and unlocking opportunities to make efficient use of on-demand infrastructure.

[6]

Analysis and Visualization

- This area of data analysis is referred to by the terms Knowledge Discovery in Databases (KDD) and Data Mining
- As a common process model and typical representative, the **CR**oss Industry **S**tandard **P**rocess for Data Mining **CRISP-DM** is presented
- Afterwards, different process groups and algorithms of knowledge discovery in databases are explained and assigned to specific task classes.

[7]

Analysis and Visualization

Techniques for data analysis can be grouped into, but are not limited to, the following categories:

- **Data fusion:** Techniques to consolidate data produced by multiple sources, such as location data produced by mobile phones and GPS-enabled vehicles.
- **Data mining:** techniques to extract patterns from large data sets, such as the relationships between discrete nodes in a transportation network.
- **Optimization:** techniques to reorganize complex systems and processes to improve their performance according to one or more parameters, such as travel time or fuel efficiency.
- **Visualization:** techniques used for generating images, diagrams, or animations to communicate the results of data analysis, such as traffic maps. Visualization techniques are used both during and after data analytics to make sense of the information.

Analysis and Visualization

Development of the data volume

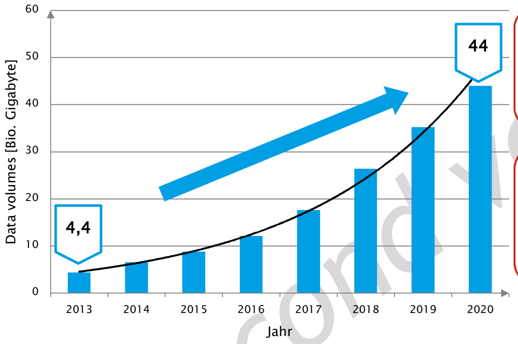


Abb. 1: development of data volume world wide, vgl. [Turner et al., 2014]

Drivers
- Auto-ID, localization and sensor technologies
- Industry 4.0

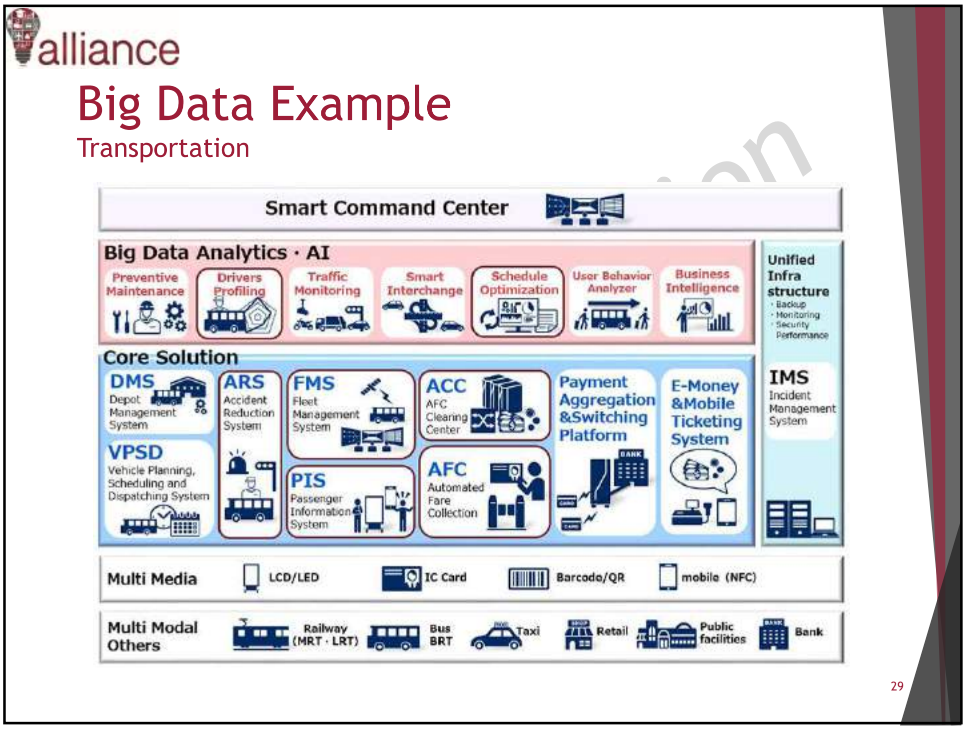
[Kagermann et al., 2013], [Turner et al., 2014]

In 2013:
- 80 % of data were managed by companies
- 22 % of data were suitable for analyses

[Turner et al., 2014]

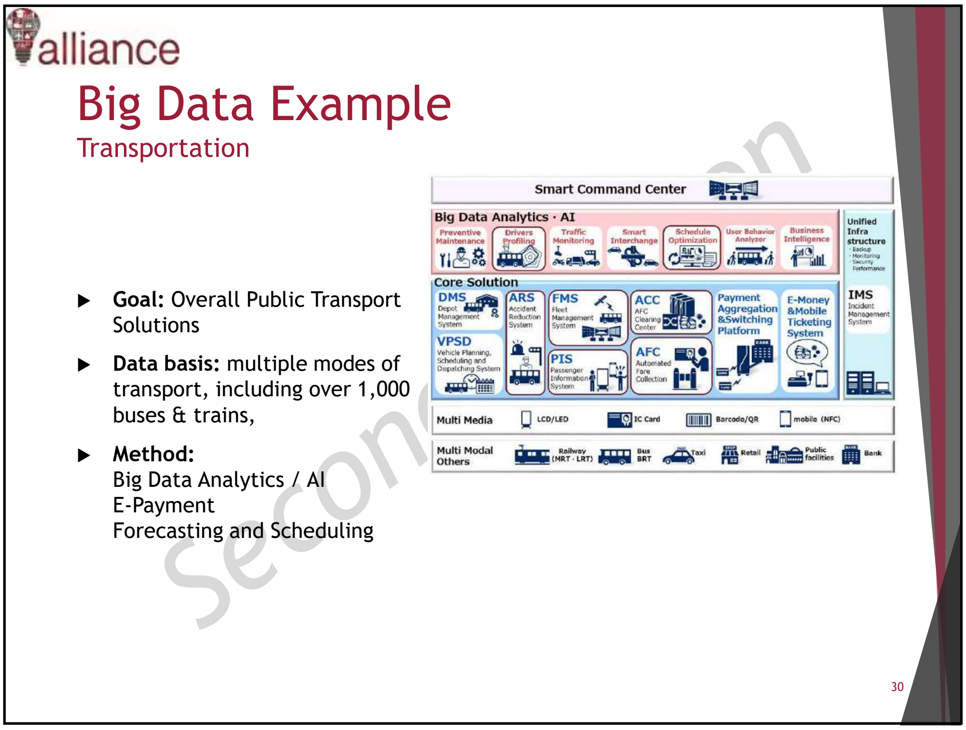
Great potential to extract new information about the behavior of real systems

Only 1% of data were used for analyses by companies!
[Turner et al., 2014]



Big Data Example

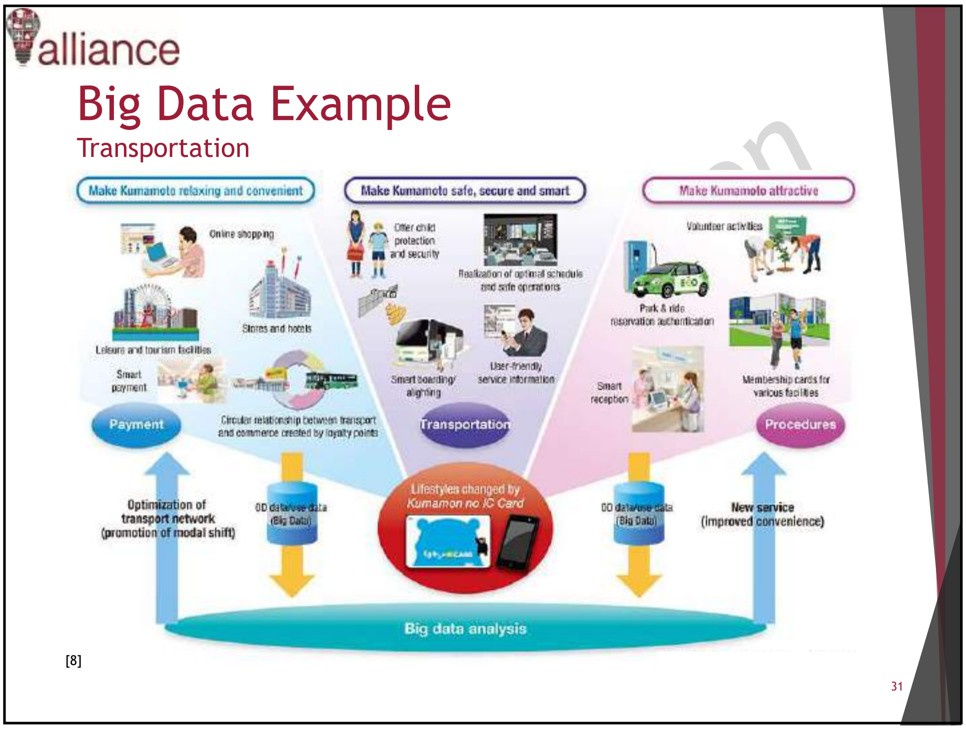
Transportation



Big Data Example

Transportation

- **Goal:** Overall Public Transport Solutions
- **Data basis:** multiple modes of transport, including over 1,000 buses & trains,
- **Method:**
  Big Data Analytics / AI
  E-Payment
  Forecasting and Scheduling



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Big Data Example

Transportation

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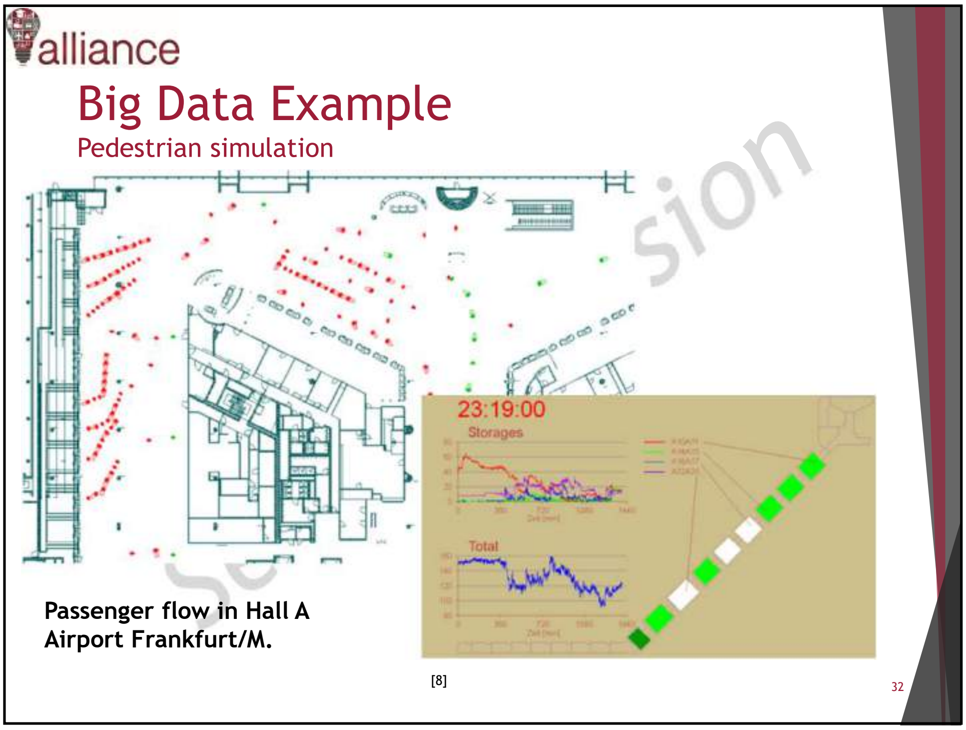

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Big Data Example

Pedestrian simulation

Passenger flow in Hall A Airport Frankfurt/M.

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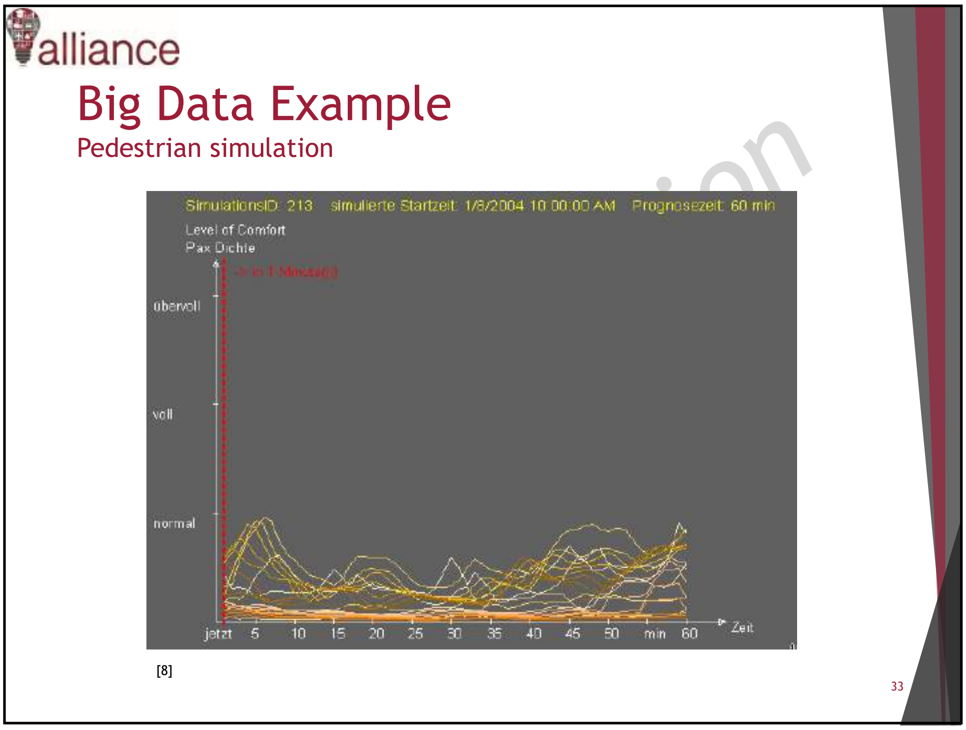

Big Data Example

Pedestrian simulation

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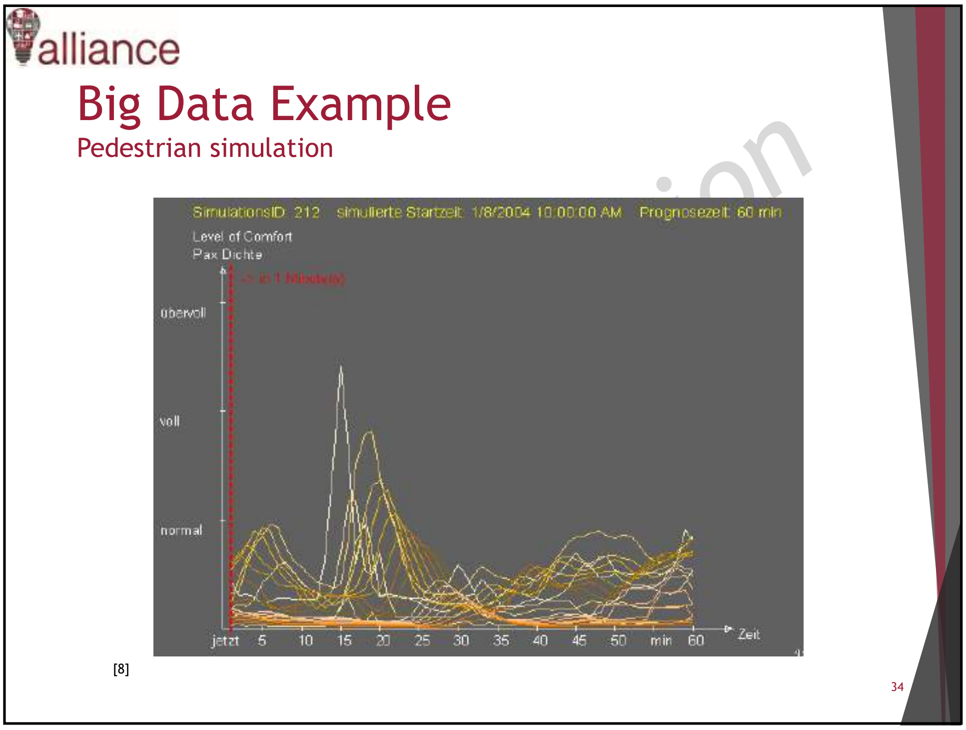

Big Data Example

Pedestrian simulation

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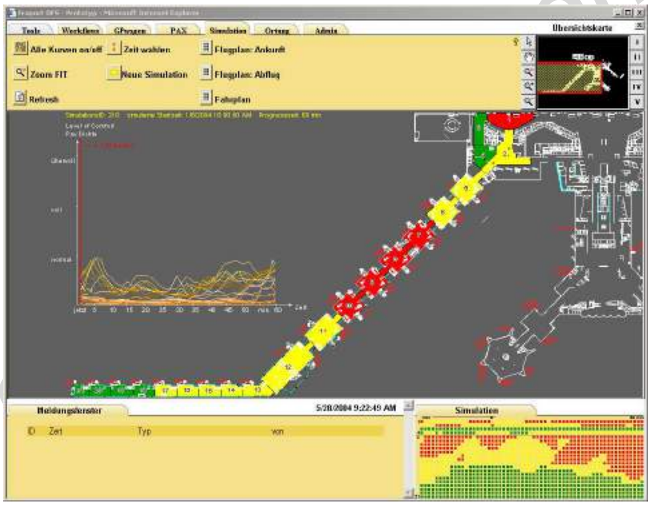
Big Data Example

Pedestrian simulation



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Case-Study

METRO(Passenger Transport)

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Case-Study

METRO(Passenger Transport)

Noumber of journeys in 2013/2014

Roads (minus Taxi/PHV)	Buses	London Underground	Cycling
3.65bn	2.4bn	1.26bn	205.3m
Taxi and PHV	London Overground	DLR	Tramlink
147.5m	135.7m	101.6m	31.2m
Rivers	Santander cycles	Emirates Air Line	Dial-a-ride
8.6m	8.2m	1.5m	1.4m

- *What are the objective criteria according to which the system will be investigated?*
- *What methods can be used for data analysis?*
- *What are applicable, future solutions?*

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Case-Study

METRO(Passenger Transport)

30 million journeys on road and public transport networks every day

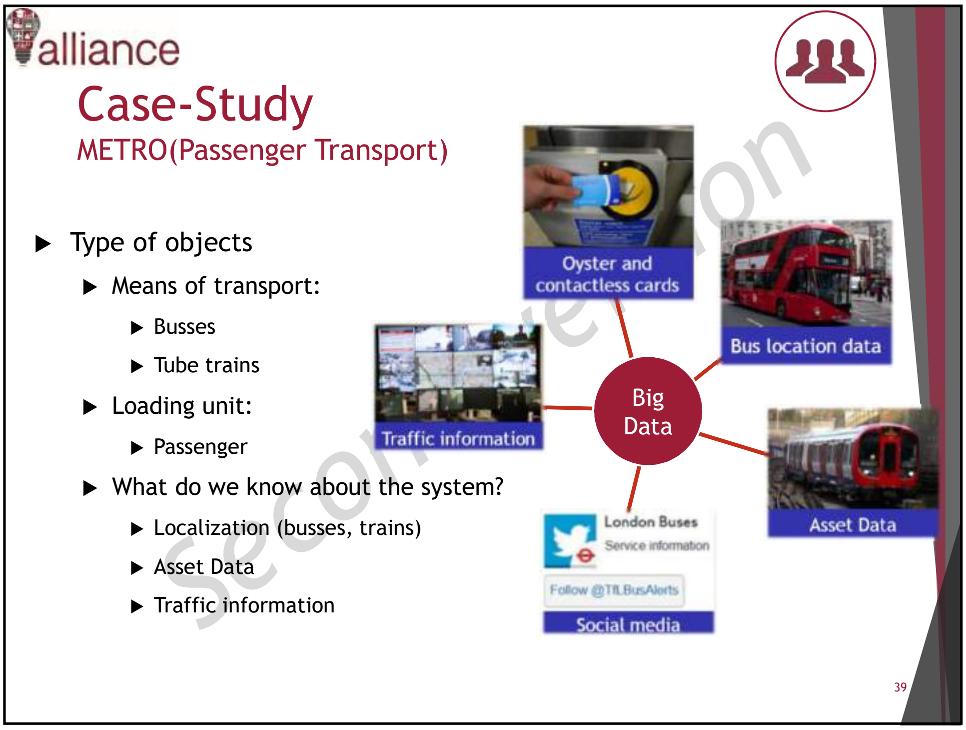
10.6 per cent shift to public transport, cycling and walking since 2000

One of the world's largest programmes of capital investment

580km of busiest roads, 6,200 traffic signals and control flow of traffic

Taxi and private hire

Congestion Charging and Low Emission Zone



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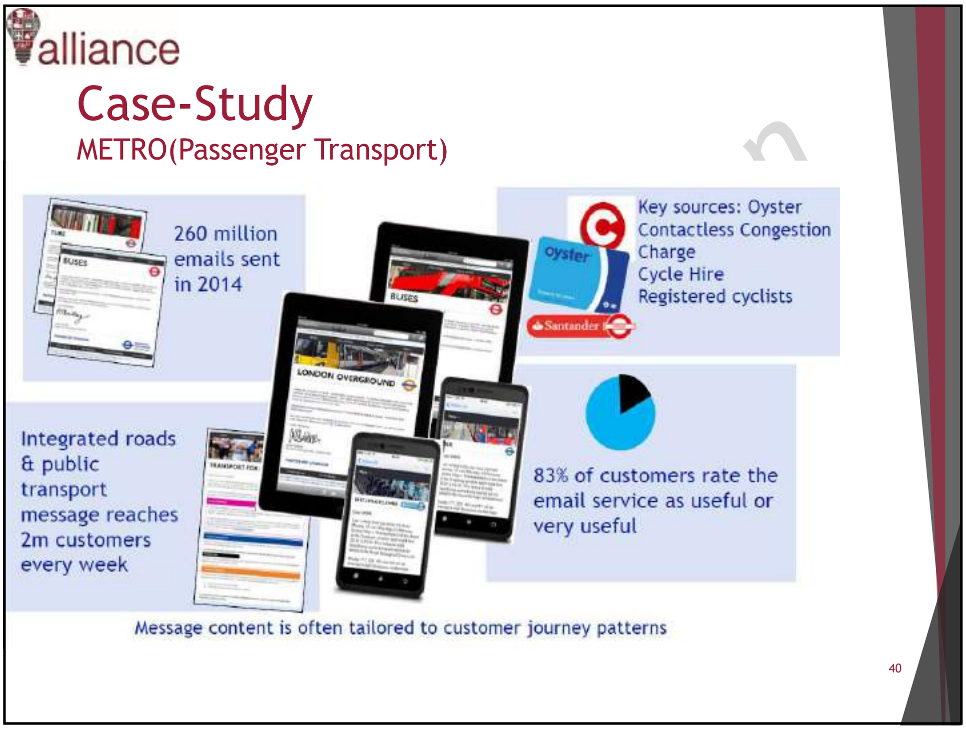
Case-Study

METRO(Passenger Transport)

- Type of objects
  - Means of transport:
    - Busses
    - Tube trains
  - Loading unit:
    - Passenger
  - What do we know about the system?
    - Localization (busses, trains)
    - Asset Data
    - Traffic information



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Case-Study

METRO(Passenger Transport)

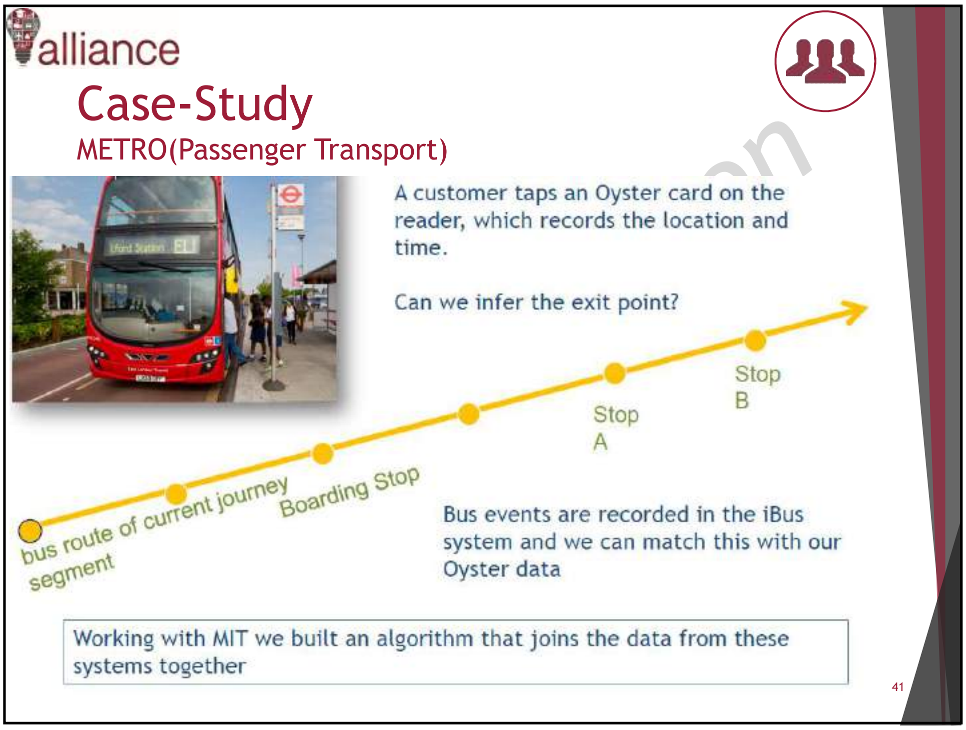
260 million emails sent in 2014

Key sources: Oyster Contactless Congestion Charge Cycle Hire Registered cyclists

Integrated roads & public transport message reaches 2m customers every week

83% of customers rate the email service as useful or very useful

Message content is often tailored to customer journey patterns



Case-Study

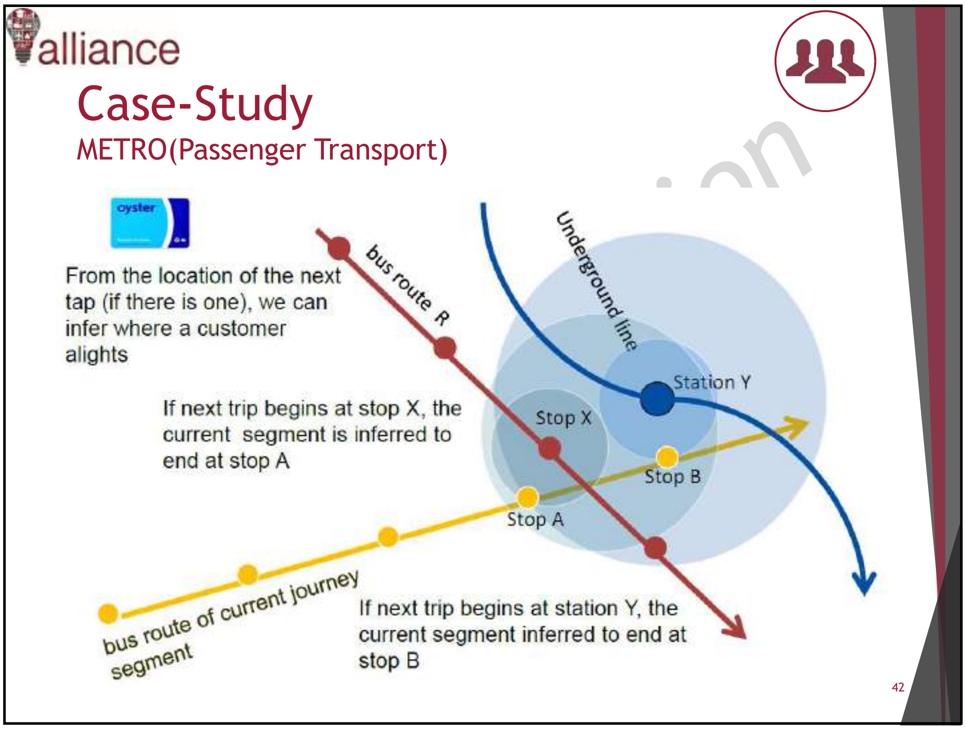
METRO(Passenger Transport)

A customer taps an Oyster card on the reader, which records the location and time.

Can we infer the exit point?

Bus events are recorded in the iBus system and we can match this with our Oyster data

Working with MIT we built an algorithm that joins the data from these systems together



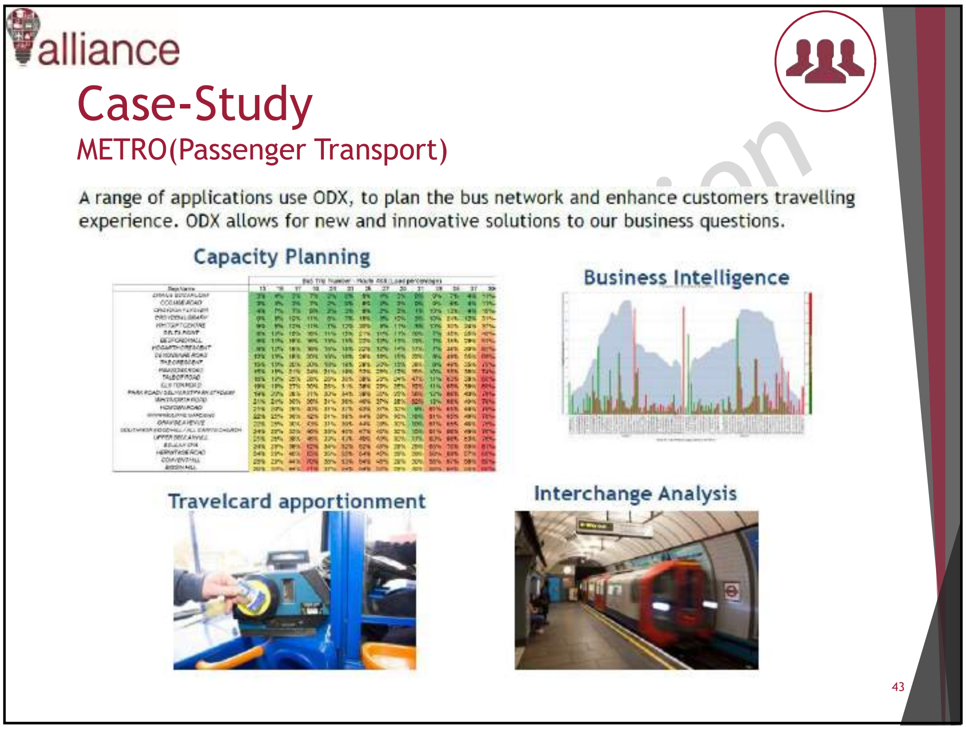
Case-Study

METRO(Passenger Transport)

From the location of the next tap (if there is one), we can infer where a customer alights

If next trip begins at stop X, the current segment is inferred to end at stop A

If next trip begins at station Y, the current segment inferred to end at stop B



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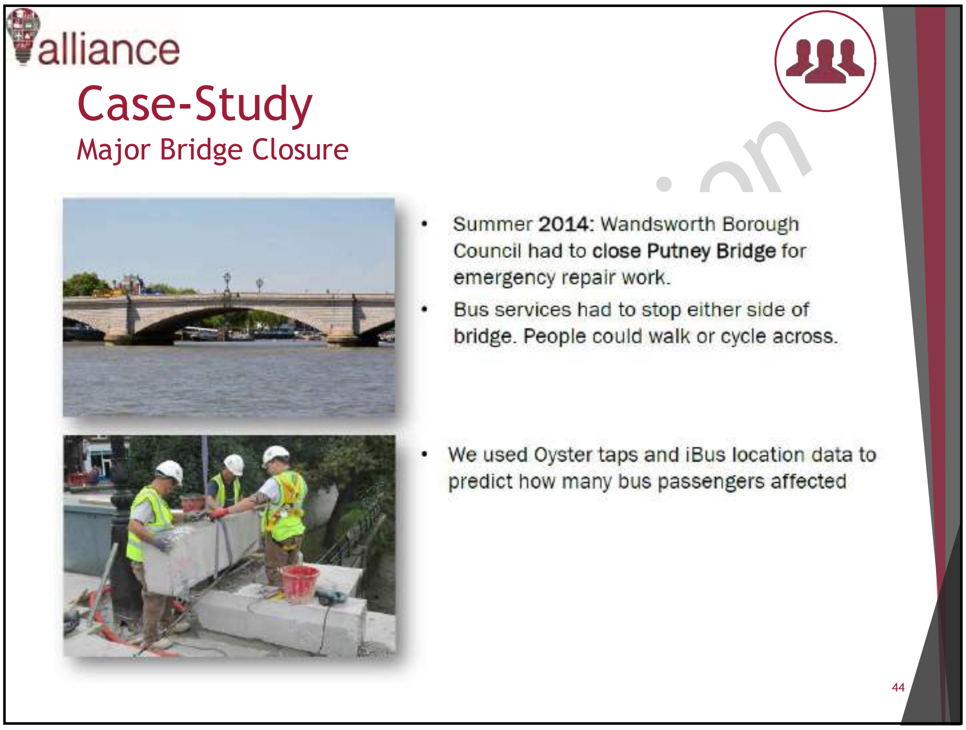
Case-Study

METRO(Passenger Transport)

A range of applications use ODX, to plan the bus network and enhance customers travelling experience. ODX allows for new and innovative solutions to our business questions.



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Case-Study

Major Bridge Closure

- Summer **2014**: Wandsworth Borough Council had to **close Putney Bridge** for emergency repair work.
- Bus services had to stop either side of bridge. People could walk or cycle across.
- We used Oyster taps and iBus location data to predict how many bus passengers affected

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Case-Study

Analytics (Putney Bridge)

- Approx **40,000 unique Oyster** made **111,000 bus journeys** a week that crossed the bridge
- Roughly **half** of these journeys **started** or **ended very close to the bridge**, so no bus transfer necessary.

- **56,000** journeys crossed the bridge in the middle of a trip. These would require two bus trips, one either side of the bridge
- Result: arranged to offer transfer facilities so that customers would not be charged twice
- Sent **targeted emails** to provide customers with information about alternative routes to **minimise** the impact

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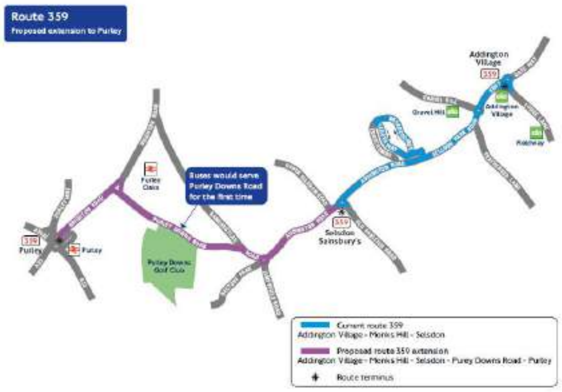
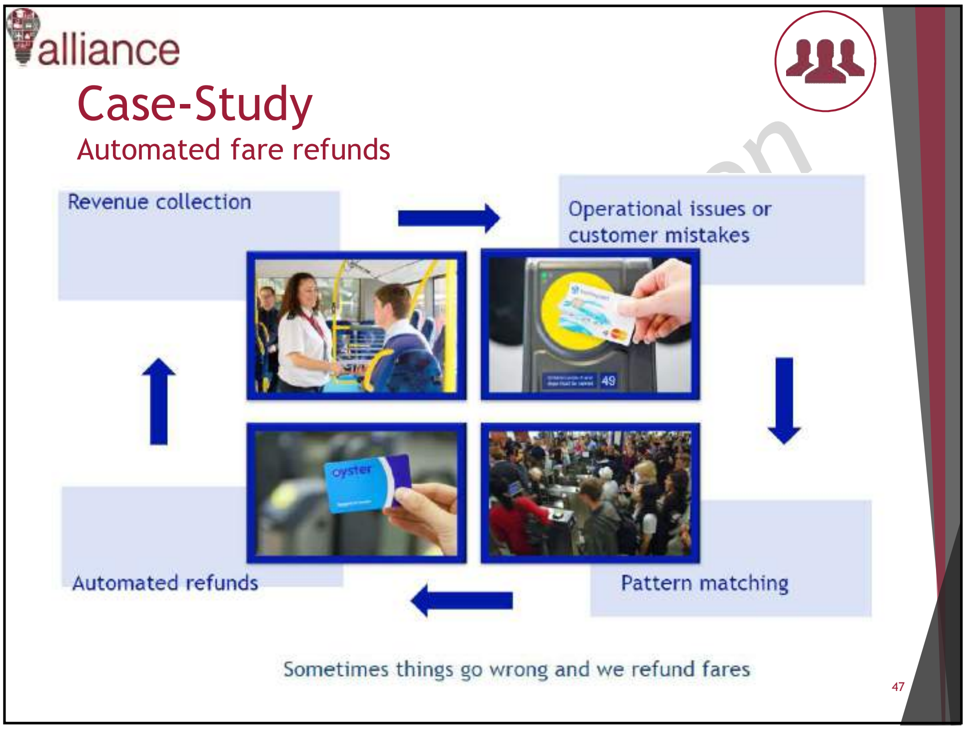
Case-Study

Capacity Planning



Using ODX the bus network serving New Addington has been completely restructured to better serve passenger needs.



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Case-Study

Automated fare refunds

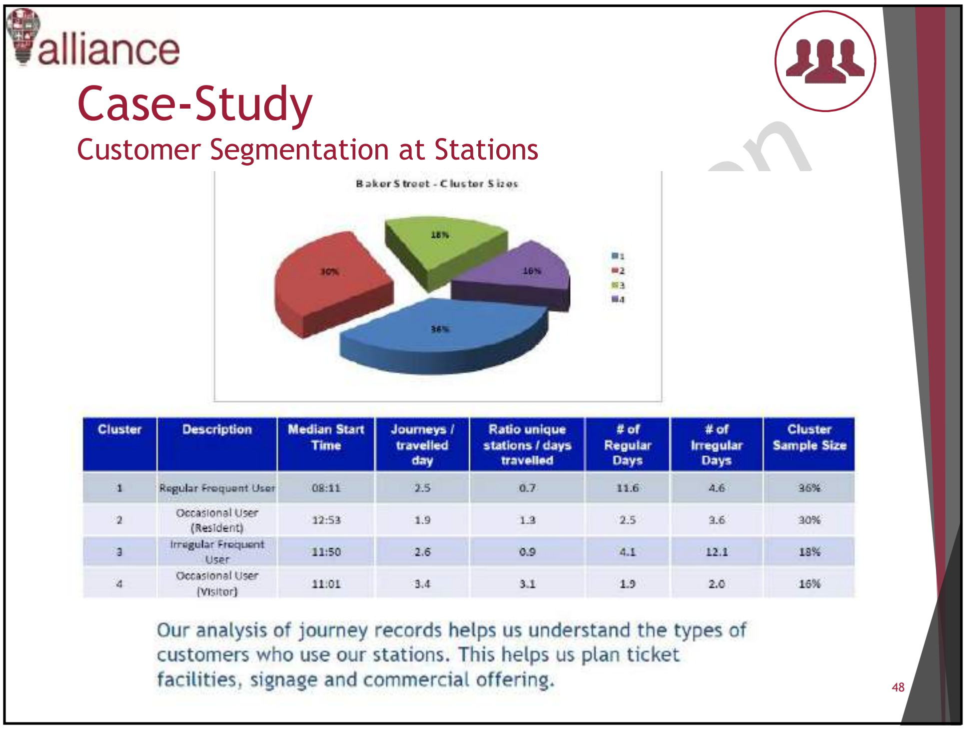
Revenue collection

Operational issues or customer mistakes

Automated refunds

Pattern matching

Sometimes things go wrong and we refund fares



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Case-Study

Customer Segmentation at Stations

Cluster	Description	Median Start Time	Journeys / travelled day	Ratio unique stations / days travelled	# of Regular Days	# of Irregular Days	Cluster Sample Size
1	Regular Frequent User	08:11	2.5	0.7	11.6	4.6	36%
2	Occasional User (Resident)	12:53	1.9	1.3	2.5	3.6	30%
3	Irregular Frequent User	11:50	2.6	0.9	4.1	12.1	18%
4	Occasional User (Visitor)	11:01	3.4	3.1	1.9	2.0	16%

Our analysis of journey records helps us understand the types of customers who use our stations. This helps us plan ticket facilities, signage and commercial offering.

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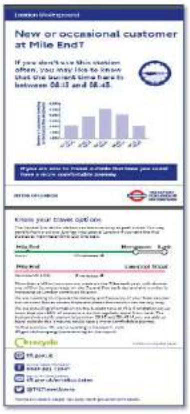
Case-Study

Influencing Travel

Leaflet



New or occasional customer at Mile End?

Whiteboard poster

Highbury & Islington station

New or occasional customer at this station?

The busiest time here is between 0815 and 0830

TfL is investing to improve the capacity and frequency of Tube services but we know that at certain times and places the network can be very busy.

If you are able to travel outside this time you could have a more comfortable journey.

MAYOR OF LONDON

TRANSPORT FOR LONDON

Email

Announcement

Leytonstone – to be played from 0800 – 0830

"TfL is investing to improve the capacity and frequency of Tube services but we know that at certain times and places the network can be very busy.

The busiest time here is between 08:15 and 08:30.
If you are able to travel outside this time you could have a more comfortable journey."

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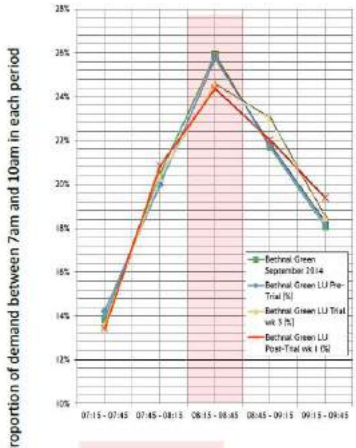
Case-Study

Influencing Travel



The results suggests change in passenger behaviour:

- Demand distribution over the peak period consistent between pre trial and September periods
- Approximate 5% shift in demand during target time period of 08:15 to 08:45.
- Total Peak Demand over the trial period relatively unchanged

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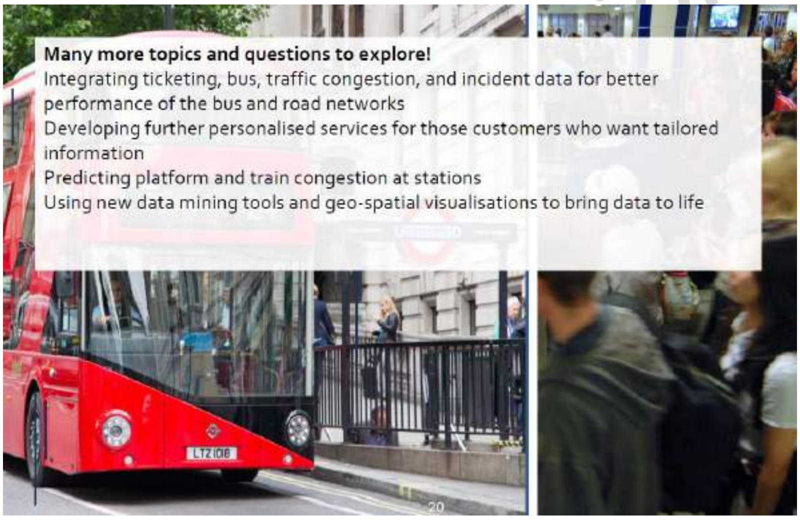
Case-Study

Future Aims



Many more topics and questions to explore!

Integrating ticketing, bus, traffic congestion, and incident data for better performance of the bus and road networks

Developing further personalised services for those customers who want tailored information

Predicting platform and train congestion at stations

Using new data mining tools and geo-spatial visualisations to bring data to life

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Thanks for your attention!

David Weigert, M. Sc.
Fraunhofer Institute for Factory Operation and Automation IFF Magdeburg
david.weigert@iff.fraunhofer.de

Sandtorstraße 22
39106 Magdeburg

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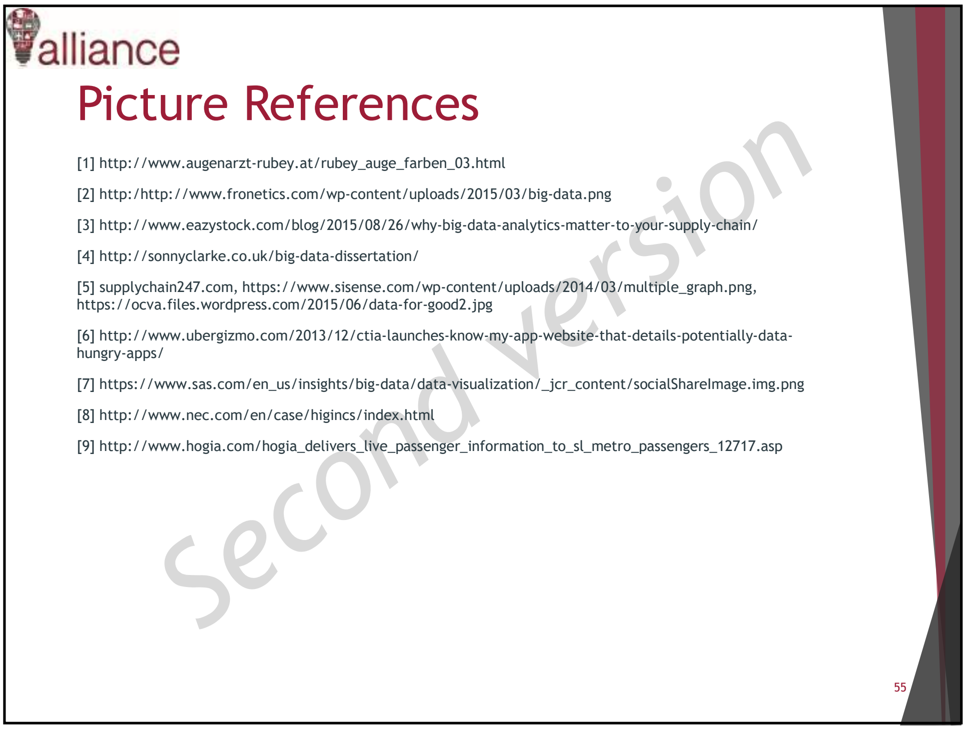

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Thank you for your kind attention!