# EUROPEAN UNION
# HORIZON 2020 RESEARCH & INNOVATION PROGRAMME

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## D2.3

# Course material on smart solutions for the interconnection of transportation networks

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## DOCUMENT CONTROL SHEET

| | | | |
|---|---|---|---|
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| **Project Title** | Enhancing excellence and innovation capacity in sustainable transport interchanges | | |
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| **Deliverable no.** | 2.3 | **Title** | Course material on smart solutions for the interconnection of transportation networks |
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|---|---|
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| 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 first version of the ALLIANCE course material on smart solutions for the interconnection of transportation networks. The material is expected to be updated in two specific milestones of the project thus, after the realization of each of the two summer schools.

# 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 third deliverable of WP2 (Work Package 2) and its scope is to provide the first version of the ALLIANCE course material on smart solutions for the interconnection of transportation networks.

Following the introductory chapter, the subsequent sections of this deliverable include: Chapter 2, presents an overview of the “Sustainable Transport Interchange Program – STIP”, and Chapter 3 the courses’ metadata and the first 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 graduates 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, 2016a):

1. 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.
2. 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.
3. 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, 2016a):

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** | | Information systems for intermodal freight transport |
| **C8** | | Design of passenger transport interchanges |
| **C9** | | Design of freight transport interchanges |
| **C10** | | Smart technologies for efficient logistics |
| **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, 2016a):

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).

# 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 metadata of the 13 courses are analytically presented from Table 3.1 to Table 3.14.

**Table 3.1:** Course C0

<table>
<tr><th colspan="2">Course: C0</th></tr>
<tr><th>Title</th><th>Research methodology and teamwork setup</th></tr>
<tr><td>Thematic area</td><td>-</td></tr>
<tr><td>Responsible Institute</td><td>Transport and Telecommunication Institute - TTI, Latvia<br>University of Thessaly – UTH, Greece</td></tr>
<tr><td>Lecturers</td><td>Irina Yatskiv (Jackiva) (TTI)<br>Eftihia Nathanail (UTH)</td></tr>
<tr><td>Aim</td><td>• Present techniques of conducting literature review<br>• Guide how to use databases, search engines and electronic libraries<br>• Explain how to write a scientific report<br>• Explain how to prepare and present research work<br>• Organize teams for conducting the summer school project.</td></tr>
<tr><td colspan="2">Learning outcomes</td></tr>
<tr><td colspan="2">• Look into databases, search engines and electronic libraries to retrieve information about a topic<br>• Organize a scientific report<br>• Conduct state-of-the-art<br>• Document methodology and results<br>• Work as a team member.</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>1</td></tr>
<tr><td>Key words</td><td>Research, process, paper, presentation, literature, review dissertation, references, ethics</td></tr>
<tr><td>Syllabus</td><td>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.<br><br>In the course students acquire basic principles of analysis and overview of scientific publications which are necessary for the development of thesis.<br><br>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.<br>Course topics:<br>• Research process<br>• Literature review. Citation indexes<br>• Quantitative research<br>• Research dissemination (dissertation, research publication, poster, presentation, scientific report, oral)</td></tr>
</table>

<table>
<tr><td></td><td colspan="2">

- Typical structure of articles and abstracts to scientific report
- Citations and references
- Ethics and Plagiarism.

</td></tr>
<tr><td>Bibliography</td><td colspan="2">

- The Writing Lab & The OWL at Purdue and Purdue University (1995-2011)
- A Guide for Writing Research Papers Based on Modern Language Association (MLA), 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.

</td></tr>
<tr><td rowspan="6">Teaching methods</td><td>Lecture</td><td>x</td></tr>
<tr><td>Demonstration</td><td></td></tr>
<tr><td>Hands on/games</td><td></td></tr>
<tr><td>Exercises</td><td></td></tr>
<tr><td>Visits at facilities</td><td></td></tr>
<tr><td>Other (describe): Case studies</td><td></td></tr>
<tr><td rowspan="5">Evaluation methods</td><td>Homework</td><td></td></tr>
<tr><td>Class project</td><td></td></tr>
<tr><td>Interim examination</td><td></td></tr>
<tr><td>Final examinations</td><td></td></tr>
<tr><td>Other (describe)<br>……………………………………….</td><td></td></tr>
<tr><td>Creative Commons (CC) Licenses</td><td colspan="2">CC-Attribution-NonCommercial-NoDerivatives</td></tr>
<tr><td>Number of topics</td><td colspan="2">7</td></tr>
</table>

| Lecture content | |
|---|---|
| 1 | Research process |
| 2 | Work with the literature and international scientific citation system. Citation indexes |
| 3 | Quantitative research |
| 4 | Types of research dissemination |
| 5 | Typical structure of articles and abstracts to scientific report |
| 6 | Citations and references |
| 7 | Ethics and Plagiarism |
| 8 | Suggested literature |

**Table 3.2:** Course C1

| **Course: C1** | |
|---|---|
| **Title** | **The European policy on intermodal transport** |
| **Thematic area** | Governance |
| **Responsible Institute** | University of Thessaly, Greece |
| **Lecturer** | Giannis Adamos |
| **Aim** | • Present and analyse the basic concepts on intermodality<br>• Identify stakeholders that play an important role in intermodal transport, pinpoint their competences and distribute the tasks that each one realizes in the domain, by revealing overlaps or complementarities<br>• Identify trends and challenges that will influence the shaping of future European Transport Policy<br>• Review the European legislation and policies in terms of transport modes (road, rail, waterborne, air), transport system environment, intermodality and financing<br>• Review, analyse and assess the planning and financing schemes developed in the European Union addressing intermodal transport. |
| **Learning outcomes** | |
| • Provide an understanding of the basic concepts on intermodal transport, including: intermodality, passenger and freight urban interchanges, long-short distance interconnection, unban/interurban interconnection<br>• 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<br>• Acquire theoretical knowledge of the European Union's policies and legislation on intermodality<br>• 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** | 1 |
| **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, urban passenger and freight transport interchanges, long-short distance interconnection and urban/interurban interconnection.<br>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. Norway, Finland, Czech Republic and Greece, and to investigate the role that other regulatory actors may have.<br>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.<br>**Course topics:**<br>• Basic concepts<br>• Transportation in an era of change<br>• Future changes in European Transport Policy<br>• Obstacles and problems<br>• Decision-making framework<br>• Actors and interrelations<br>• European institutional and legal framework<br>• Planning and financing schemes<br>• Applications. |
| **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.<br>• 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.<br>• 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.<br>• CLOSER, 2011. CLOSER Deliverable D4.1. Analysis of the decision-making framework. CLOSER Project.<br>• CLOSER, 2012. CLOSER Deliverable D4.2. Policy Advisory Group recommendations. CLOSER Project.<br>• European Commission (2001). White Paper " European transport policy for 2010: Time to decide (CEC, 2001).<br>• European Commission (2004): Towards passenger intermodality in the European Union. Brussels.<br>• 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.<br>• European Commission, 2007. "GREEN PAPER - Towards a new culture for urban mobility", Brussels, 25.9.2007 COM (2007) 551 final.<br>• 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.<br>• 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.<br>• 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.<br>• United Nations Population Division (2009), ‘World population prospects — The 2008 revision’. | |
| **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)<br>……………………………………… | |
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| **Number of topics** | 9 | |
| **Lecture content** | | |
| 1 | Background | |
| 2 | Basic concepts | |
| 3 | Transportation in an era of change | |
| 4 | Future changes in European Transport Policy | |
| 5 | Obstacles and problems | |
| 6 | Decision-making framework | |
| 7 | Actors and interrelations | |
| 8 | European institutional and legal framework | |
| 9 | Planning and financing schemes | |
| 10 | Applications | |
| 11 | Suggested literature | |
| **Other: case studies** | | |
| 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** | **Business models for intermodal transport interchanges** |
| **Thematic area** | Governance |
| **Responsible Institute** | Otto-von-Guericke-University Magdeburg, Germany |
| **Lecturer** | Dr.-Ing. Henning Strubelt |
| **Aim** | • Get introduced to the development and evaluation of business models<br>• Get enabled to analyze the options for and limitations to logistics implementation concepts concerning intermodal transport aspects<br>• Develop a thorough understanding of the physical and monetary aspects and processes of material flow technology in intermodal transport networks. |
| **Learning outcomes** | |
| • Acquire basic knowledge of intermodal transport interchanges and business models<br>• Acquire knowledge about the processual importance of intermodal transport interchanges in efficient supply chains<br>• Develop skills for logistical evaluations required for the selection of intermodal transport concepts and to assess economic conditions of service and functionality<br>• 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** | The 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.<br>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.<br>The exercise section is divided into two 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 a case study with the objective of deepening the understanding of application fields and assessing intermodal technologies. This is facilitated by the discussion of possibilities and their pros and cons. Further the aspects of sustainability and costs are evaluated and a business model for the participants' preferred variant is to be developed. The first exercise section is done individually, while the second is intended to be done in small groups.<br>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.<br>**Course topics:**<br>• Business models<br>• Stakeholders' governance models<br>• Intermodal transport<br>• Modes of transport<br>• Interchange zones<br>• Safety and security<br>• Sustainable interchanges<br>• Ownership structures<br>• Case study. | |
| **Bibliography** | • Brinkmann, B. (2005): Seehäfen, Planung und Entwurf, Springer, Berlin.<br>• Fielt, E. (2011): Business Model Definition. Business Service Management, Smart Services CRC Pty Ltd., Vol. 3.<br>• Gleissner, H., Femerling, J. C. (2013): Logistics: Basics - Exercises - Case Studies, Springer, Cham.<br>• Muller, G. (1999): Intermodal Freight Transportation, 4th Edition, Eno Transportation Foundation.<br>• Osterwalder, A., Pigneur, Y. (2010): Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers, Wiley & Sons, Hoboken, NJ.<br>• Pfohl, H.C. (2010): Logistiksysteme, Betriebswirtschaftliche Grundlagen, Springer, Cham.<br>• 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. | |
| **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 | x |
| | Interim examination | |
| | Final examinations | |
| | Other (describe)<br>………………………………………. | |
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<table>
<tr><td>Number of topics</td><td>3</td></tr>
<tr><td colspan="2">Lecture content</td></tr>
<tr><td>1</td><td>Business models</td></tr>
<tr><td>2</td><td>Stakeholder´s governance models</td></tr>
<tr><td>3</td><td>Intermodal transport</td></tr>
<tr><td>4</td><td>Modes of transport</td></tr>
<tr><td>5</td><td>Interchange zones</td></tr>
<tr><td>6</td><td>Safety and Security</td></tr>
<tr><td>7</td><td>Sustainable interchanges</td></tr>
<tr><td>8</td><td>Ownership structures</td></tr>
<tr><td>9</td><td>Case study</td></tr>
<tr><td>10</td><td>Suggested literature</td></tr>
<tr><td colspan="2">Exercises</td></tr>
<tr><td colspan="2">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 develop a pro and cons overview of the transport modes for different application fields applying different evaluation criteria. The findings are to be discussed controversially in class.<br>Respective topic: 3</td></tr>
<tr><td colspan="2">Other: case study</td></tr>
<tr><td colspan="2">A case study is used to assess current application fields of intermodal interchanges and to allow for a deepening of the understanding of application fields. Further the participants select and reason their own preferred intermodal interchange solution based on economic, ecological and technological aspects. The results are to be developed in groups and presented and discussed in class.<br>Respective topic: All</td></tr>
<tr><td colspan="2">Other: conclusion of the workshop</td></tr>
<tr><td colspan="2">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.<br>Respective topic: All</td></tr>
</table>

**Table 3.4:** Course C3

<table>
<tr><th colspan="2">Course: C3</th></tr>
<tr><td>Title</td><td>Sustainable development and transportation planning</td></tr>
<tr><td>Thematic area</td><td>Governance</td></tr>
<tr><td>Responsible Institute</td><td>University of Thessaly, Greece</td></tr>
<tr><td>Lecturer</td><td>Eftihia Nathanail, Lambros Mitropoulos</td></tr>
<tr><td>Aim</td><td>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.</td></tr>
<tr><td colspan="2">Learning outcomes</td></tr>
<tr><td colspan="2"><ul>
<li>Implement the basic concepts of transportation modelling, scenario development and forecasting</li>
<li>Identify the challenges and elements for creating sustainable transport systems</li>
<li>Develop relevant policy measures, strategies and select smart solutions to address transport oriented problems</li>
<li>Account for sustainability indicators, implement indicators to different transport systems and compare scenarios with present transport systems</li>
<li>Identify different stakeholder groups and factors influencing transport development</li>
<li>Embed environmental impact and safety assessment approach of transport interchanges.</li>
</ul></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>3</td></tr>
<tr><td>Key words</td><td>Planning, modeling, sustainability, indicators, scenarios, stakeholders, environmental impact, safety assessment</td></tr>
<tr><td>Syllabus</td><td>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 both passenger and 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 and Sustainability Urban Logistics Plans will be analysed. Indicators being estimated by impact assessment of transportation interchanges will be discussed and explained.<br>Students will get exposed to software packages dealing with transportation planning and impact assessment.</td></tr>
</table>

| | | |
|---|---|---|
| | **Course topics:**<br>• Transportation planning principles and forecasting methodologies<br>• Elements of travel planning and influencing travel decisions<br>• Delivering transport plans (incentives for smarter travel)<br>• Integration of smart solutions in sustainable transport planning<br>• Transport impacts<br>• Sustainability concepts, visions of sustainable transport systems and assessment of the present situation (performance indicators)<br>• The potential for technological development in transport and infrastructure systems in relation to various energy futures<br>• Sustainable urban development and mobility plans<br>• Environmental impacts assessment (EIA) | |
| **Bibliography** | • Cascetta (2009). Transportation System Analysis: models and applications. 2nd edition. Springer.<br>• Denos C. Gazis, Traffic Theory, Kluwer Academic Publishers, 2002.<br>• Hensher D.A., Button K.J., Handbook of Transport Modelling, Pergamon, 2000.<br>• Meyer M. and E.Miller (2000). Urban Transportation Planning 2nd Edition, McGraw-Hill Series in Transportation.<br>• Moshe E. Ben-Akiva, Steven R. Lerman (1985) Discrete Choice Analysis: Theory and Application to Travel Demand, The MIT Press.<br>• Oppenheim, N. Urban Travel Demand Modeling, From Individual Choices to General Equilibrium, J. Wiley & Sons, 1995.<br>• Ortuzar, J. D. and L. G. Willumsen, Modelling Transport, J. Wiley & Sons, 2011.<br>• Richardson, E. Ampt, and A. Meyburg, Survey Methods for Transport Planning, Eucalyptus Press, 1995.<br>• Stopher P. and M.Lee-Gosselin, Understanding travel behaviour in an era of change, Pergamon, 1997.<br>• Trip generation manual, 9th edition, Institute of Transportation Engineers ITE, 2014. | |
| **Teaching methods** | Lectures | x |
| | Demonstrations | |
| | Hands on/gaming | |
| | Exercises | |
| | Visits at facilities | |
| | Other (please describe): | |
| **Evaluation methods** | Homework | |
| | Class project | x |
| | Interim examination | |
| | Final examinations | |
| | Other (describe) ………………………………………. | |

| | |
|---|---|
| **Creative Commons (CC) Licenses** | CC-Attribution-NonCommercial-NoDerivatives |
| **Number of topics** | 9 |
| **Lecture content** | |
| 1 | Transportation planning principles |
| 2 | Planning process |
| 3 | Forecasting methodologies |
| 4 | Transport impacts |
| 5 | Sustainability assessment |
| 6 | Smart solutions in sustainable transport planning |
| 7 | Sustainable urban development and mobility plan |
| 8 | Environmental impact assessment |
| 9 | Suggested literature |

**Table 3.5:** Course C4

| **Course: C4** | |
|---|---|
| **Title** | **Operation and management of intermodal transport systems** |
| **Thematic area** | Governance |
| **Responsible Institute** | University of Thessaly, Greece |
| **Lecturers** | Eftihia Nathanail, Giannis Adamos |
| **Aim** | • This course is oriented to the operation and management of passenger and freight interchanges<br>• It analyses the organization of interchanges regarding operational functionality, management and efficiency of services<br>• 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<br>• 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<br>• Recognize and assess implications revealing from different regulatory, operational and managerial structures<br>• Analyse 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** | 3 |
| **Key words** | Interchange, operation, management, stakeholders, policy, urban planning, integrated information systems, ticketing |
| **Syllabus** | The course analyses 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.<br>In addition, the course analyses 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.<br>**Course topics:**<br>• Stakeholders’ engagement and management<br>• Policy<br>• Operational structures<br>• Management structures<br>• The role of interchanges in urban planning<br>• Main principles for management and operational structures<br>• Integrated information systems and ticketing |

| | | |
|---|---|---|
| | • Case studies | |
| **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.<br>• Banister, D. & Berechman, Y., 2001. Transport investment and the promotion of economic growth. Journal of Transport Geography, 9(2001) 209-218.<br>• Bask, A. 1999. Third Party Relationships in Logistics Services, Helsinki School of Economics and Business Administration, Licentiate Thesis, Helsinki. 140 p.<br>• City-HUB, 2013. City-HUB Deliverable D4.1. Integrated management of efficient urban interchanges.<br>• City-HUB, 2015. City-HUB Deliverable D5.2. City-HUB Handbook.<br>• European Commission, 2001. White Paper " European transport policy for 2010: Time to decide (CEC, 2001).<br>• 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.<br>• 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.<br>• 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.<br>• GUIDE (2000) Terzis, G., Last, An. GUIDE – Urban Interchanges – A Good Practice Guide – Final Report prepared for EC DG VII. April, 2000.<br>• 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.<br>• IMONODE (2005). WP3: Supply side – Intermodal network analysis. IMONODE – Efficient Integration of Cargo Transport Modes & Nodes in CADSES area.<br>• 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 |
| **Evaluation methods** | Homework | |
| | Class project | x |
| | Interim examination | |
| | Final examinations | |
| | Other (describe)<br>………………………………………. | |

| | |
|---|---|
| **Creative Commons (CC) Licenses** | CC-Attribution-NonCommercial-NoDerivatives |
| **Number of topics** | 8 |
| **Lecture content** | |
| 1 | Background |
| 2 | Stakeholders' engagement and management |
| 3 | Policy |
| 4 | Operational structures |
| 5 | Management structures |
| 6 | The role of interchanges in urban planning |
| 7 | Main principles for management and operational structures |
| 8 | Integrated information systems and ticketing |
| 9 | Case studies |
| 10 | Suggested literature |
| **Other: case studies** | |
| In this course, a number of case studies is used as part of the teaching methods. Good practices in several topics, i.e. policy, operation and management structures are presented, while the findings of a number of surveys conducted in specific European interchanges are also introduced. | |

**Table 3.6:** Course C5

| **Course: C5** | |
|---|---|
| **Title** | **Optimization of intermodal transport systems** |
| **Thematic area** | Governance |
| **Responsible Institute** | University of Thessaly, Greece |
| **Lecturer** | 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<br>• Develop mathematical formulations that take into account the optimization of the objective function, safeguarding the satisfaction of constraints and limitations<br>• 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, SITATION |
| **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.<br>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.<br>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.<br>Finally, the transportation problem is described and solved, as well as other specific applications that deal with vehicle routing, resource allocation and facility location.<br>**Course topics:**<br>• Background<br>• Rules<br>• Basic concepts<br>• Techniques<br>• Software and applications<br>• Suggested literature. |

<table>
<tr><td rowspan="1">Bibliography</td><td colspan="2">
<ul>
<li>Bertsimas DJ, Jaillet P, Odoni AR, “A priori optimization”, Operations research 38/1, 1019 – 1033, 1990.</li>
<li>Bodin LD, Golden BL, Assad AA, Ball MO, “Routing & scheduling of vehicles and crews: The state of the art”, Computers and Operations Research, 10/2, 63-211, 1983.</li>
<li>Christofides N, Mingozzi A, Toth P, “The vehicle routing problem”, in Christofides N, Mingozzi A, Toth P & Sandi C, eds, Combinatorial Optimization, Wiley, New York, NY, 315-338, 1979.</li>
<li>Crainic Theodor Gabriel, Gilbert Laporte, “Planning models for freight transportation”, European Journal of Operational Research, 1997.</li>
<li>D. W. Wang, J. W. Wang, R. Y. Zhang, and Z. Guo, Ed. Intelligent Optimization Methods. Higher Education Press, Beijing, 2007.</li>
<li>Daskin MS, “Networks and discrete location”, Wiley, New York, NY, 1995.</li>
<li>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.</li>
<li>J. Andersson, A Survey of Multiobjective Optimization in Engineering Design, Department of Mechanical Engineering, Linktjping University, Sweden, 2000</li>
<li>Pedersen, M. B., Madsen, O. B. G., & Nielsen, O. A. (2005). Optimization models and solution methods for intermodal transportation.</li>
<li>Q. B. Wang, and Z. X. Han, “The optimal routes and modes selection in container multimodal transportation networks,” Int. Conf. Optoelectron. Image Process, vol. 2, pp. 573-576, 2010.</li>
<li>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.</li>
<li>Taha Hamdy (2011). Operations Research: An introduction. Prendice Hall.</li>
</ul>
</td></tr>
<tr><td rowspan="6">Teaching methods</td><td>Lecture</td><td>x</td></tr>
<tr><td>Demonstration</td><td></td></tr>
<tr><td>Hands on/games</td><td></td></tr>
<tr><td>Exercises</td><td></td></tr>
<tr><td>Visits at facilities</td><td></td></tr>
<tr><td>Other (describe):</td><td></td></tr>
<tr><td rowspan="5">Evaluation methods</td><td>Homework</td><td></td></tr>
<tr><td>Class project</td><td>x</td></tr>
<tr><td>Interim examination</td><td></td></tr>
<tr><td>Final examinations</td><td></td></tr>
<tr><td>Other (describe)<br>………………………………………</td><td></td></tr>
<tr><td>Creative Commons (CC) Licenses</td><td colspan="2">e.g. CC-Attribution-NonCommercial-NoDerivatives</td></tr>
<tr><td>Number of topics</td><td colspan="2">6</td></tr>
</table>

| Lecture content | |
|---|---|
| 1 | Background |
| 2 | Rules |
| 3 | Basic concepts |
| 4 | Techniques |
| 5 | Software and applications |
| 6 | Suggested literature |

**Table 3.7:** Course C6

<table>
<tr><th colspan="2">Course: C6</th></tr>
<tr><td>Title</td><td>Intelligent services for passenger transportation</td></tr>
<tr><td>Thematic area</td><td>Smart solutions</td></tr>
<tr><td>Responsible Institute</td><td>Otto-von-Guericke-University Magdeburg, Germany</td></tr>
<tr><td>Lecturer</td><td>Dr.-Ing. Henning Strubelt</td></tr>
<tr><td>Aim</td><td>• Get introduced to public transport management and its technical services<br>• Get a research summary covering passenger transport (modes) and an overview of information technology for the passenger transport market<br>• Understand the use of telematics to manage public transport networks and the development and implementation of flexible, reliable, and efficient multimodal transport concepts<br>• Gain an overview of possible IT application fields for passenger transport (e.g. ticketing, routing, etc.).</td></tr>
<tr><td colspan="2">Learning outcomes</td></tr>
<tr><td colspan="2">• Acquire knowledge about smart information systems for multimodal travel and platforms to coordinate integrated transport services<br>• Understand the levels of ITS deployment and their possibilities for passenger networks<br>• Introduction to the use of essential tools to conduct strategic analyses for network planning and optimization<br>• Understand the combination of strengths of different transport modes (multimodal concepts).</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>Logistics, Intelligent transport services, multimodal transport, passenger transport</td></tr>
<tr><td>Syllabus</td><td>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.<br>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 the evaluation and subsequent discussion of current applications 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.</td></tr>
</table>

| | | |
|---|---|---|
| | 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.<br>**Course topics:**<br>• Mobility goals<br>• Public transport management<br>• Passenger transport modes<br>• Information technology for passenger transport market<br>• Telematics for public transport network<br>• 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).<br>• 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).<br>• 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).<br>• 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).<br>• Intertraffic (2016): Intertraffic Amsterdam, Smart Mobility, available online at: http://www.intertraffic.com/amsterdam/innovations/smart-mobility (accessed 10 Oct. 2016).<br>• Nökel, K., Gentile, G. (2016): Modelling Public Transport Passenger Flows in the Era of Intelligent Transport Systems, Springer, Cham.<br>• 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).<br>• 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, available online at: https://people.hofstra.edu/geotrans/eng/ch3en/conc3en/ch3c1en.html (accessed 5 Oct. 2016).<br>• 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).<br>• 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)<br>……critical discussion and summary………………………… | x |
| **Evaluation methods** | Homework | |
| | Class project | x |
| | Interim examination | |
| | Final examinations | |
| | Other (describe)<br>………………………………………. | |
| **Creative Commons (CC) Licenses** | e.g. 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 | Ticketing | |
| 13 | Applications – Case study | |
| 14 | Suggested Literature | |
| **Exercises** | | |
| 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.<br>*Respective topics: 8,13* | | |
| **Other: case study** | | |

| |
|---|
| A case study is used to assess current application fields of intelligent services for passenger transport and allows for a deepening of the understanding of application fields.<br>*Respective topics: 9,12* |
| **Other: conclusion of the workshop** |
| 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. |

**Table 3.8:** Course C7

<table>
<tr><th colspan="2">Course: C7</th></tr>
<tr><td>Title</td><td>Information systems for intermodal freight transport</td></tr>
<tr><td>Thematic area</td><td>Smart solutions</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>Dipl.-Wirt.-Inform. Oliver Meier</td></tr>
<tr><td>Aim</td><td>• Basic understanding of information systems in logistics<br>• Selection, classification and application of information systems<br>• Description and analysis of information structures and information flows<br>• Selection and application of information systems for logistical tasks<br>• What is big data and knowledge discovery.</td></tr>
<tr><td colspan="2">Learning outcomes</td></tr>
<tr><td colspan="2">• Basic understanding of information systems in logistics<br>• Selection, classification and application of information systems<br>• Description and analysis of information structures and information flows<br>• Selection and application of information systems for logistical tasks<br>• What is big data and knowledge discovery.</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>Logistics, information systems, big data, multimodal transport, data warehouse management</td></tr>
<tr><td>Syllabus</td><td>The course consists of three parts. The first part has a lecture style structure with an introduction to the topics of information systems, data handling, big data, data warehouse architecture and knowledge discovery in a logistical context.<br>The second part is a report about a successful research project on the subject of tracking and tracing of chemical goods at multimodal transport routes in Europe.<br>The third part will give some time for discussion, valuation and a short summery.<br>Course topics:<br>• Roles of information in logistics<br>• Definition<br>• Information needs<br>• Data<br>• Information systems</td></tr>
<tr><td>Bibliography</td><td>• Chapman, Pete, J. Clinton, R. Kerber, T. Khabaza, T. Reinartz, C. Shearer und r. Wirth(2000). CRISP-DM 1.0 – Step-by-step data mining guide. SPSS Inc., USA.<br>• Fleischmann, Bernhard (2018). Grundlagen: Begriff der Logistik, logistische Systeme und Prozesse – Begriffliche Grundlagen. In: Arnold, Dieter, H.</td></tr>
</table>

| | | |
|---|---|---|
| | Isermann, A. Kuhn, H. Tempelmeier and K. Furmans, Hrsg.: Handbuch Logistik, Kap. A 1.1, S. 3-12. Springer Verlag, Berlin, 3. Aufl.<br>• Kagermann, Henning, W. Wahlster und J. Helbig (2013). Deutschlands Zukunft als Produktionsstandort sichern – Umsetzungsempfehlungen für das zukunftsprojekt Industrie 4.0 – Abschlussbericht des Arbeitskreises Industrie 4.0. acatech – Deutsche Akademie der Technikwissenschaften e.V., Promotorengruppe Kommunikation der Forschungsunion Wirtschaft – Wissenschaft, Frankfurt am Main.<br>• Koeppen, Veit, G. Saake, K.-U. Sattler (2014). Data Warehouse Technologien. Mitp, Verlagsgruppe Hüthig Jehle Rehm GmbH, 2. Aufl.<br>• Partsch, Helmuth (2010). Requirements-Engineering systematisch. Springer-Verlag, Berlin Heidelberg, 2. Aufl.<br>• Schenk, Michael, A. Krampe, O. Poenicke, K. Richter, H. Seidel (2012).<br>• Informationslogistik. In: Krampe, Horst, H.-J. Lucke und M. Schenk, Hrsg.: Grundlagen der Logistik – Theorie und Prxis logistischer Systeme, Kap. 4, S. 97-129. HUSS-Verlag GmbH, München, 4. Aufl.<br>• Straube, Frank (2004). E-Logistik – Ganzheitliches Logistikmanagement. Springer-Verlag, Berlin Heidelberg.<br>• 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.<br>• Vieweg, Iris, C. Werner, K.-P. Wagner, T. Hüttle und D. Backin (2012). Einführung Wirtschaftsinformatik – IT-Grundwissen für Studium und Praxis. Gabler Verlag \| Springer Fachmedien, Wiesbaden.<br>• Weber, Rainer (2012). Technologie von Unternehmenssoftware. Springer-Verlag, Berlin Heidelberg. | |
| **Teaching methods** | Lecture | x |
| | Demonstration | |
| | Hands on/games | |
| | Exercises | |
| | Visits at facilities | |
| | Other (describe)<br>………discussion, valuation and summary……………… | x |
| **Evaluation methods** | Homework | |
| | Class project | x |
| | Interim examination | |
| | Final examinations | |
| | Other (describe) | |
| **Creative Commons (CC) Licenses** | e.g. CC-Attribution-NonCommercial-NoDerivatives | |
| **Number of topics** | 5 | |
| **Lecture content** | | |
| 1 | Contents | |

| | |
|---|---|
| 2 | Role of information in logistics |
| 3 | Definitions |
| 4 | Information system |
| 5 | Information needs |
| 6 | Data |
| 7 | Big Data |
| 8 | Data Warehouse Architecture |
| 9 | Knowledge Discovery |
| **Other: case study** | |
| Demonstration of the results of a research project of several central European countries. In this course the focus will be at the results of a pilot test with several tracking and tracing systems. | |
| **Other: critical discussion** | |
| Concluding the main topics and findings are recapitulated. A critical discussion, involving all participants. | |

**Table 3.9:** Course C8

<table>
<tr><th colspan="2">Course: C8</th></tr>
<tr><td>Title</td><td>Design of passenger transport interchanges</td></tr>
<tr><td>Thematic area</td><td>Smart solutions</td></tr>
<tr><td>Responsible Institute</td><td>University of Thessaly, Greece</td></tr>
<tr><td>Lecturer</td><td>Eftihia Nathanail, Giannis Adamos</td></tr>
<tr><td>Aim</td><td>• Gain skills to design medium and large scale infrastructure and increase the perception of creating effective and efficient solutions that rely on safety principles<br>• Understand the design requirements and special characteristics of passenger interchanges for designing accessible infrastructure<br>• The course aims at achieving a synergy between substantive technical knowledge and safety consideration knowledge.</td></tr>
<tr><td colspan="2">Learning outcomes</td></tr>
<tr><td colspan="2">• Acquire practical knowledge of design aspects for passenger transport interchanges<br>• Possess a good understanding of passenger interchanges, know design principles of accessibility and acquire basic engineering skills in interchange planning<br>• 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<br>• Ensure that students have a sound understanding of the key issues affecting the planning, safety and comfort of passenger terminals.</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>3</td></tr>
<tr><td>Key words</td><td>Interchange, design, users, access/egress, facilities, accessibility, safety, way-finding, permeability, legibility</td></tr>
<tr><td>Syllabus</td><td>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.<br>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.</td></tr>
</table>

<table>
<tr><td></td><td colspan="2">Course topics:<br>• Interchange zones<br>• Users<br>• Access/egress<br>• Transport and transfer<br>• Understanding the interchange<br>• Facilities and retailing<br>• Safety and security<br>• Accessibility<br>• Comfort<br>• Facilities at different types of interchanges<br>• Case studies.</td></tr>
<tr><td>Bibliography</td><td colspan="2">• 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.<br>• CITY-HUBs: Sustainable and Efficient Interchange Stations. Taylor and Francis Group, 2015.<br>• 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.<br>• Edwards, B., 2011. Sustainability and the Design of Transport Interchanges. Abingdon, UK: Routledge.<br>• FDOT, 2007. Quality/Level of Service Handbook, Florida Department of Transportation (http://www.dot.state.fl.us/planning/systems/sm/los/).<br>• Green, C. and Hall, G., 2009. Better Rail Stations, Department for Transport.<br>• 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.<br>• GUIDE, 2000 Terzis, G., Last, An. GUIDE – Urban Interchanges –A Good Practice Guide –Final Report prepared for EC DG VII. April, 2000.<br>• Ministry of Transport, NSW, 2008. Guidelines for the Development of Public Transport Interchanges, MoT, NSW.<br>• Network Rail, 2011. Guide to Station Planning and Design, Issue 1, Network Rail, London.<br>• Rail Safety and Standards Board, 2013. Guidance on the implementation of station travel plans. RSSB.<br>• Sintropher Project, 2011. Good Practice in Transport Interchanges, Sinotropher Project, UCL.<br>• 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.<br>• Translink, 2011. Transit Passenger Facility Design Guidelines, Translink, Burnaby.<br>• Transport for London, 2009. Interchange Best Practice Guidelines, Transport for London, London.<br>• 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.</td></tr>
<tr><td>Teaching methods</td><td>Lecture</td><td>x</td></tr>
</table>

| | | |
|---|---|---|
| | Demonstration | |
| | Hands on/games | |
| | Exercises | |
| | Visits at facilities | x |
| | Other (describe): Case studies | x |
| **Evaluation methods** | Homework | |
| | Class project | x |
| | Interim examination | |
| | Final examinations | |
| | Other (describe) ………………………………………. | |
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| **Number of topics** | 11 | |
| **Lecture content** | | |
| 1 | Background | |
| 2 | Basic concepts | |
| 3 | Interchange zones | |
| 4 | Users | |
| 5 | Access/egress | |
| 6 | Transport and transfer | |
| 7 | Understanding the interchange | |
| 8 | Facilities and retailing | |
| 9 | Safety and security | |
| 10 | Accessibility | |
| 11 | Comfort | |
| 12 | Facilities at different types of interchanges | |
| 13 | Case studies | |
| 14 | Suggested literature | |
| **Visit at facilities** | | |
| 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. | | |
| **Other: case study** | | |
| 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. | | |

**Table 3.10:** Course C9

| **Course: C9** | |
|---|---|
| **Title** | **Design of freight transport interchanges** |
| **Thematic area** | Smart solutions |
| **Responsible Institute** | University of Thessaly, Greece |
| **Lecturer** | Eftihia Nathanail |
| **Aim** | Gain skills to design intermodal freight infrastructures and increase seamless transhipment and secure interconnections. |
| **Learning outcomes** | |
| • Knowledge of design aspects for intermodal freight terminals<br>• Good understanding of requirements of freight transport terminals and the complexity introduced by multi-disciplinarily of the associated activities<br>• 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** | Design, intermodality, legal framework, city terminal, freight villages, industrial and logistic parks, special logistic areas |
| **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.<br>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.<br>The main modules which comprise these terminals will be presented, and their functionalities and interactions will be explained.<br>**Course topics:**<br>• Elements of freight transport interchanges<br>• European legal framework - guidelines<br>• Categories of freight transport interchanges<br>• City terminals<br>• Freight villages<br>• Industrial and logistic parks<br>• Special logistic areas<br>• Cases studies<br>• Port of Rotterdam<br>• Manchester Airport – World Freight Terminal |

| | | |
|---|---|---|
| **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.<br>• CEC, Transport Infrastructure Needs Assessment in Central and Eastern Europe - TINA project.<br>• Department of Justice. (2010). 2010 ADA Standards for Accessible Design. Retrieved from http://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards.pdf.<br>• European Conference of Ministers of Transport, 2002, Transport Infrastructure Regional Study in the Balkans (TIRS).<br>• Europlatforms, 1996, Europlatforms E.E.I.G. Yearbook 1996, Bruxelles/Bologna.<br>• 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.<br>• 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/.<br>• 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.<br>• 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.<br>• Windborne International Group, 1994, Intermodal Freight Centers in Europe: a Strategic Analysis.<br>• World Bank, 2000, The Road to Stability and Prosperity in Southeastern Europe, March. | |
| **Teaching methods** | Lecture | x |
| | Demonstration | x |
| | Hands on/games | |
| | Exercises | |
| | Visits at facilities | |
| | Other (describe): Case studies | |
| **Evaluation methods** | Homework | |
| | Class project | x |
| | Interim examination | |
| | Final examinations | |
| | Other (describe)<br>………………………………………. | |
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| Number of topics | 10 |
|---|---|
| **Lecture content** | |
| 1 | Introduction |
| 2 | Elements of Freight Transport Interchanges |
| 3 | European legal framework - guidelines |
| 4 | Categories of freight transport interchanges |
| 5 | City terminals |
| 6 | Freight villages |
| 7 | Industrial and logistic parks |
| 8 | Special logistic areas |
| 9 | Cases studies |
| 10 | Port of Rotterdam |
| 11 | Manchester Airport – World Freight Terminal |
| 12 | Suggested literature |
| **Demonstration** | |
| Demonstration of videos for the case studies of the Port of Rotterdam and the Manchester Airport as freight transport interchanges. | |

**Table 3.11:** Course C10

| **Course: C10** | |
|---|---|
| **Title** | **Smart technologies for efficient logistics** |
| **Thematic area** | Smart solutions |
| **Responsible Institute** | Fraunhofer Institute for Factory Operation and Automation IFF |
| **Lecturer** | Olaf Poenicke |
| **Aim** | Teaching of basics for ICT for freight relevant applications for<br>• Identification (Auto-ID)<br>• Localization<br>• Condition Monitoring<br>• 3D-Scanning<br>• Information Logistics (data acquisition, data transmission, data processing, data analysis, etc.). |
| **Learning outcomes** | |
| • The audience gains basic information and experience (demonstration and hands-on) about modern information and communication technologies that are relevant in the sector of freight transport<br>• 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 the freight transport sector<br>• Furthermore open fields for R&D can be identified to discuss approaches for future international collaborative R&D projects. | |
| **Prerequisites (if any)** | |
| • Basic knowledge about logistics<br>• Technical understanding | |
| **Language** | English |
| **Hours** | 2 |
| **Key words** | Smart Logistics, Auto-ID, Localization, Condition Monitoring, 3D-Scanning |
| **Syllabus** | The course will be divided into three modules.<br>**Module 1** – will teach the basics of the different technologies as listed above. Starting from an overview on ICTs relevant for freight transport applications, single relevant technologies like RFID, GNSS localisation or 3D scanning will be explained in detail. The Module 1 will also give a brief overview on typical applications of the ICTs and development trends.<br>Duration approx. 75 mins.<br>**Module 2** – will give short demonstrations and a hands-on for the two technologies of RFID and 3D scanning. 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.<br>Duration approx. 30 mins.<br>**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.<br>Duration approx. 15 mins. |

| | | |
|---|---|---|
| **Bibliography** | • Schenk, M. (Hrsg.): Produktion und Logistik mit Zukunft – Digital Engineering and Operation. Springer, 2015.<br>• Richter, K.: Lecture – Telematik und Identtechnik, Otto-von-Guericke-Universität Magdeburg, 2015/2016.<br>• Finkenzeller, K. (Hrsg.): RFID-Handbuch: Grundlagen und praktische Anwendungen von Transponders, kontaktlosen Chipkarten und NFC.<br>• Krampe, H., Lucke, H., Schenk, M. (Hrsg.): Grundlagen der Logistik: Theorie und Praxis logistischer Systeme. Huss Verlag, 2012.<br>• Bartneck, N., Klaas, V., Schönherr, H.: Prozesse optimieren mit RFID und Auto-ID. Publicis Publishing, 2008.<br>• Roth, A. (Hrsg.): Einführung und Umsetzung von Industrie 4.0: Grundlagen, Vorgehensmodell und Use Cases aus der Praxis. Springer, 2016.<br>• Poenicke, O.: Workshop – Grundlagen Auto-ID und RFID, Fraunhofer IFF, 2016.<br>• Norms and Standards – e.g. GS1 – Tag Data Standard (version 1.9); VDA 5500; DIN 66277. | |
| **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** | e.g. CC-Attribution-NonCommercial-NoDerivatives | |
| **Number of topics** | 4 | |
| **Lecture content** | | |
| 1 | Background | |
| 2 | Auto-ID and IT infrastructure | |
| 3 | Radio and image based positioning | |
| 4 | 3D scanning | |
| 5 | Condition monitoring | |
| **Demonstration** | | |
| It will be given short demonstrations and a hands-on for the two technologies of RFID and 3D scanning. 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. | | |

| Hands on games |
|---|
| It will be given short demonstrations and a hands-on for the two technologies of RFID and 3D scanning. 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. |

**Table 3.12:** Course C11

| **Course: C11** | |
|---|---|
| **Title** | **Decision making methodologies** |
| **Thematic area** | **Decision making** |
| **Responsible Institute** | University of Thessaly, Greece |
| **Lecturers** | Eftihia Nathanail, 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<br>• Understand key methods for supporting logistics decision making<br>• Set goals, objectives and organize alternatives<br>• Understand most important decision making methods and problem building given alternatives and different stakeholders<br>• Evaluate alternatives with different units by considering normalization techniques<br>• Perform analysis, synthesis, and address problem issues and develop critical thinking skills to treat tradeoffs between alternatives<br>• Manage data and build decision support models in spreadsheets<br>• Use available tools for performing decision making. | |
| **Prerequisites (if any)** | |
| - | |
| **Language** | English |
| **Hours** | 3 |
| **Key words** | Decision making, social cost benefit analysis, multi-stakeholder multi-criterial analysis, transferability and adaptability analysis, risk analysis |
| **Syllabus** | The students are exposed to (a) social cost benefit analysis and (b) multicriteria assessment methodologies.<br>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.<br>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.<br>Risk assessment, transferability and adaptability analysis are also described and respective indicators and estimation methodologies are explained.<br>**Course topics:**<br>• Social cost benefit analysis<br>• Multi-stakeholder multi-criteria analysis<br>• Transferability and adaptability analysis |

| | | |
|---|---|---|
| | • Risk analysis | |
| **Bibliography** | • Cascetta (2009). *Transportation System Analysis: models and applications.* 2nd edition. Springer.<br>• CE Delft Report (2007). *Handbook on estimation of external cost in the transport sector*. EC DG Tren.<br>• Sinha, K.C. and Labi, S. (2007). *Transportation Decision Making. Principles of Project Evaluation and Programming.* Wiley.<br>• NIJKAMP, P., RIETVELD, P. and VOOGD, H., (1990). Multi-criteria Evaluation in Physical Planning, Elsevier Science, Amsterdam.<br>• Glenaffric Ltd (2007) Six Steps to Effective Evaluation: A handbook for programme and project managers.<br>• Paolo Beria, Ila Maltese and Ilaria Mariotti. Multicriteria versus Cost Benefit Analysis: a comparative perspective in the assessment of sustainable mobility.<br>• HEATCO (2005) Developing harmonised European approaches for transport costing and project assessment. Deliverable 1: current practice in project appraisal in Europe.<br>• 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.<br>• COM – The European Commission (2007) Greenbook 2007 – Towards a new culture for urban mobility. Commission of the European Communities, Brussels. | |
| **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** | 4 | |
| **Lecture content** | | |
| 1 | Background | |
| 2 | Multi-stakeholder Multi-criteria analysis | |
| 3 | Weighing | |
| 4 | Normalization | |

| | |
|---|---|
| 5 | Cost benefit analysis |
| 6 | Adaptability and transferability analysis |
| 7 | Risk analysis |
| 8 | Example |
| 9 | Suggested literature |
| **Exercises** | |
| Students will be divided into teams representing different stakeholder groups and they will be asked to solve a transport based multi-criteria problem by applying a decision making methodology. Each group (stakeholder) will state their preference in the decision making process by providing different weights in identified measures of performance. Final results of the evaluation will be shared in the class. | |

**Table 3.13:** Course C12a

| **Course: C12a** | |
|---|---|
| **Title** | **Data collection methods: Surveys** |
| **Thematic area** | Decision making |
| **Responsible Institute** | University of Thessaly, Greece |
| **Lecturer** | Eftihia Nathanail |
| **Aim** | The aim of this course is to:<br>• Provide an understanding of qualitative methods in data collection<br>• Present how a qualitative transport survey is organized<br>• Provide an overview of transport survey methods, the practical problems of sample design, the collection and application of transport-related data<br>• Introduce the process of surveys' analysis results in order to draw useful conclusions. |
| **Learning outcomes** | |
| • Identify appropriate methods for transport, traffic and spatial data collection.<br>• Understand the role of sampling in data collection<br>• 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 intercollegiate course will be organized and offered by two institutes: Fraunhofer (2 hours) (quantitative data collection methods) and University of Thessaly (1 hour) (qualitative data collection methods).<br>The main part will focus on describing how to set up a survey, how to cover aspects of sample estimation and experimental design and will introduce some basic statistical methods for data base preparation and analysis.<br>Analytically, this course will present a step-by-step guidebook for organizing and conducting 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.<br>**Course topics:**<br>• Setting up a survey<br>• Sampling<br>• Data collection methods<br>• Data collection techniques<br>• Research designs |

| | |
|---|---|
| | • Strengths and weaknesses of each method<br>• Statistical analysis. |
| **Bibliography** | • Abdel-Aty M., (2003), “Hybrid Distribution and Response Techniques for an Origin-Destination Travel Survey”, ITE Journal, pp. 22-27.<br>• Amekudzi, A., Meyer, M., & Ross, C. (2011). Transportation planning for sustainability guidebook. Washington, D.C.: U.S. Federal Highway Administration.<br>• 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.<br>• Bayart, C., Bonnel, P., & Morency, C. Survey mode integration and data fusion.<br>• Bonnel, P. (2009). Transport survey methods. Bingley, UK: Emerald.<br>• 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.<br>• 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.<br>• 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.<br>• Hagen L., Zhou H., Pirinccioglu F., (2006), “Development of Revised Methodology for Collecting Origin-Destination Data”, Florida Department of Transportation (FDOT), USA.<br>• 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.<br>• NOVELOG project (2016). Framework for Data, Information and Knowledge Collection for Urban Freight and Service Demand Understanding. Deliverable 2.1.<br>• Ortuzar J.D., Willumsen L.G., (1990), “Modeling transport”, 4th edition (published 2011), Wiley.<br>• Peter Stopher. Collecting, Managing, and Assessing Data Using Sample Surveys. Cambridge University Press, 2012. 246p.<br>• Survey Sampling. Theory and Methods, 2nd edition. Arijit Chaudhuri, Horst Stenger. Charman&Hall, 2005.- 380 p.<br>• 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<br>• Travel survey methods, freight data systems, and asset management 2011. (2011). Washington, D.C.<br>• 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 | x |
| | Interim examination | |
| | Final examinations | |
| | Other (describe) ………………………………………. | |
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| **Number of topics** | 7 | |
| **Lecture content** | | |
| 1 | Setting up a survey | |
| 2 | Sampling | |
| 3 | Data collection methods | |
| 4 | Data collection techniques | |
| 5 | Research design strengths and weaknesses of each method | |
| 6 | Statistical analysis | |
| 7 | Suggested literature | |

**Table 3.14:** Course C12b

| **Course: C12b** | |
|---|---|
| **Title** | **Data collection methods: Historical and observed data** |
| **Thematic area** | Decision making |
| **Responsible Institute** | Otto von Guericke University Magdeburg, Germany<br>Fraunhofer Institute for Factory Operation and Automation IFF |
| **Lecturer** | M.Sc. David Weigert |
| **Aim** | • Participants receive a basic introduction to decision theory and their extensive use in logistics<br>• 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. |
| **Learning outcomes** | |
| • Understanding of the handling, function and application and use of the currently available data sources in logistics<br>• Deepening and delimiting decision theory within logistics | |
| **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 a holistic concept for the analysis and modeling of large amounts of data. Always from the aspect of logistics.<br>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. In the area of telematics and ID technology, technologies for data analysis are increasingly being used. 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.<br>It should be clear that there is not only one solution to deal with Big Data within the logistics. The participants should be made aware of the facts and be given an extended insight.<br>**Course topics:**<br>• Quantitative data collection methods<br>• Data collection and sampling<br>• Open data sources<br>• Sampling, response, experimental and quasi-experimental design, survey design, and ethical Issues<br>• Data analysis and visualization, fusion techniques |

| | |
|---|---|
| | • Big data in transport |
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<table>
<tr><td></td><td colspan="2">• 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.</td></tr>
<tr><td rowspan="6">Teaching methods</td><td>Lecture</td><td>x</td></tr>
<tr><td>Demonstration</td><td></td></tr>
<tr><td>Hands on/games</td><td></td></tr>
<tr><td>Exercises</td><td></td></tr>
<tr><td>Visits at facilities</td><td></td></tr>
<tr><td>Other (describe)</td><td></td></tr>
<tr><td rowspan="5">Evaluation methods</td><td>Homework</td><td></td></tr>
<tr><td>Class project</td><td>x</td></tr>
<tr><td>Interim examination</td><td></td></tr>
<tr><td>Final examinations</td><td></td></tr>
<tr><td>Other (describe)<br>……………………………………….</td><td></td></tr>
<tr><td>Creative Commons (CC) Licenses</td><td colspan="2">e.g. CC-Attribution-NonCommercial-NoDerivatives</td></tr>
<tr><td>Number of topics</td><td colspan="2">6</td></tr>
<tr><td colspan="3">Lecture content</td></tr>
<tr><td>1</td><td colspan="2">Introduction</td></tr>
<tr><td>2</td><td colspan="2">Quantitative data collection methods</td></tr>
<tr><td>3</td><td colspan="2">Data collection</td></tr>
<tr><td>4</td><td colspan="2">Data sources and open data</td></tr>
<tr><td>5</td><td colspan="2">Survey design and ethical issues</td></tr>
<tr><td>6</td><td colspan="2">Data analysis and visualization</td></tr>
<tr><td>7</td><td colspan="2">Big data</td></tr>
<tr><td>8</td><td colspan="2">Big data in transport</td></tr>
<tr><td colspan="3">Other: case study</td></tr>
<tr><td colspan="3">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.</td></tr>
</table>

## 3.2 Lectures

The first version of the program's lectures are presented in the following sections. The material is expected to be updated in two milestones of the project thus, after the realization of each of the two summer schools.

# 4 References

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# 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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# General information

| Course title | Operation and management of intermodal transport systems |
|---|---|
| Hours | 1 |
| Lecturer/Institution | Prof.Irina Yatskiv (Jackiva)<br>Transport and Telecommunication Institute<br>Jackiva.I@tsi.lv<br>Prof. Eftihia (Teti) Nathanail<br>University of Thessaly<br>enath@uth.gr |
| Teaching methods | Lecture |
| Prerequisites | - |

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## 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:**
  - Look into databases, search engines and electronic libraries to retrieve information about a topic
  - Organize a scientific report
  - Conduct state-of-the-art
  - Document methodology and results
  - Work as a team member



3

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## Topics

1. Research process
2. Literature review
3. Quantitative research
4. Research dissemination
   - Dissertation
   - Research publication
   - Poster
   - Presentation
   - Scientific report
   - Oral
5. Citations and references
6. Ethics and Plagiarism

First version

4

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# RESEARCH – “A SYSTEMATIZED EFFORT TO GAIN NEW KNOWLEDGE“





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# 1. 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.**
- **The Research Process to produce new knowledge, or to offer a new manner of understanding present knowledge**
- **Purposes of Research**
  - *Exploration*

  gaining some familiarity with a topic, discovering some of its main dimensions, and possibly planning more structured research
  - *Description*
  - *Explanation*

  Take it one step further
- **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

## Phases of Research Process

- Problem definition
- Literature review
- Formulate hypothesis
- 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.





## 2. Literature review

- It is necessary for the researcher to conduct an extensive survey connected with the problem.
- A literature review goes through earlier research that has already been done on the 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

# alliance Locating information

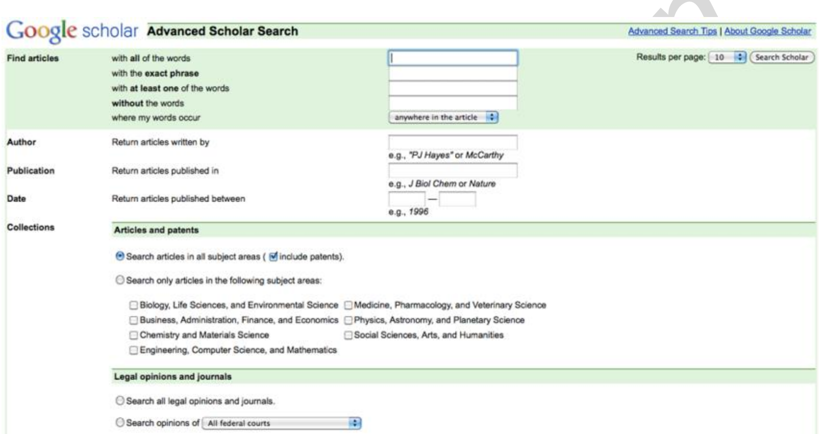
- **(a) Books**
- **(b) Journals**
  - Journal indexes (magazines, scholarly journals) tie together journals and articles on your subject.
  - Each subject area has its own journal index.
  - Be sure you are using the correct index for your subject.
- **(c) Newspapers**

  For accessing the most recent day-to-day events, such as:
  - international, or bi-lateral agreements
  - local and national politics
  - natural disasters
  - social problems, other events, etc.





# alliance Internet is a powerful source



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## Internet is a powerful source

| Name | Discipline(s) | Description | Access Cost | Provider(s) |
|---|---|---|---|---|
| Academic Publications eJournal | Multidisciplinary science (student based) | Student driven research abstracts, posters, articles, science specific search engine, public forum [1] | Free | APeJ search[2] |
| Academic Search | Multidisciplinary | Several versions: Complete, Elite, Premier, and Alumni Edition[3] | Subscription | EBSCO Publishing [4] |
| Directory of Open Access Journals | Journals | | Free | Lund University[45] |
| Google Scholar | Multidisciplinary | | Free | Google[56] |
| Science Citation Index | Science (General) | Part of Web of Science | Subscription | Thompson Reuters[105] |
| ScienceDirect | Multidisciplinary | | Subscription | Elsevier[106] |
| Scirus | Science (General) | | Free | Elsevier[107] |
| Scopus | Multidisciplinary | | Subscription | Elsevier[108] |
| SpringerLink | Multidisciplinary | | Free abstract & preview; | Springer [116] |



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## Transportation related search

| | | |
|---|---|---|
| TRIS | http://ntlsearch.bts.gov/tris/index.do | Transportation related search engine. Articles, journals, publishers and authors can be found. |
| Science.gov | http://science.gov | A USA goevmment gateway to over 50 million pages of authoritative selected science information |
| TLCat | http://ntl.bts.gov/link.html | Transportation Libraries Catalog. Scientific search engine specialized on transportation. |
| IPL | http://www.ipl.org | The "Internet Public Library" webportal with links to various scientific websites, including transportation related. |
| Ntis | http://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.engnetbase.com | Engineering handbooks publisher - Not available free of charge. |
| Digital Engineering Library | http://www.digitalengineeringlibrary.com | Internet engineering library - Not available free of charge, only abstracts available |

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# State of 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*

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# Established Journal Measure

- **(a) 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
- **(b) 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.*

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## Writing a Literature Review Paper. **Select** and read **your sources**

- Explore the articles 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 some more.
- Often databases will suggest ways to focus your topic by providing lists of subtopics. Each click on these will narrow your results further.
- 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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## Writing a Literature Review Paper. Select and **read your sources**

- Once you've settled on a topic, the next step is to choose which resources to review. When looking at 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.
- To read the simplest articles first. This will give you the vocabulary you need and help you understand the more challenging articles in your collection. Give yourself time to understand each article. If you're confused, it's going to be reflected in your paper.

## Writing a Literature Review Paper. Write your review - 1

- A literature review has three main sections:

  *a. the introduction*
  *b. the body, and*
  *c. the conclusion.*

- In **introduction**

  - define or identify the general topic, issue, or area of concern. That is, 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.





## Writing a Literature Review Paper. Write your review - 2

- The **body** of your paper 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.

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## Writing a Literature Review Paper. Write your review - 3

- For the **conclusion** of paper:

  a. summarize **major contributions** of significant studies and articles to the body of knowledge under review

  b. point out **major methodological flaws** or **gaps** in research, inconsistencies in theory and findings, and areas or issues pertinent to future study

  c. tween **the central topic** of the literature review and a larger area of study, such as a discipline, a scientific endeavor, or a profession.

Material adapted from:
The University of Wisconsin, Madison: Review of Literature (©2009) at http://writing.wisc.edu/Handbook/ReviewofLiterature.html





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## 3. 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

# 4. Research dissemination

- Promote and exchange knowledge.
- Inform the scientific community.
- Safeguard research results.
- Contact potential cooperators.
- Demonstrate accountability.
- Facilitate fund raising.
- Enable researcher's promotion.





# Research dissemination through …

- **Dissertation:** 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. Due to their length, dissertations are organized into chapters and usually end with a final concluding chapter.

- **Research publication:** articles go through a much shorter review process, anywhere from three months to one year. However, they are also reviewed by peers (scholars who are experts in the field of study) and journal editors. Because of their conciseness, they tend to follow a standard format.

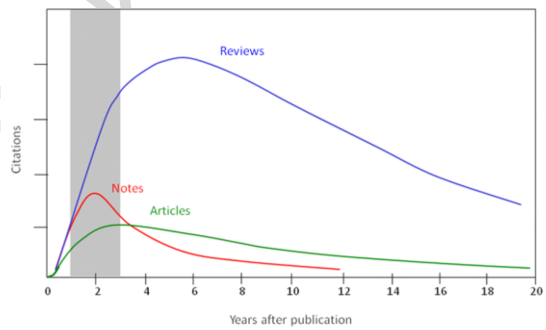
*"The goal of scientific research is publication…A scientific experiment, no matter how spectacular the results, is not complete until the results are published."*

*@Robert A. Day - How to write and Publish a Scientific Paper*

## alliance — Types of the articles

- **Full articles/ Original 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.
- **Review papers/ perspectives:** 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.
- **Conference papers**








## alliance — 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**

# 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? |





# Abstract – The Summary of Work

Introduction
- state of knowledge (Big picture to specific)
- what is the question
- statement of hypothesis (optional)

Methods
Results
Discussion
Summary

*Please ensure that the abstract is as complete, accurate, and clear as possible, but not unnecessarily long.*
*We may screen original research articles by reading only the abstract.*

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## Basic Rules in scientific writing

- Avoid Long Phrases
- Parallel Sentences
- Omit Needless Words
- Creating a flow between sentences
- Avoid Repetition
- Sneaky Plurals
- Avoid Gender Specific Pronouns
- Use because to mean "because"
- Correct use of Verbs





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## Research dissemination through …

- **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.

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

| 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 |

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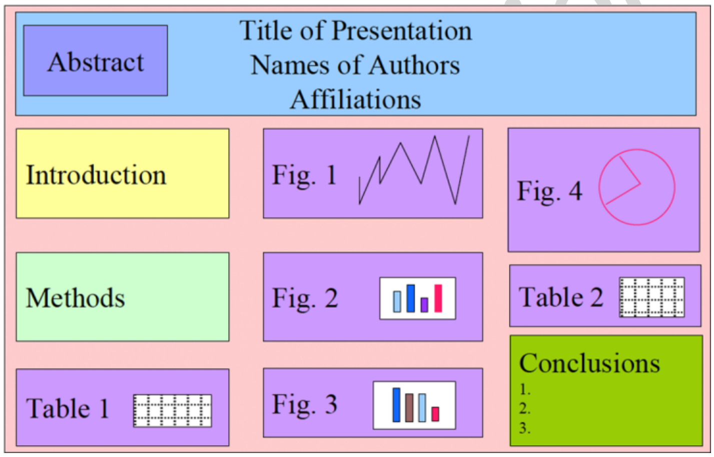
# The poster – a sample

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# Research dissemination through …

## Oral 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.



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# Oral Presentation

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.

***Sourse:*** *Nicholas Higham (1998). Handbook of Writing for the Mathematical Sciences, University of Manchester, UK*

*DOI: http://dx.doi.org/10.1137/1.9780898719550*





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# 5. Citations and references

**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)

**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.**

*Source: CITY-HUBs, 2015*

# 6. 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 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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## 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
- No one who fulfils the criteria should be excluded

*And agree authorship before starting the study!*



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Thank you for your attention!

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# The European policy on intermodal transport

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

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## Background





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## Background

- Transportation is directly associated to the every-day activities of humans and covers the need of people to be transported to specific locations, but also to receive goods required for their activities
- 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!

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# Theoretical methodologies





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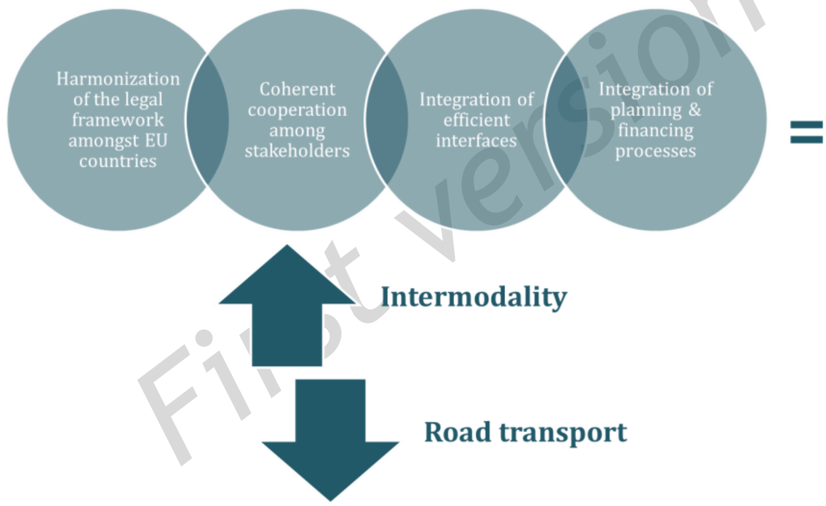
# Basic concepts

| | |
|---|---|
| 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 |
| 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 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 |
| 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” |

*Sources: EC, 2007; Adamos & Nathanail, 2015; CLOSER, 2011*

## Transportation in an era of change








## Future changes in European Transport Policy (1/2)

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

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

## alliance Future changes in European Transport Policy (2/2)

**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 (Source: United Nations)
  - 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)





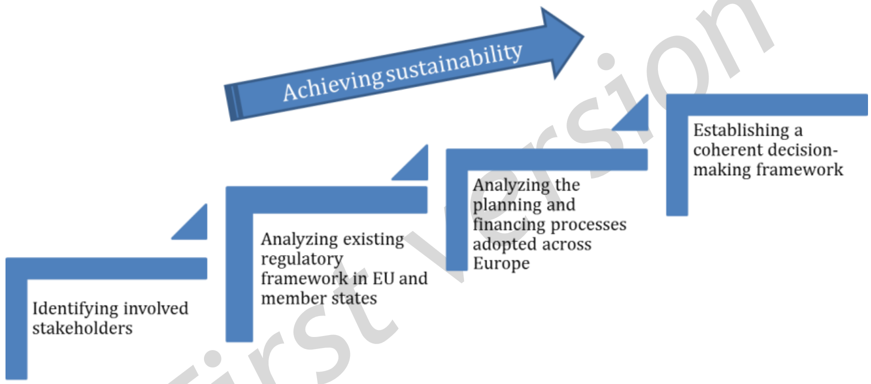
## alliance Defining obstacles & problems

- 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?








## alliance Decision-making framework

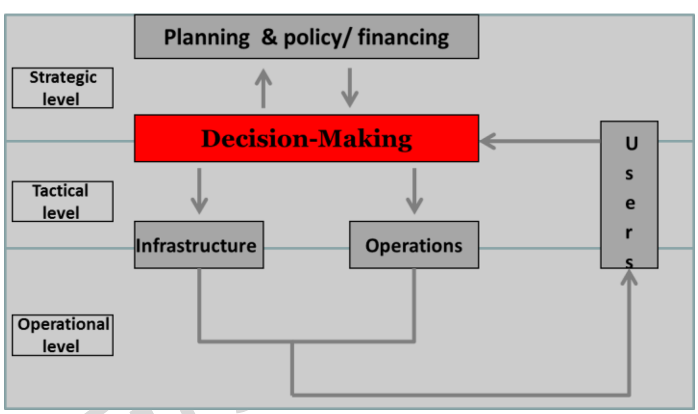



**Fig. 1:** Illustration of D-M processes in intermodality

*Source: CLOSER, 2012*

# alliance Basic actors and interrelations

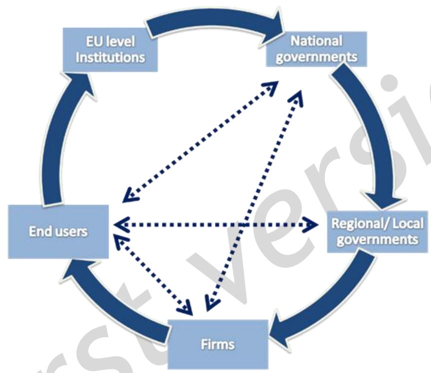



**Fig. 3:** Basic actors and interrelations among them

*Source: Adamos et al., 2012*





# alliance Actors and areas of involvement

**Table 1:** Actors 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<br>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<br>Regulations | Financing of the development of interfaces (infrastructure, construction, services, etc.)<br>Initiatives for investments in the domain | Provision of equal transportation services to all citizens<br>Promotion of information society | Improvement of transport energy efficiency<br>Promotion of green transport<br>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<br>Benefits from the provision of passengers and freight services<br>Administration f resources for regional development | Provision of sustainable urban transport to all citizens<br>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)<br>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<br>Land investments for the development of interfaces<br>Stability in pricing policy<br>Criticism of rationality of investments | Equal transportation conditions to all users<br>Enhancement of safety and security for passengers and goods<br>Improvement of work conditions | Compliance with national and European environmental issues<br>Demand for environmentally friendly transport projects<br>Avoidance of land and nature encroachment |

*Source: Adamos et al., 2012*

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



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## European institutional framework

- European Union (EU) is an organization of economic and political cooperation between 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 instruments:

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

*Source: htpp://europa.eu*

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# EU Policies (1/2)

| | |
|---|---|
| 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: htpp://europa.eu*



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# EU Policies (2/2)

| | |
|---|---|
| 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. |
| 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. |
| 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. |

*Source: htpp://europa.eu*

## 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, 2011*

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## Regulatory framework at national level

- The Ministry of Transport 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, 2011*

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# 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, 2011*



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# Indicative legislation (1/2)

| | |
|---|---|
| Road transport | - Council Regulation (EEC) No 684.92 of 16 March 1992 on common rules for the internal carriage of passengers by coach<br>- Bus and the 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<br>- 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 |
| Waterborne transport | - Council Directive 95/64/EC of 8 December 1995 on statistical returns in respect of carriage of goods and passengers by sea |



*Source: CLOSER, 2011*

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# Indicative legislation (2/2)

| | |
|---|---|
| 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<br>- 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<br>- 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 |
| 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<br>- Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system<br>- 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 |

*Source: CLOSER, 2011* 23

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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*

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## 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 TRPs 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*

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## 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*





## Applications

alliance **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., expect 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 under 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*

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alliance **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*

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# 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*





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# 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*

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# Freight terminals



**Kuehne & Nagel terminal**

- Due to the private status of the terminal, private actors are mostly involved in all staged of the planning process, excluding the regulatory framework and the evaluation/ selection, for which national authorities are responsible
- National authorities are met in the state of 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 infrastructures, 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*



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# 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.
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- 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.
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- United Nations Population Division (2009), ‘World population prospects — The 2008 revision’.

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# Building business models for intermodal transport interchanges

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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
- Case study
- 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*

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# Business models



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# Business models

Definitions:

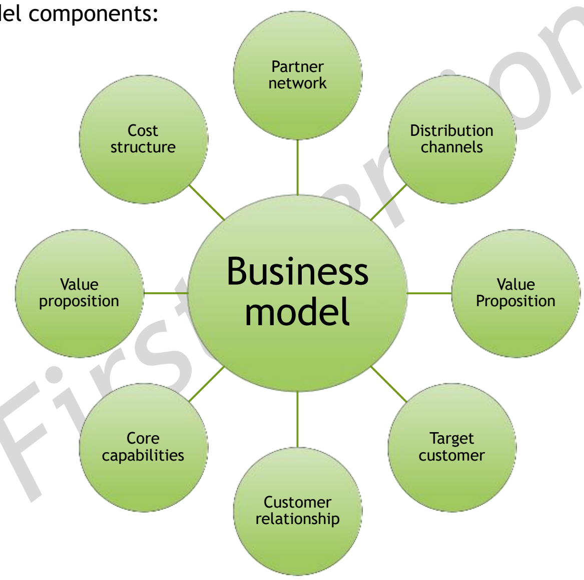
"A business model describes the value logic of an organization in terms of how it creates and captures customer value." [Fielt (2011), p. 3.]

"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

Business model components:








# 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

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# Stakeholders' governance models





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## 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 programmes
- **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.

*Source: Di Ciommo, 2004; Martens, 2007*

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# Intermodal transport





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# Intermodal transport

- Refers to the transportation of freight from their origin to their destination by a sequence of at least two different transportation modes
- 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

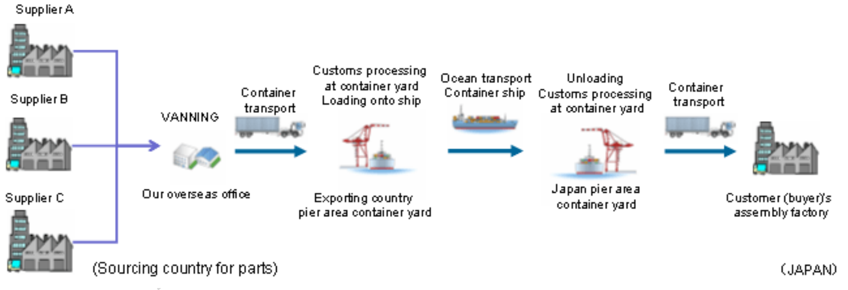
Pic: Duisport (n.d.).

# 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)


Pic: Road Railer, cct Intermodal Sweden (2007).

Intermodal transport: Truck – ship

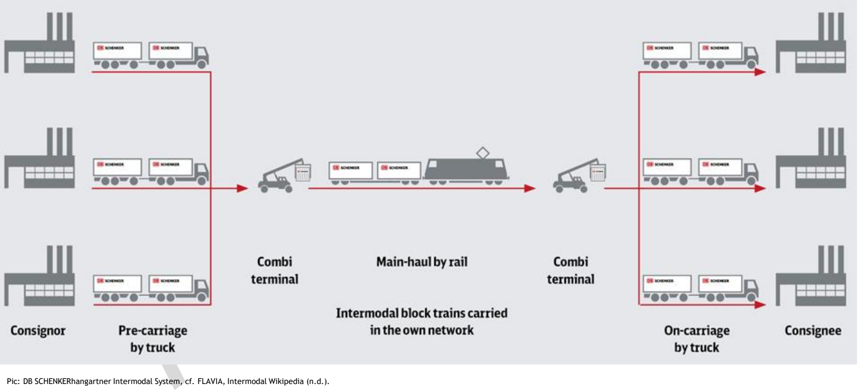



Pic: Maruzen Showa (n.d.).

11

# Intermodal transport

Intermodal transport: Truck – railway




Pic: DB SCHENKERhangartner Intermodal System, cf. FLAVIA, Intermodal Wikipedia (n.d.).

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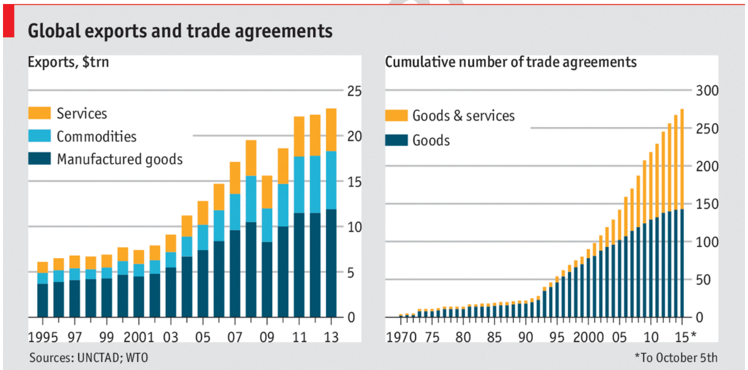
# Intermodal transport

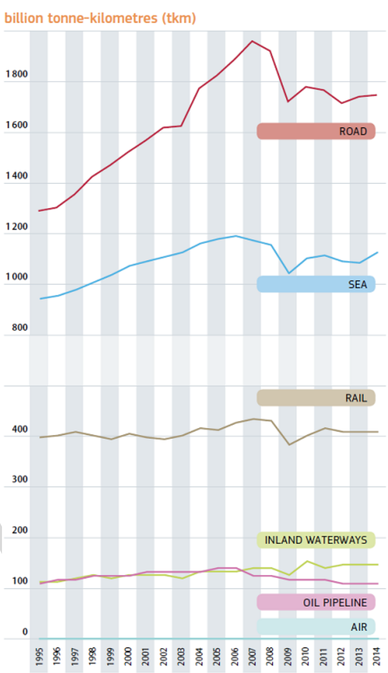
- Reasons for intermodal transport:
  - Combines the advantages of each transportation mode used
  - Reducing prodigality in logistics
  - Reduction of costs
  - More environmentally friendly
  - Exhibits significant growth in the future due to globalization




Cf. Economist (2015).



Modal Split – Freight Transport – Statistics – EU 28




EU Statistical Pocketbook (2016), p. 35.

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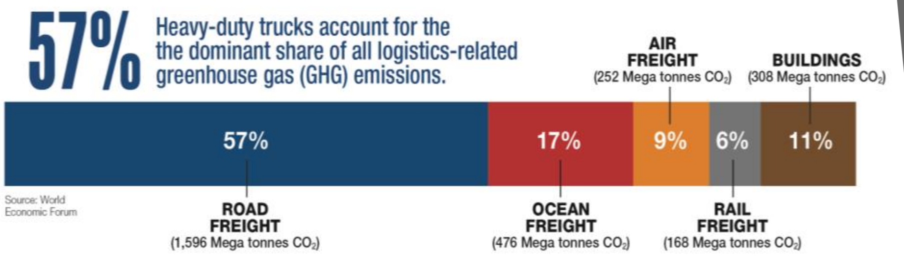
# Intermodal transport

- Comparison of the greenhouse gas emission between different transportation modes




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



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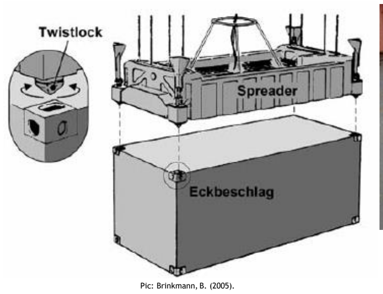
# Intermodal transport

- 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: Brinkmann, B. (2005).

Pic: Container spreader Timars C-lift, Timars (n.d.).

Pic: Full option spreader OCT, VDL Containersystemen (2012).

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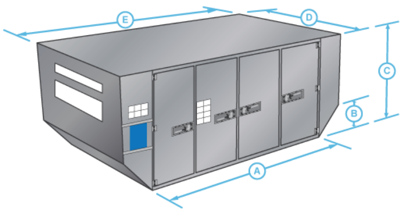
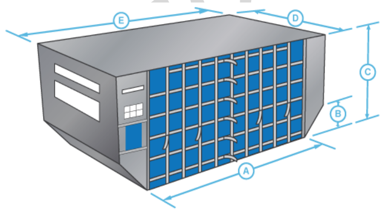
# Intermodal transport

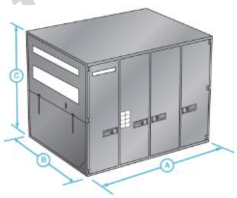
- Plane uses different containers (Unit Load Device – ULD)
  - Smaller than normal containers
  - More efficient utilization of the plane




Container - ALM




Container - ALF




Container - AMA

Pic: Blueprint Global (2016).



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# Intermodal transport

- Different modes of transport:

Pic: pallet2ship (n.d.).

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# 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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# Modes of transport

Exercise

| | 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.

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# Modes of transport

Exercise

| | Truck | Rail | Inland vessel | Ship | Plane |
|---|---|---|---|---|---|
| Transport time | light green | orange | orange | yellow | light green |
| Adherence to schedule | light green | yellow | yellow | yellow | light green |
| Transport costs | yellow | yellow | yellow | yellow | orange |
| Flexibility | light green | orange | orange | yellow | yellow |
| Infrastructure | light green | yellow | orange | yellow | yellow |

Legend: very well (dark green, light green, yellow, orange, red) → awfully bad

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



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# Interchange zones

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# 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:

Mobile truck

Pic: MOBILER, Rail Cargo Austria, Verkehrsrundschau (2012).

Straddle Carrier

Pic: Kalmar industries (2010).

Cargo & Container Loader

Pic: Delticgroup (2012).

Reach Stacker

Pic: Reach Stacker C 4026-4535 CH, Linde (n.d.).

Lift AGV

Pic: Terex Gottwald Lift AGV, Terex (n.d.).

AGV

Pic: AGV, Terex (n.d.).

# Interchange zones

- Used cranes for loading processes:

Transtainer (RMG)

Pic: Terminal Intermodal, Terex (n.d.)

Container gantry crane

Pic: Container gantry crane, Nauticexpo (n.d.)

Container gantry crane - tandem/twin

Pic: Tandem lift spreader of a STS container crane, LASSTEC - load sensing system, Conductix (n.d.)

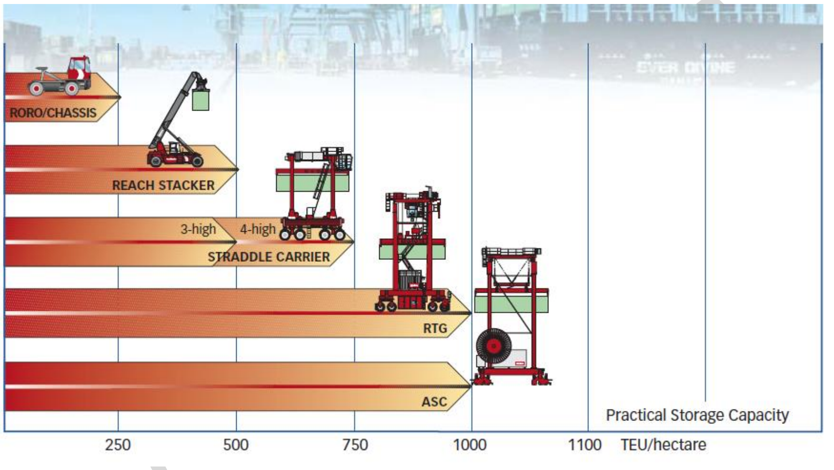
Container gantry crane - tandem/triple


Pic: RAM Spreaders Singflex STS crane spreader system, WorldCargo News (2014).



# 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


BASF intermodal transport terminal, Ludwigshafen, Germany

Pic: Loading of trucks at HHLA Container Terminal, BASF (2015).

Ship - truck loading


Port Hamburg, Germany

Pic: Loading of trucks at HHLA Container Terminal, Bildarchiv HH, (n.d.).

Truck - plane loading


Airport Frankfurt am Main, Germany

Pic: Truck and airplane from Berlin to Canada, Deutsche Bahn AG, Michael Neuhaus (2014).



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# Interchange zones

- Examples:

CargoBeamer:
Truck - rail loading


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

Railrunner:
Truck - rail loading


Pics: Terminal Anywhere Solutions, Railrunner (n.d.)

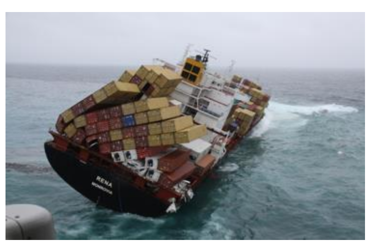
# Safety and Security



## 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
- 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

Pic: Gursten, S. (2014).



Pic: World Maritime News, http://worldmaritimenews.com/archives/160925/why-containers-get-lost-at-sea/

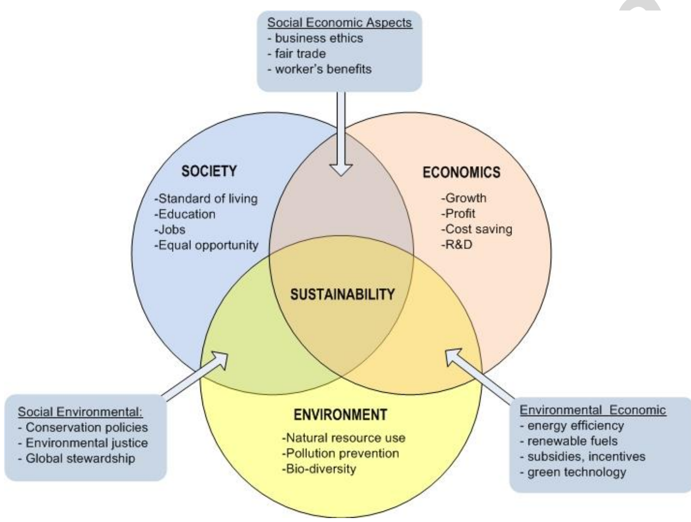
# Sustainable interchanges





# Sustainable interchanges

- Three pillars of sustainable development




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
- The most profitable operating models include public ownership of assets
- 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.

*Source: City-HUB, 2013*

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# 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.

*Source: City-HUB, 2013*

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# Case study





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# Case study

First version

Railport:

A railport or rail cargo logistics center is a multifunctional logistics location with direct rail link in order to connect several transport modes. Due to its dominant position within the transport system, this is usually road transport with connections to the highway network and direct access to the distribution network in the catchment area. It is also possible and reasonable to provide connections to inland waterways, airports, and pipeline networks.

Deutsche Bahn AG and its transport and logistics department DB Schenker pursue the idea of offering their customers an integrated door-to-door service by making use of these multifunctional and multimodal rail logistics centers throughout Europe. The development of this concept was triggered by the idea of more deeply integrating the railroad system in order to unlock new logistics potential. This also helps decongest the road infrastructure and thus decreases the ecological impact by using eco-friendly modes of transport. Railports are mostly built in the vicinity of already existing freight depots or cargo terminals.

Railports offer the possibility of transshipping and storing many different types of goods:

- Units of combined cargo traffic (e.g. container, swap bodies, trailers)
- Cranable large-sized goods (e.g. steel products, pipes, wood, machines)
- General cargo (e.g. palletized goods, paper rolls, furniture)

However, the services offered at railports go much beyond the mere storage and transshipment of goods. Goods also need to be prepared for on-carriage and distribution throughout the region. This involves services such as picking, inventory management, quality checks, clearing, and delivery or collection of the goods to the region or from the region.

Cf. Gleissner, Fermerling (2013), p. 46.

## Case study

Exercise:

Design a transportation system for this case study 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.





## 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. Transportation planning principles
2. Planning process
3. Forecasting methodologies
4. Transport impacts
5. Sustainability assessment
6. Smart solutions in sustainable transport planning
7. Sustainable urban development and mobility plans
8. Environmental impact assessment
9. Suggested literature

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# Transportation planning principles





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## General

- 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: http://www.vtpi.org/planning.pdf

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# 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: http://www.vtpi.org/planning.pdf

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# 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: http://www.vtpi.org/planning.pdf

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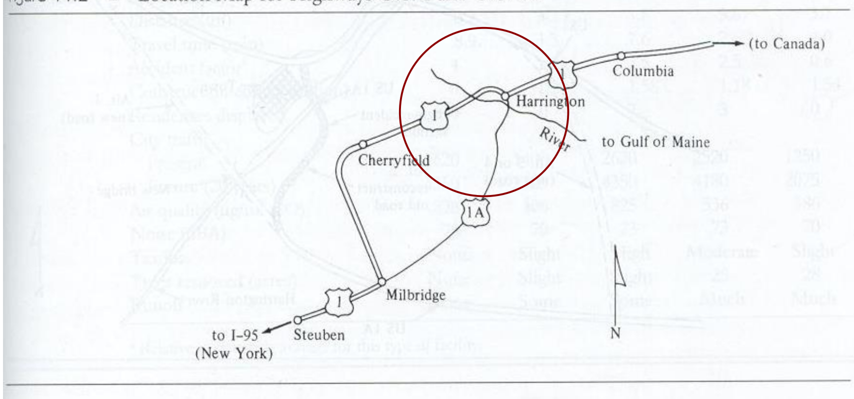
# Example

Step 1: Situation definition:

Problem → Need for a transport improvement

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




Reference: The Ira A. Fulton College of Engineering and Technology

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# Example

Step 2: Problem definition

Describe the problem in terms of the objectives to be

Objective = Reduce traffic congestion, Improve safety, Maximize net highway-user benefits, etc.

Criteria = Measures of effectiveness: Travel time, accident rate, delays (interested in reductions in these MOEs)

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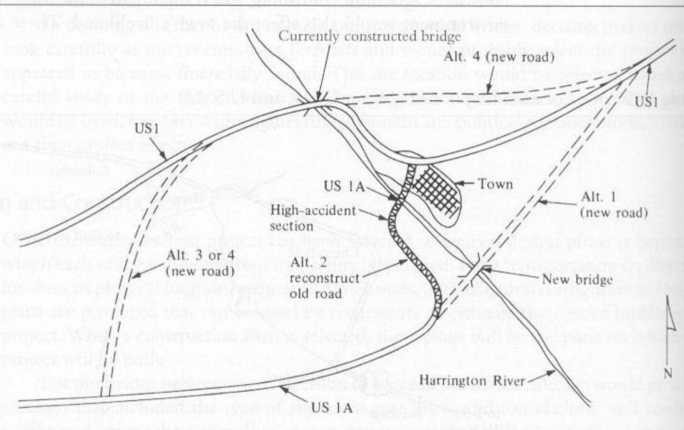
# Example

**Step 3: Search for solutions**

Options at this stage.

■ Alternative Routes for Highway Relocation

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# Example

**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[a] | 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 |
| Air quality (μg/m³ CO) | 825 | 306 | 825 | 536 | 386 |
| Noise (dBA) | 73 | 70 | 73 | 73 | 70 |
| Tax loss | None | Slight | High | Moderate | Slight |
| Trees removed (acres) | None | Slight | Slight | 25 | 28 |
| Runoff | None | Some | Some | Much | Much |

[a] Relative to statewide average for this type of facility.

# Example

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

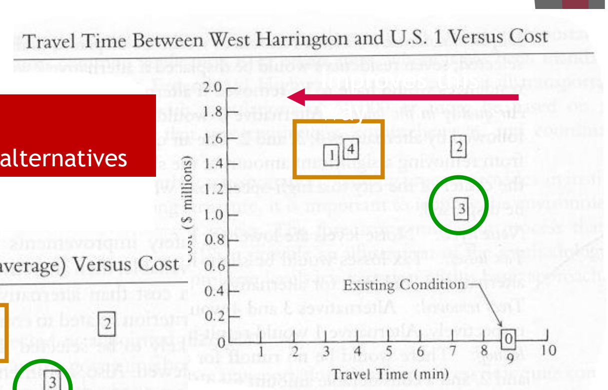
| Criterion/Alternative | 0 | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | | | Alternatives | | |
| Travel time | 4 | 1 | 3 | 3 | 2 |
| Accident factor[a] | 5 | 2 | 4 | 3 | 1 |
| Cost ($ millions) | 1 | 3 | 5 | 2 | 4 |
| Residences displaced | 1 | 1 | 3 | 2 | 1 |
| Air quality | 4 | 1 | 4 | 3 | 2 |
| Noise | 2 | 1 | 2 | 2 | 1 |
| Tax loss | 1 | 2 | 4 | 3 | 2 |
| Trees removed (acres) | 1 | 2 | 2 | 3 | 4 |
| Increased runoff | 1 | 2 | 2 | 3 | 3 |

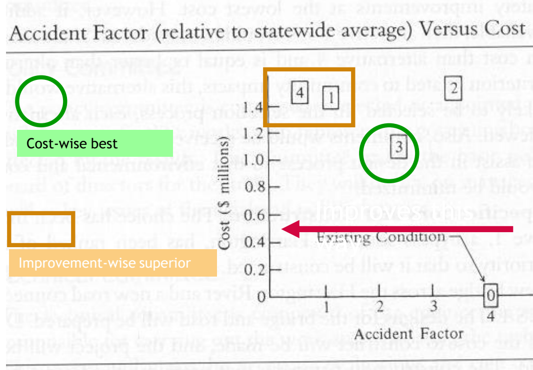
Note: 1 = highest; 5 = lowest.

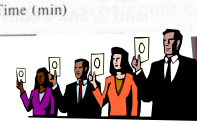
# Example

## Step 6: Evaluation

Estimate criteria and compare alternatives



Multi-objective evaluation problem.

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# Example

Step 7: Choose alternative

Step 8: Specification and construction



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# Planning process

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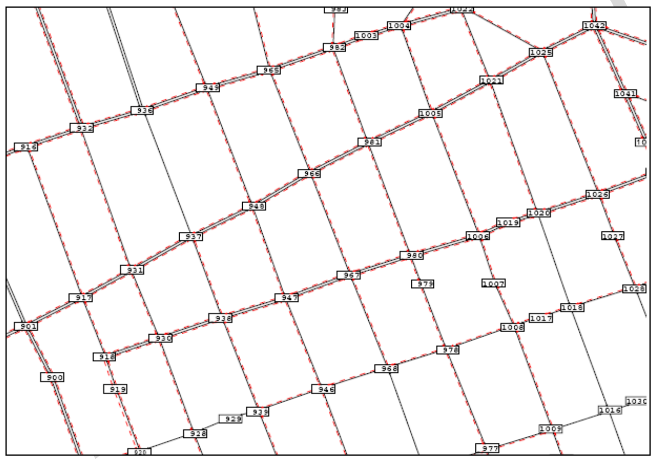
# Define zones of study (1/2)



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# Define zones of study (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

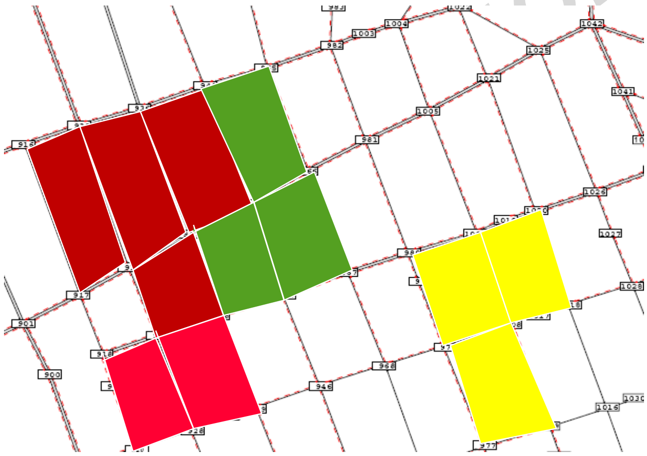
**Centroid:**

- 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.

# Socioeconomic characteristics of zones



# Define network

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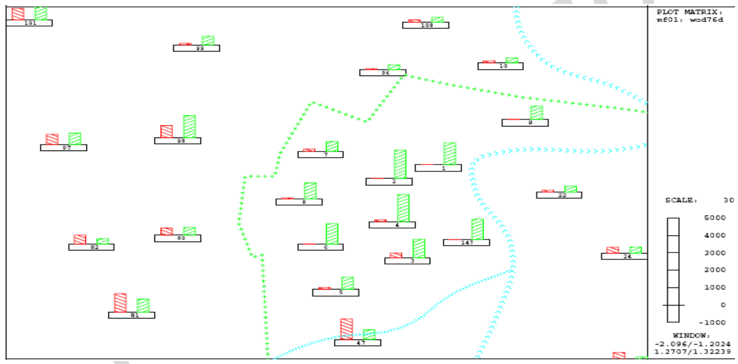
# Trip generation

Estimate trips which are generated and attracted per zone

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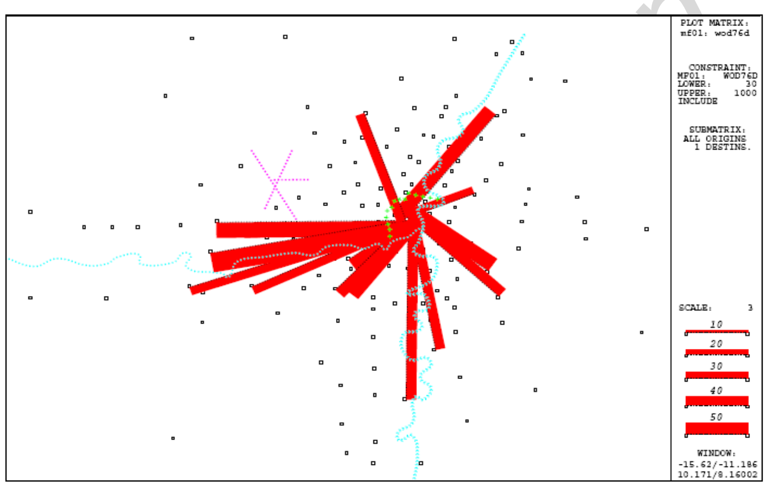
# Trip distribution

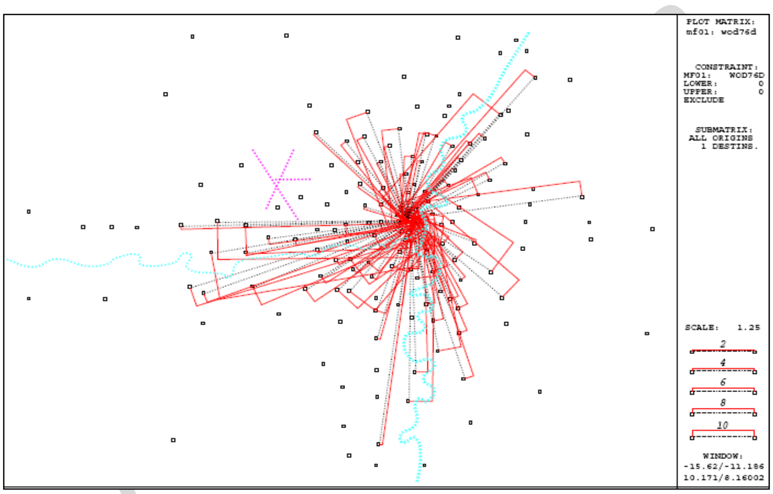


## O - D Matrix Example

| Origins | Destinations 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 | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_6$ | |



## Modal split



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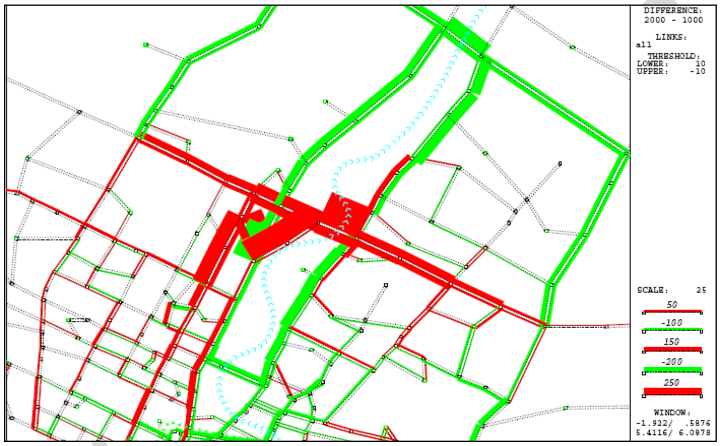
# Trip assignment

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# Forecasting methodologies

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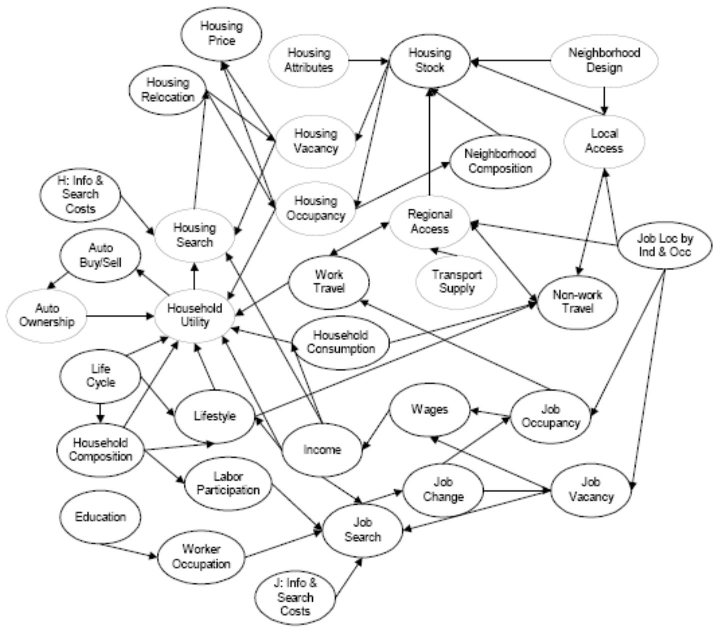


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# Need for Traffic Forecasting

Transportation Forecasting is used to estimate the number of travelers or vehicles that will use a given transportation facility in the future

- Traffic planning
- Geometric design
- Pavement design

The conventional approach to transportation forecasting is based on what is commonly know as the ***'four step model'***

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# What is it used for?

Transportation forecasting models have often been used in a ‘predict and provide’ mode to determine the *highway capacity* needed in response to predicted growth in traffic volumes.

Often, in this case, the full impact of changes in land use is not properly taken into account and the resulting induced traffic is over looked.



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# Four basic elements of the urban transportation forecasting process

1. Data collection (population, land use, etc.)
2. Analysis of existing conditions and calibration
3. Forecast of future travel demand
4. Analysis of the results

# Developing transport models

**Process of developing transport models:**

1. Convert real world into Traffic Analysis Zones – Then convert highways and traffic analysis zones into a set of nodes and links building a graph
2. Data collection
3. Developing mathematical model
4. Model calibration
5. Define variables
6. Apply model
7. Evaluating model



# Transport models

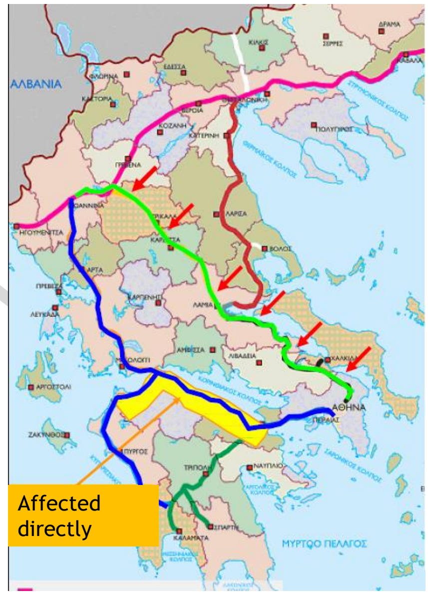
**Step 1**

- 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

# Example

Example: Forecasting traffic volumes

Area that is affected directly and indirectly






# Transport models

## Step 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.

⬇

- Explore travel behavior – Trip generation and mode choice

⬇

- Research stated preference

## Transport models

### Step 3.

- **Define model**
  i. Model structure
     i. Deterministic, static
     ii. Stochastic, dynamic
  ii. Define function of model
     i. Linear
     ii. 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 2 perceives route 2 as the fastest

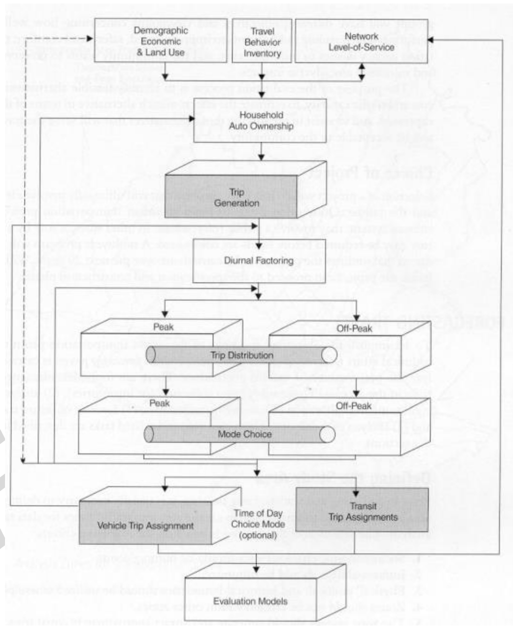
**Static model** $Y = f(x, \theta)$

- ✓ 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)

# Travel demand model flowchart




# The Four Step Model

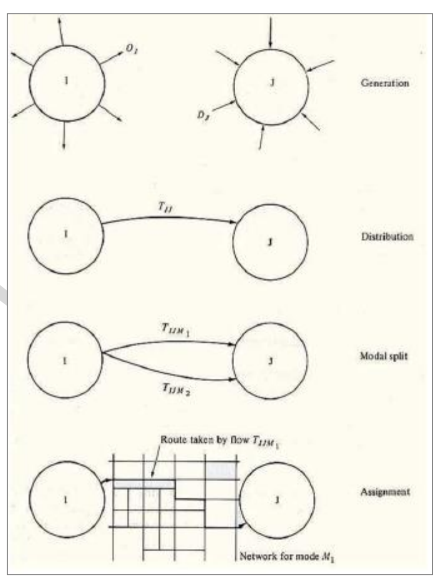
- **Trip Generation**

  *Estimates the number of trips from given origins and destinations*
- **Trip Distribution**

  *Determines the destination for each trip from a given origin*
- **Mode Choice**

  *Determines the mode choice for each trip*
- **Route Assignment**

  *Determines the specific route for each trip*



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# Limitations

Some limitations of 4-step and other older models

- 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

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# Trip generation

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 |

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# Trip Distribution Models

You can consider this as the probability spatial distribution P(Tj)

- Gravity Model
  - $T_{ij} = T_i \dfrac{A_j / C_{ij}^{a}}{\text{Sum}\,(A_x / C_{ix}^{a})}$
    - $T_{ij}$ = 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



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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 | $T_{21}$ | $T_{22}$ | $T_{23}$ | $T_{24}$ | $T_{25}$ | $T_{26}$ | $O_2$ |
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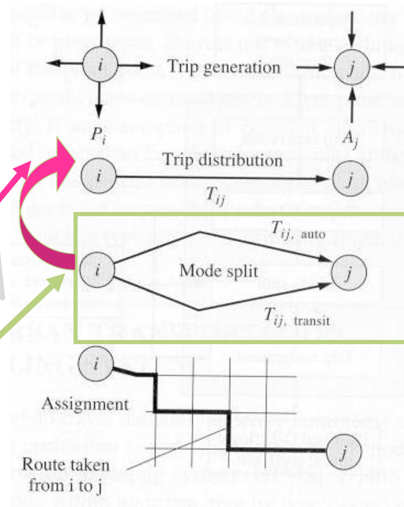
| 6 | $T_{61}$ | $T_{62}$ | $T_{63}$ | $T_{64}$ | $T_{65}$ | $T_{66}$ | $O_6$ |
| Sum | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $D_5$ | $D_6$ | |

# Modal split

Split trips to different available transportation modes

Trip-end models
vs.
Trip-interchange models






# What affects people's mode choice?

Characteristics of the trip: trip distance, time of day, trip purpose

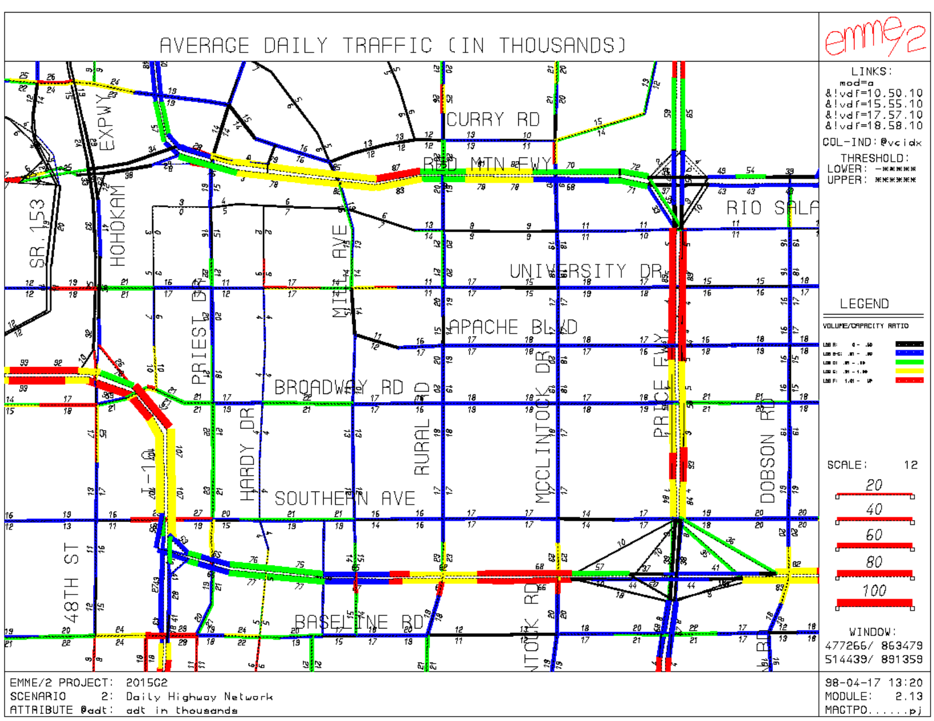
Characteristics of the trip maker: Income, # of autos available, family size, residential density, gender

Characteristics of the transportation system: riding time, waiting time, transfers, out-of-pocket cost

# Trip / Traffic Assignment Questions

- 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?





# Activity based models (1/2)

- Replicate actual traveler decisions and thus may provide better forecasts of future travel patterns
- incorporate some significant advances over 4-step tripbased models (Example: explicit representation of realistic constraints of time and space and linkages among activities and travel, for an individual person as well as across multiple persons in a household)
- Activity-based models can be used to evaluate alternative investments and policies that are difficult to test using traditional trip-based or sketch-planning models.

**TABLE 1.1. KEY TRAVEL QUESTIONS AND ANSWERS**

| Key Travel Questions | Trip-Based Model Components | Activity-Based Model Components |
|---|---|---|
| What activities do people want to participate in? | Trip generation | Activity generation and scheduling |
| Where are these activities? | Trip distribution | Tour and trip destination choice |
| When are these activities? | None | Tour and trip time of day |
| What travel mode is used? | Trip mode choice | Tour and trip mode choice |
| What route is used? | Network assignment | Network assignment |

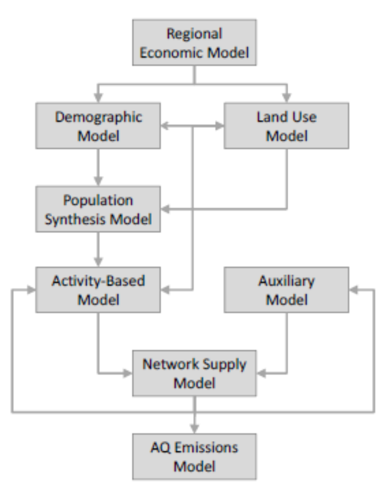
Reference: Activity-Based Travel Demand Models, a primer (2015)

# Activity based models (2/2)

Features

- Individual travelers
- Interrelated decision making
- Detailed information
- Integrated travel demand model system



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

## alliance Intermodal models

Definitions:

- Intermodal transportation is the shipment of cargo and the movement of people involving more than one mode of transportation during a single seamless journey.
- Intermodal transportation system is a collection of passengers and cargo moving via multiple modes of transportation, the vehicles that move them, the routes along which they are moved, the terminals at which they are stored, transferred etc. and the processes which they experience while being moved.

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



## alliance Intermodal models - Mathematical modeling

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

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

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# Transport impacts





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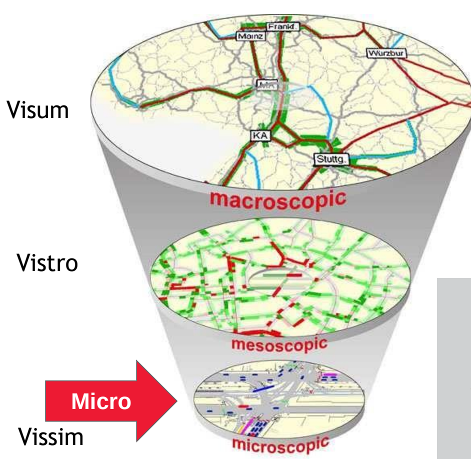
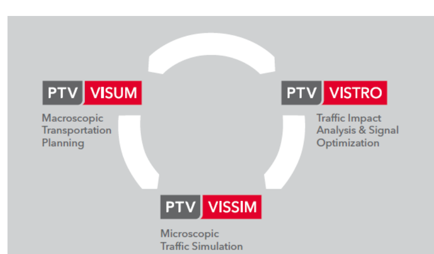
# Modeling Levels



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# Traffic flow simulation means…

Modeling traffic flow with computer programs

Why?

Because we want to answer relevant questions, such as:

- How long is the expected travel time from A to B, given a certain *demand* and a certain *supply*
- 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
- The other way around: I require a certain Level of Service (LOS): How much can the demand be increased without violating this requirement?



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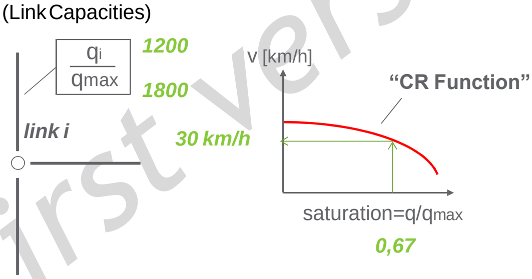
# Classification of simulation models

Models can be classified with respect to aggregation level and temporal aspects

**Task: Model the average speed on link i**

Macroscopic, Static (Link Capacities)



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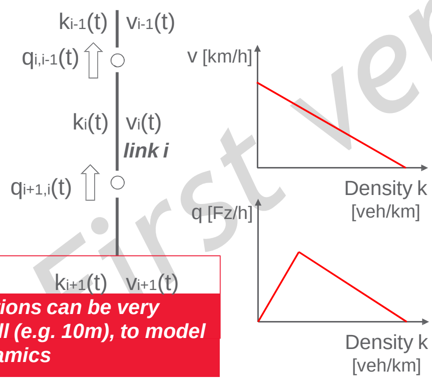
# Classification of simulation models

**Task: Model the average speed on link I**
Macroscopic, Dynamic (Flow Model)

***Time dependent states***




***Sections can be very small (e.g. 10m), to model dynamics***

$v_i(t)=f(k_i(t))$

$k_i(t)=f(k_i(t-1),q_{i,i-1}(t-1), q_{i+1,i}(t-1))$

$q_{i+1,i}(t-1)=f(k_{i+1}(t-1),k_i(t-1))$

$q_{i,i-1}(t-1)=f(k_i(t-1),k_{i+1}(t-1))$

***Dynamic:***
*Congestion + Spillback can be modeled!*



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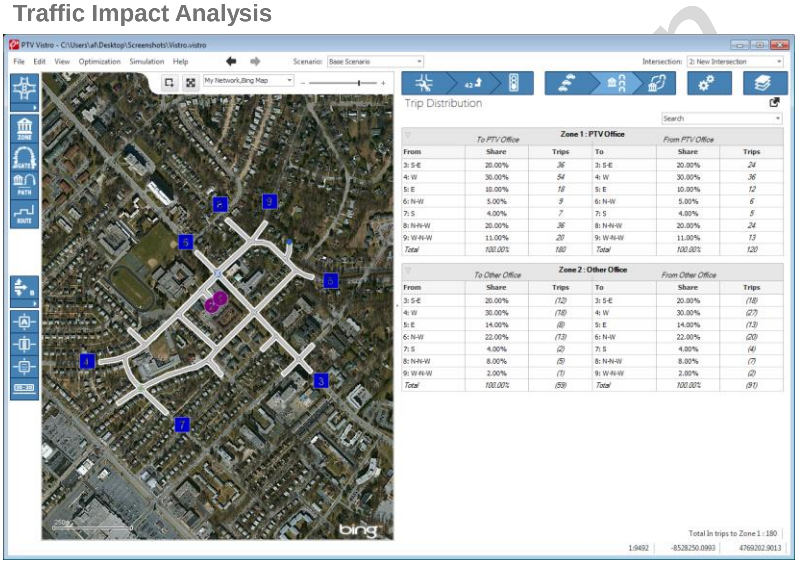
# Mesoscopic – Vistro (1/2)

**Traffic Impact Analysis**




http://vision-traffic.ptvgroup.com/en-us/home/

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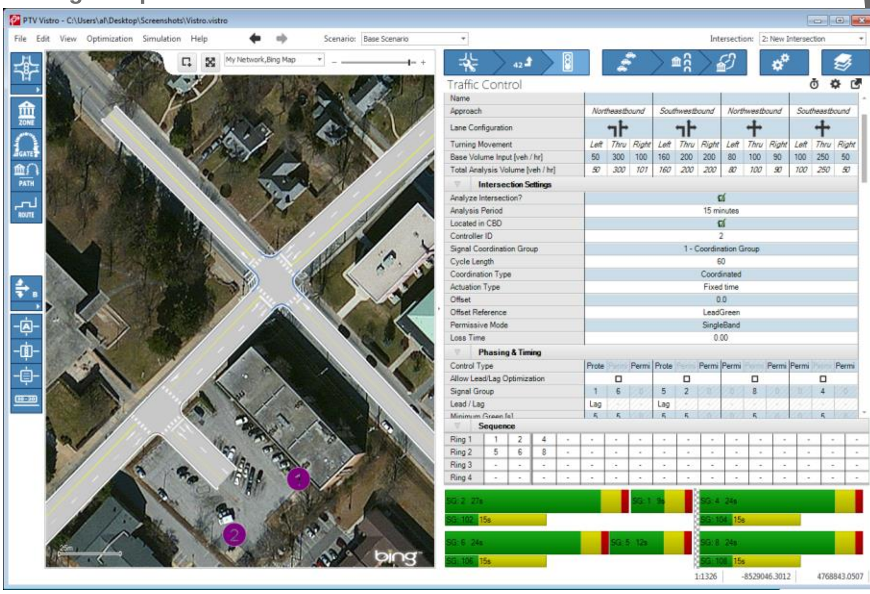
# Mesoscopic – Vistro (2/2)

## Signal optimization




http://vision-traffic.ptvgroup.com/en-us/home/

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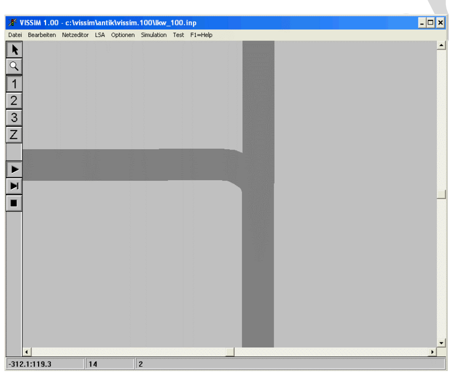
# 1993-94: VISSIM 1.0

- Multi-anticipative car-following with 2 vehicles ahead
- Explicit stochastic decision at amber based on required deceleration
- Detailed model of transit priority logic as used in Karlsruhe
- Interface to signal-control software VS-PLUS





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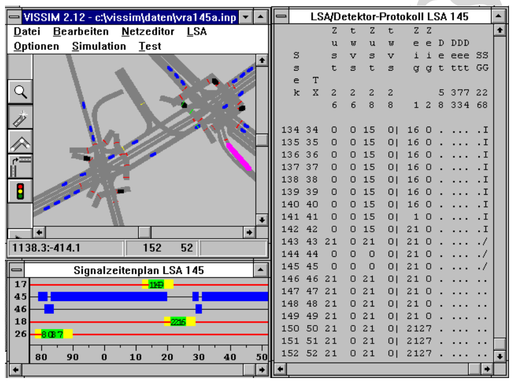
# 1994-97: Focus on signal control

- Part of the SIEMENS traffic engineering suite as „SIMULA“
- VAP: VISSIM‘s programming language for signal control logic




First North-American project!



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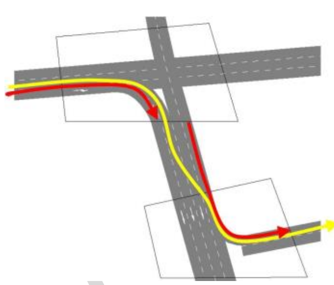
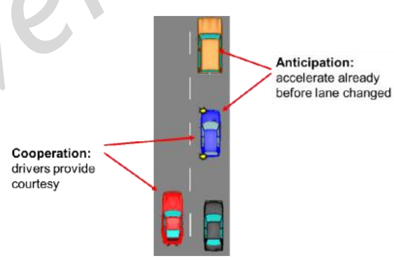
# 1994-97: Behavior vehicles driving on routes

**Before:** Turning proportions at junctions
**Now:** Vehicles follow user-defined series of links

Mandatory lane changes, requiring tactical driving behavior





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# 2000: VISSIM 3.0

- Many small improvements for signal control, public transport and driving behavior
- Transit vehicle dwell times computed from number of boarding and alighting passengers and the door characteristics of the vehicles
- Logit Model for stop decision at amber

**3D graphics!**

Left-hand driving!



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# 2000: Freeway traffic flow

Model for US freeway traffic (free lane choice)

„Wiedemann 99“ driving behavior

There is no Wiedemann99 publication!

Minor changes from 74: less stochasticity, linear thresholds

TRB 2001,
120 citations (google scholar)

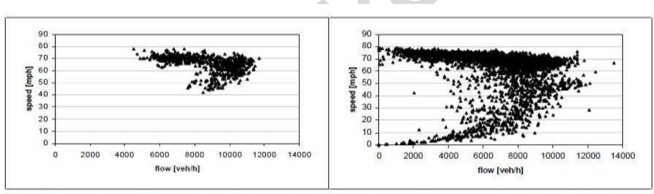


FIGURE 4. Speed-flow relationship on five-lane US freeway; measurement on the left, simulation result on the right.



Reference: Fellendorf, M. and P.Vortisch (2001).

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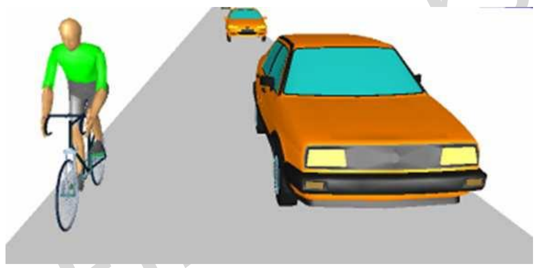
# 2001: Continuous lateral movement

- Federal research project about cyclists in the German HCM
- Lateral position now anywhere in the lane
- Pretty simple lateral behaviour model



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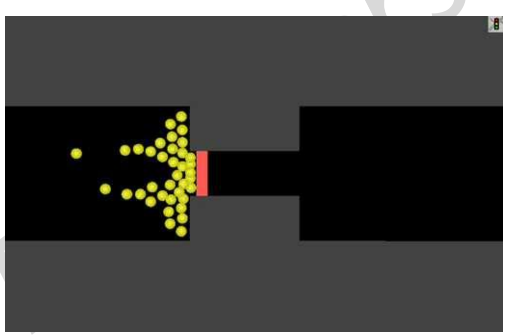
# 2006: First steps towards pedestrians

Prototype interface to Dirk Helbing's Social Force Model



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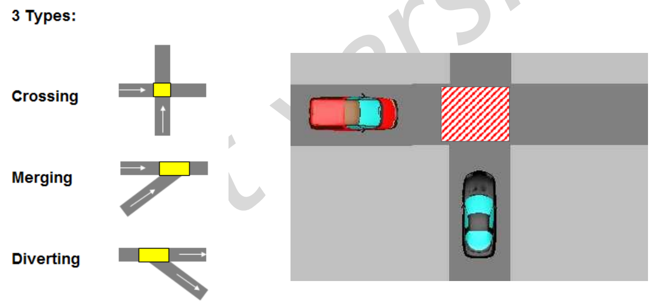
# 2007: Conflict areas

Replaced the old priority rules

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

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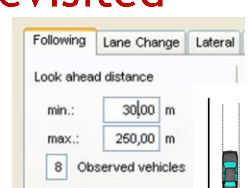
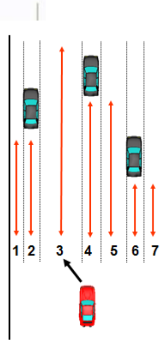
# 2007: Non-Lane based driving revisited

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# 2008: Pedestrians modeling

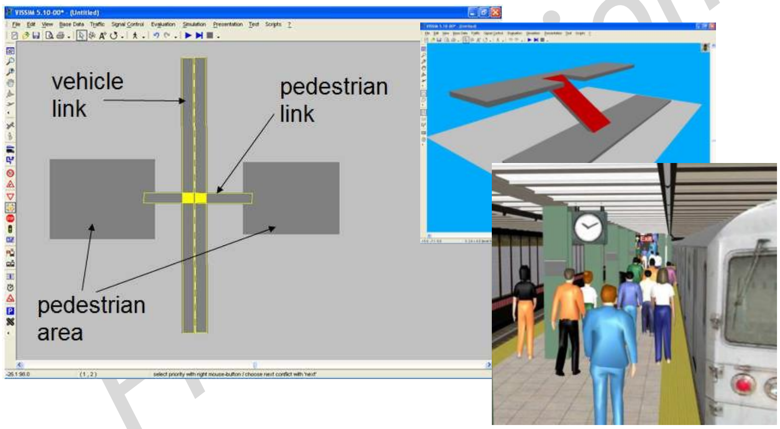


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**Table-1: Sidewalk Level of Service Classification**

| Sidewalk Level of Service | Characteristics of Sidewalk |
|---|---|
| **LOS A** | Pedestrian Space > 60 ft²/p, Flow Rate = 5 p/min/ft, pedestrians move in desired paths without altering their movements in response to other pedestrians. Walking speeds are freely selected, and conflicts between pedestrians are unlikely. |
| **LOS B** | Pedestrian Space > 40-60 ft²/p, Flow Rate > 5-7 p/min/ft, there is sufficient area for pedestrians to select walking speeds freely to bypass other pedestrians, and to avoid crossing conflicts. At this level, pedestrians begin to be aware of other pedestrians, and to response to their presence when electing a walking path. |
| **LOS C** | Pedestrian Space > 24-40 ft²/p, Flow Rate > 7-10 p/min/ft, space is sufficient for normal walking speeds, and for bypassing other pedestrians in primarily unidirectional streams. Reverse-direction or crossing movements can cause minor conflicts, and speeds and flow rate are somewhat lower. |
| **LOS D** | Pedestrian Space > 15-24 ft²/p, Flow Rate > 10-15 p/min/ft, freedom to select individual walking speed and to bypass other pedestrians is restricted. Crossing or reverse-flow movements face a high probability of conflict, requiring frequent changes in speed and position. The LOS provides reasonably fluid flow, but friction and interaction between pedestrians is likely |
| **LOS E** | Pedestrian Space > 8-15 ft²/p, Flow Rate > 15-23 p/min/ft, virtually all pedestrians restrict their normal walking speed, frequently adjusting their gait. At the lower range, forward movement is possible only by shuffling. Space is not sufficient for passing slower pedestrians. Cross- or reverse-flow movements are possible only with extreme difficulties. Design volumes approach the limit of walkway capacity, with stoppages and interruptions to flow. |
| **LOS F** | Pedestrian Space = 8 ft²/p, Flow Rate varies p/min/ft, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent unavoidable contact with other pedestrians. Cross-and reverse-flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued pedestrians than of moving pedestrian streams. |

Pedestrian LOS for sidewalks and sideways is calculated using the pedestrian unit flow rate. In addition to LOS grades A to F, space (ft²/p), speed (ft/s), and the volume-to-capacity (v/c) ratio can also be derived from the Table-2.

**Table-2: PLOS Criteria (HCM 2000)**

| LOS | Space (ft²/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.

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# TODAY: State of the art simulator with 3D-visualization


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# Active traffic management on freeways

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## Exclusive bus/tram lanes

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## Public transport priority

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# Public transport and shared space


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# Pedestrian simulation

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# Automated parking facilities


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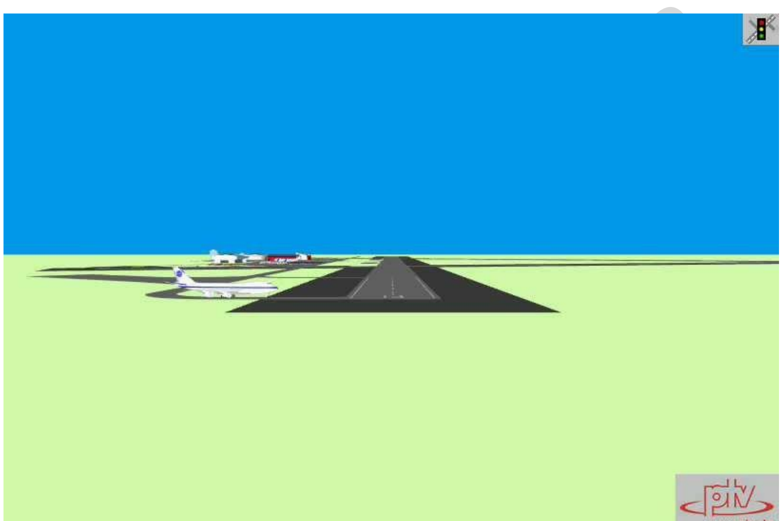
# Airport simulation



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# Container terminals

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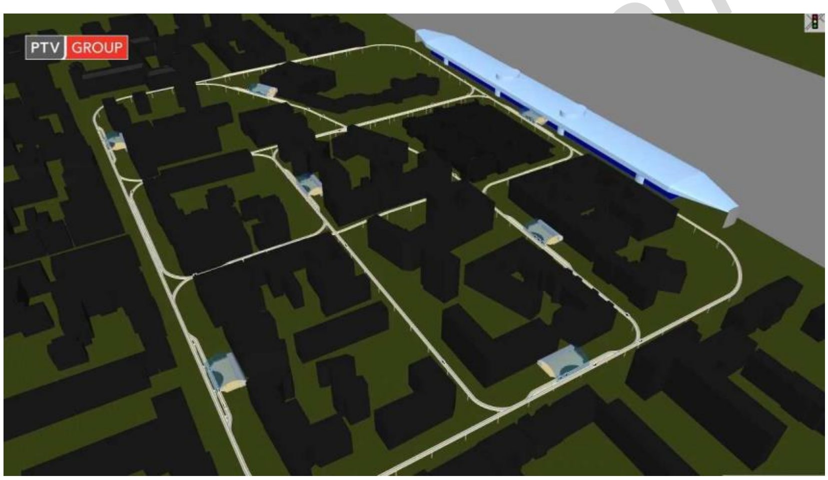
# New transport systems - PRT



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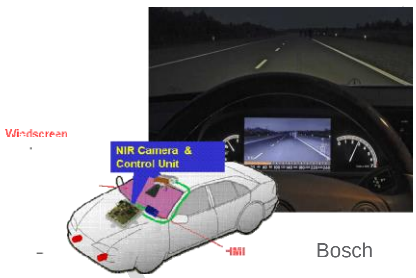
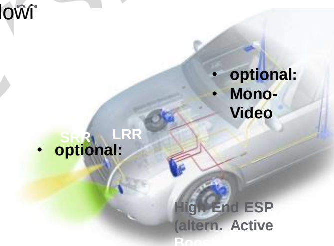
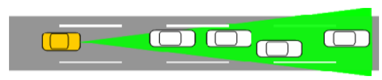
# Simulation of driver assistance systems

- Intelligent Cruise Control
- Night Vision
- often comfort or safety features, no capacity effect
- Modelled as parameter changes in car-followi



Bosch





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# Why do we simulate traffic?

Modeling in general:

Analyze measures before implementation (to safe money!)

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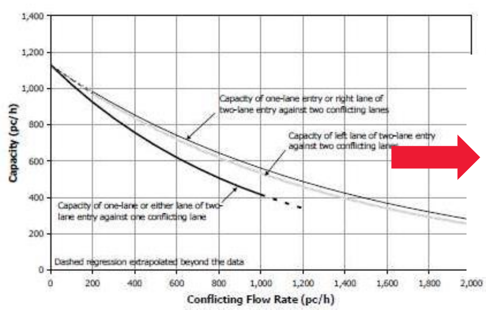
# Why do we simulate traffic?

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




$$d = \frac{3{,}600}{c} + 900T\left[x - 1 + \sqrt{(x-1)^2 + \frac{\left(\frac{3{,}600}{c}\right)x}{450T}}\right] + 5 \times \min[x,1]$$

where

$d$ = average control delay (s/veh),
$x$ = volume-to-capacity ratio of the subject lane,
$c$ = capacity of the subject lane (veh/h), and
$T$ = time period (h) ($T$ = 0.25 h for a 15-min analysis).

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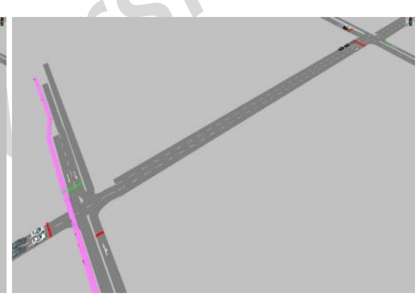
# Why do we simulate traffic?

Networks: facilities (e.g. Intersections) are not independent
Example: Same network, same demand



Simple methods
cannot distinguish!

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# Why do we simulate traffic?

Congestion spillback effects

Waiting Time for
right turning vehicles??

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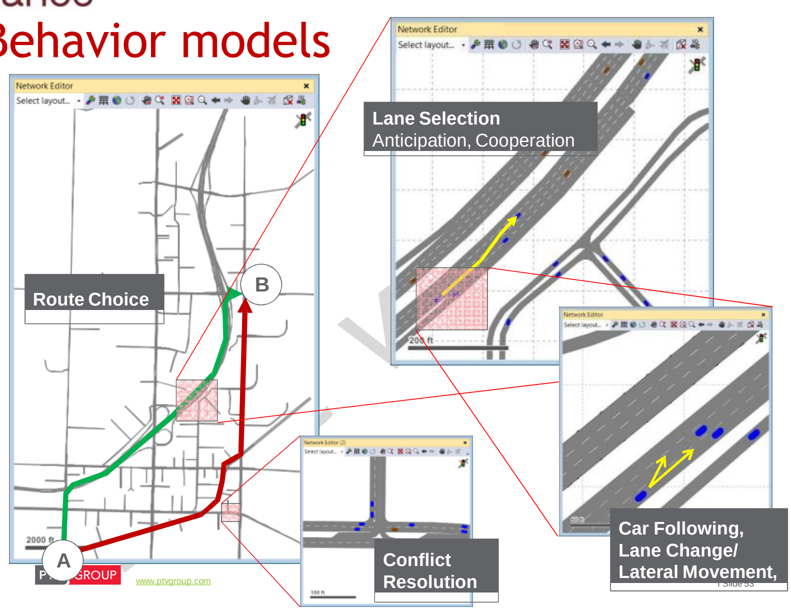
# Behavior models



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# Car following basics

**Follower** **Leader**

How does a vehicle (“Follower”) behave, given the behavior of a „leading vehicle“ (“Leader”)?

Traffic Dynamics from an individual drivers' perspective

One Lane only (for now)

Covering all traffic situations: High speed, stop-and-go, jam, …

Special Case:

Free (unconstrained) driving → no interaction with the “Leader”



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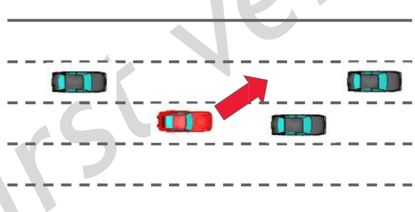
# Lane changing basics

Situation: Multiple Lanes

In some situations, drivers want to change the lane (“lane selection” → later)

There are decisions and actions



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# Lane changes in VISSIM

**There are basically two kinds of lane changes in Vissim**

Free lane change (because of more room / higher speed)

- Drivers only change lane if the other lane is better
- They do not disturb other drivers

Necessary lane change (in order to reach the next connector of a route)

- Drivers need to change the lane
- They are getting more and more aggressive



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LANE CHANGING

## LANE CHANGES IN VISSIM: FREE LANE CHANGE

Sustainability assessment

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# Definition

"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."

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# Definition

The CST 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

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# Why Sustainable Transport? (1/3)

Transportation outcomes:

- Traffic congestion

  1985→2005: Increase of 72% in delay & 85% in total cost of congestion (TTI 2007)

- Emissions

  1990→2003: 20% increase in U.S (BTS 2005)

- Noise

  Road transport : 60% of total transportation noise

- Road safety

  Globally → 1.2million deaths & 500m injuries (WHO 2004)

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# Why Sustainable Transport? (2/3)

Transportation – environmental concerns in U.S.

- Combustion of fossil fuels accounts for about 31% of total $CO_2$ emissions and 26% of total greenhouse gas emissions in 2011
- Total consumption of petroleum products appears to be leveling off
- 11% decrease of $CO_2$ emissions between 2004 and 2010

**Improvements in vehicle efficiency and changes in vehicle travel**



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# Why Sustainable Transport? (3/3)

Vehicle efficiency and new travel modes:

- Hybrid electric vehicle sales increased by 30% between 2005 and 2010
- Huge increase in car-sharing (CS) 2000=A few hundred → 2012 =~ 800,000
- CS users reduce their vehicle miles traveled by an average 44%
- CS results vary: In Europe, a CS vehicle reduces the need for 4 to 10 privately owned vehicles; it is 6 to 23 privately owned vehicles in N. America

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## Rating Programs

- Leadership in Energy and Environmental Design (LEED)
- CEEQUAL → U.K. for Civil Engineering Projects
- Green Roads
- GreenLITES → N.York DOT for planning, project design and operation
- Sustainable Highways Self Evaluation Tool→FHWA





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## Objectives

- Create a sustainability framework that can be used by decision makers to incorporate sustainability into urban transportation planning
- Propose estimable indicators that cover the spectrum of sustainable transportation and make feasible the comparison between different alternatives (or technologies, trips, corridors, etc.)
- Use the sustainability framework to develop a sustainability assessment tool

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# Multicriteria assessment

- Analytic Hierarchy Process (AHP),
- Multi-Attribute Utility Theory (MAUT),
- Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE)
- ELimination Et Choix Traduisant la REalite (ELECTRE)
- Dominance-based Rough Set Approach (DRSA)
- Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
- Simple Multi Attribute Rated Technique (SMART)
- Weighted Sum model (WSM)
- Weighted Product model (WPM)

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## Smart solutions in sustainable transport planning

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# Smart Transportation

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



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# Technology and data

- New technologies → transforming traffic management systems and the analysis of travel activity and transport modelling.
- Technology and data to make life in cities safer, smarter and more sustainable.
- Smart solutions involve data gathering, real-time processing, data analytics and visualization.
- Using data ultimately aims to support better decision and enable innovation.
- Transport-related data gaps may limit ability to take advantage of “intelligent mobility” market.
- Open transport data, sensor data, crowdsourcing and other social media sources,
- Big data → support decision-making in important policy areas.

https://blog.idoxgroup.com/2015/07/16/how-data-and-smart-city-infrastructure-can-support-transport-planning/

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## Why is smart transport important?

- ITS→ alleviating traffic congestion, assist inefficient mobility (passenger and goods) and enable efficient use of urban transport infrastructure.
- Some examples of situations where ITS has played a key role in aiding decisions are:
- Commuters –Making travel-related decisions (if, when, and how), choosing transportation options, accessing public transport timings, viewing ride-sharing options, etc.
- Traffic Police –Tracking traffic rule violations, communicating incident information, clearing traffic congestion, etc.



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## 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: http://sustainabilitynext.in/cstep/intelligent-systems-for-smart-and-sustainable-transport/#prettyPhoto

# 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 United States.

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 United States.

Clean renewable solar energy

Reference: National academies of sciences, engineering, medicine



# New modes

**Hydrogen-powered Tram Developed in China**

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

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# Sustainable urban development and mobility plan



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# Support the uptake of SUMP (2010-13)


- Common understanding of 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

## Mobility plans portal (2012)


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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


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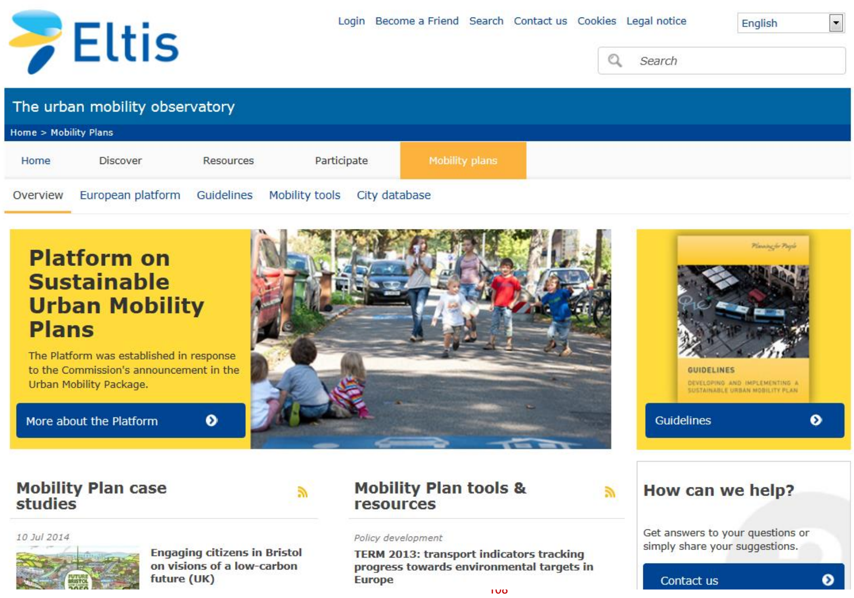
# Mobility Plans portal

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# SUMP related projects and initiatives

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# 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



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# 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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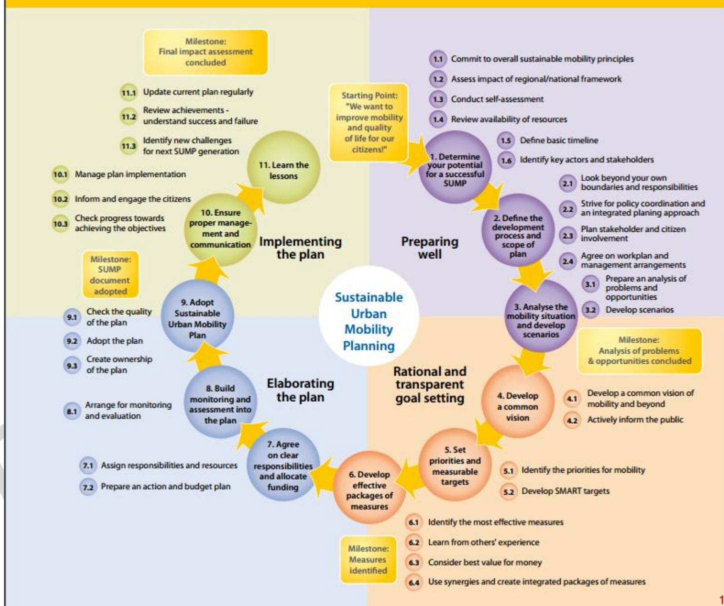
## PROCESS

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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, decsions for or against urban mobility measures can obtain a significant level of "public legitimacy".

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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)

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# 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.

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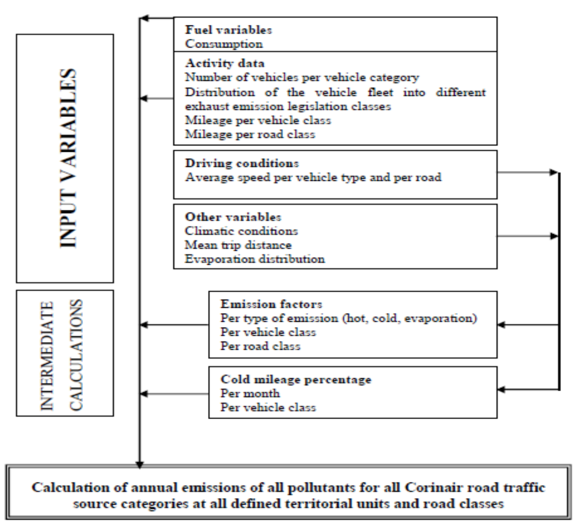
# Input Data



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# 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]*

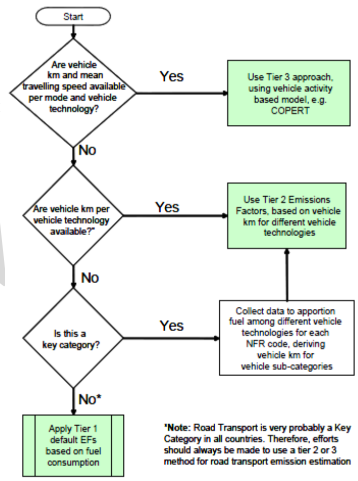
$E_{TOTAL} = E_{HOT} + E_{COLD}$

$E_{HOT}$ : 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!

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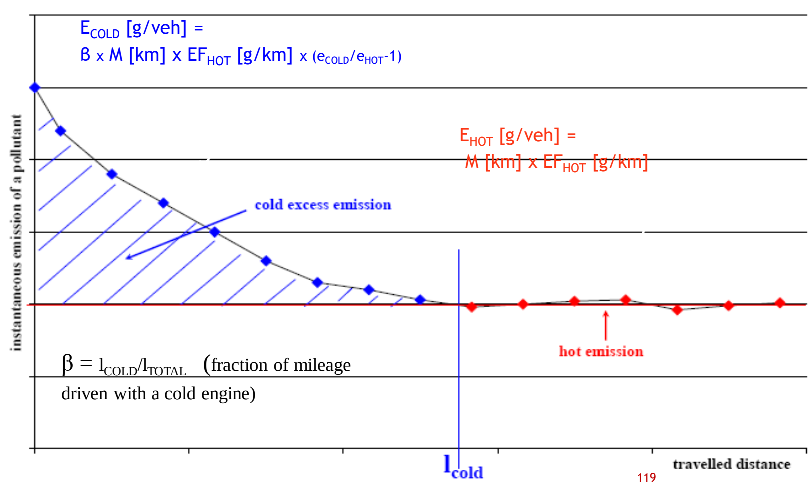
# General Concept for Exhaust Emissions/Consumption

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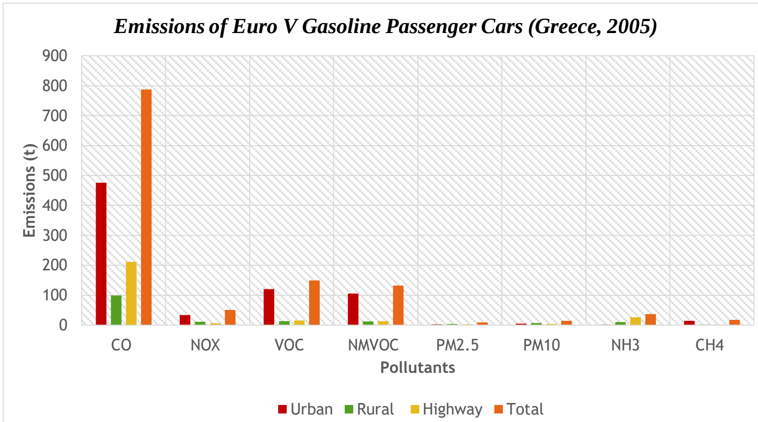
Source: http://www.eionet.europa.eu/events/training/

# 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.

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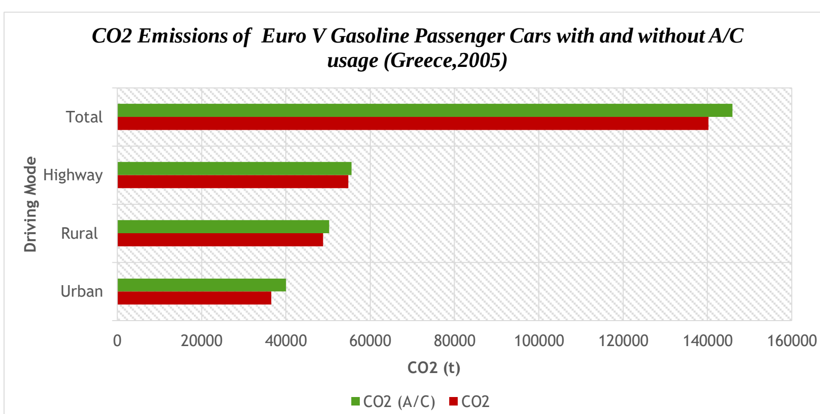
# Output Data Example 2




- ✓ 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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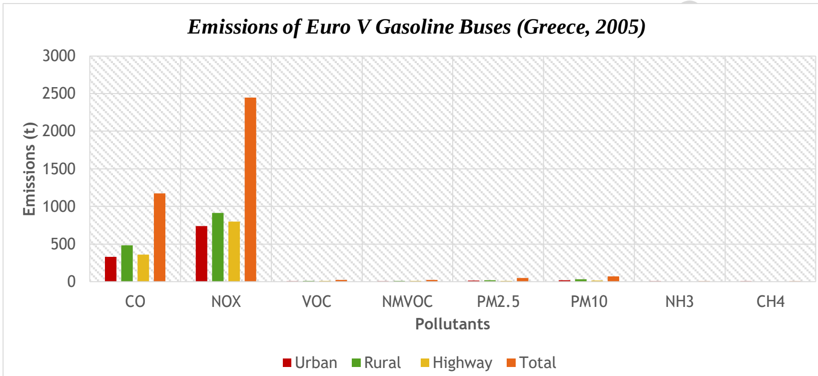
# Output Data Example 3




- ✓ 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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# Operation and management of intermodal transport systems

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

- Background
- Stakeholders' engagement and management
- Policy
- Operational structures
- Management structures
- The role of interchanges in urban planning
- Main principles for management and operational structures
- Integrated information systems and ticketing
- Case studies
- 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 considered satisfactory 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

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# Theoretical methodologies



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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



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## alliance 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 latter stages of implementation





## alliance 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

# alliance 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.*

## Passenger interchanges

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

*Source: CITY-HUBs, 2015*



# alliance Which stakeholders to involve?

## Freight interchanges

| 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, 2016*

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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 |

*Source: CITY-HUBs, 2015*





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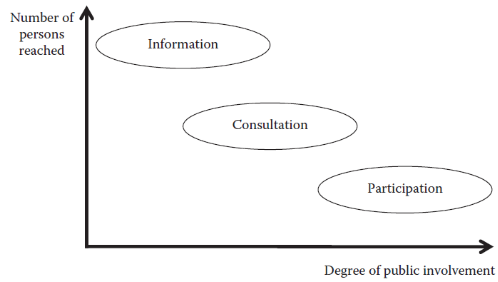
# Public involvement

- 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<br>Information is shared with stakeholders | Several ways: questionnaires, information days, leaflets and meetings<br>Listening and learning should lead to a common understanding<br>Targeted at particular groups | Two-way dialogue between stakeholders and professionals<br>Direct discussions among the various parties<br>Co-decision-making |

*Source: CITY-HUBs, 2015*

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# 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.

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# alliance Operational structures

- Key factors that form the operational profile of an interchange and make it competitive are:
  - Location
  - Infrastructure
  - Geographical coverage
  - Cargo profile
  - Modes
  - Services

**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.

**Good practice (freight): Port of Constantza, Romania**

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





# alliance 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 (passengers): 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.

**Good practice (freight): 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.

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# Problem stating and solution approach





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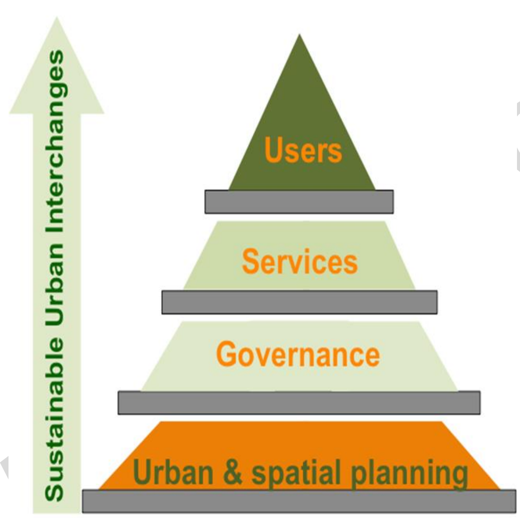
## The role of interchanges in urban planning




**-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*





## Main principles for management and operational structures

- An interchange is a dynamic facility, and the Interchange Management Plan should reflect this characteristic

- Opportunities should be given to those involved in the interchange (interested parties) to meet on a regular basis to discuss developments

*Source: City-HUB, 2013*

## 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, 2013*





## 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





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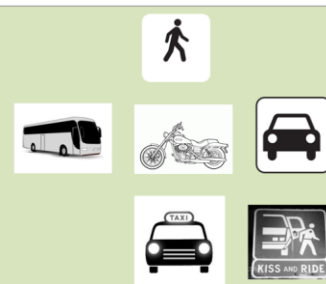
# The interchanges

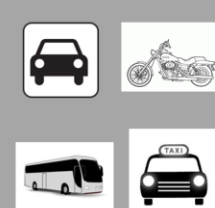
### Intercity coaches of Magnesia

- **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*

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## Method

**Step 1:**
Extensive review of policies & initiatives at a national and European level

↓ ⇡

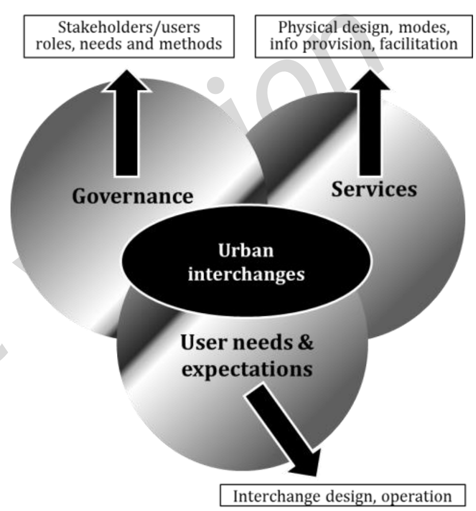
**Step 2:**
Analysis of surveys conducted at urban terminals in Greece

↓ ⇡

**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*

## alliance 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<br>- Energy strategy plan<br>- Greener bus fleet |

*Source: Adamos et al., 2015* 27

## alliance 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* 28

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**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: 5736056,4 | 15,42 €/TEU and 18106190,23 €/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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## alliance 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





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# Suggested literature


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# Optimization of intermodal transport systems

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



## Content

- Background
- Rules
- Basic concepts
- Techniques
- Software and applications
- Suggested literature

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# Background

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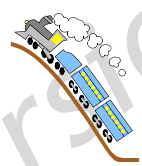
# Optimization Principles

First version

- Formulation of the problem = art and skill = as a new language



- Multiple formulations may exist - some are better than others

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## Basic elements

- What do we know?
  - Data

*!Data: Demand prices, costs, ability / capacity, people needed*

- *small letters at the beginning of the alphabet*
- *known from scratch or can be calculated*

- What we have to decide?
  - Decision variables
  - Auxiliary variables (also decision variables)

*!Decision variables*

- *production volumes, storage, shipments between plants and distribution centers, quantities of raw materials, number of employees who work from the beginning, students allocation to educational programs*
- ***what** should be calculated - we need to know*
- *capital letters at the end of the alphabet*





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## Basic elements

- What is the goal?
  - objective function

*!Objective function*

- *what we want to minimize or maximize*
- *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

***!Indices: Used for numbering (e.g. demand points, candidate positions, scenarios, time periods, route paths, facilities)***

- *i, j, k (average of the alphabet)*
- *placed like indicators*
- *corresponding sets (I, J, K)*

*!Parameters*

- *as the data, but may change from run to run*

# Rules



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# 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:
  - Indexes and sets
  - Data entry
  - Decision variables



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## Optimization Rules

**Rule no. 3**

- When we define the data or variables with words, this index should also be determined

$d_{ij}$ =distance between production plant i and demand node j

YES

$d_{ij}$ = distance

NO



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## Optimization Rules

**Rule no. 4**

- No indexes should be in the objective function without explanation

$$\text{minimize} \quad \sum_{i\in I}\sum_{j\in J} c_{ij} X_{ij}$$

YES

$$\text{minimize} \quad \sum_{i\in I} c_{ij} X_{ij}$$

NO
The 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 to 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 given as entry data. Decision variables are not shown.





# 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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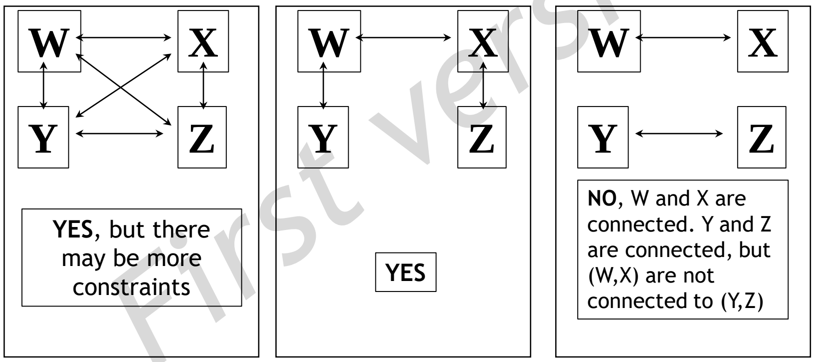
# Optimization Rules

## Rule no. 6 (Continue)

- It is not necessary that the variables are directly linked





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# Optimization Rules

## Rule no. 7

- If a variable or fixed constrain has an index, then:
    - The sum should be performed upon the index, or
    - There is a need to identify the index values for which the constraints apply
    - Both cannot be applied to the same constraint

***Example***

$$\sum_{j\in J} X_{ij} = 1 \qquad \forall i \in I$$

YES

$$\sum_{j\in J} h_{ik} d_{ijk} Y_{ijk} \le D \qquad \forall i \in I$$

NO. **We must determine what happens to index k**

$$\sum_{j\in J} Y_{ij} = 1 \qquad \forall j \in J$$

NO. **We sum up for j and define that the constrain applies to all *j*. But, what about the 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 no constraint depending on the value of the variable





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# 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 constrain. Could lead to no strong relationships**

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## Typical constraints

- **Total constraint**

$$\sum_{j \in J} X_j = p$$

- The total of $X_j$ 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**

$$\sum_{k \in K_j} X_{jk} \leq 1 \quad \forall j \in J$$

- 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

- **Supply constraints**

$$\sum_{j \in J} X_{ij} \leq S_i \quad \forall i \in I$$

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

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## Typical constraints

- **Demand constraints**

$$\sum_{i \in I} X_{ij} \geq D_j \quad \forall j \in J$$

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

- **Connection of constraints**

$$Y_{ij} \leq X_j \quad \forall i \in I, \forall j \in J$$

- $X_j$ 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)

$$Z_i - \sum_{j \in J} a_{ij} X_j \leq 0 \quad \forall i \in I$$

- 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

$$\left( \sum_{j \in J} a_{ij} X_j \geq 1 \right)$$

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# Typical constraints

- **Maximum constraints**

$$W \geq \sum_{j \in J} d_{ij} Y_{ij} \qquad \forall i \in I$$

- 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

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*

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# 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*

$Y_{ij} - X_j \le 0 \quad \forall i \in I, \forall j \in J$ *Connection constraints*

$W \ge \sum_{j\in J} d_{ij} Y_{ij} \quad \forall i \in I$ *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*





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# 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*

$Y_{ij} - X_j \le 0 \quad \forall i \in I, \forall j \in J$ *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*

$Y_{ij} - X_j \le 0 \quad \forall i \in I, \forall j \in J$ *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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# Basic concepts



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## 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)



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## Introduction to operational research

The problem of the Operational Research concerns the selection of variables' values x1, x2, ..., xn, in order to optimize the objective function f (x1, x2, ..., xn), 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



## Techniques

## 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

$$\max Z = f(x) = c_1x_1 + c_2x_2 + c_3x_3 + \ldots + c_nx_n$$

- Constraints

$$\alpha_{11}x_1 + \alpha_{12}x_2 + \alpha_{13}x_3 + \ldots + \alpha_{1n}x_n \leq b_1$$
$$\alpha_{21}x_1 + \alpha_{22}x_2 + \alpha_{23}x_3 + \ldots + \alpha_{2n}x_n \leq b_2$$
$$\ldots$$
$$\alpha_{m1}x_1 + \alpha_{m2}x_2 + \alpha_{m3}x_3 + \ldots + \alpha_{mn}x_n \leq b_m$$

$$x_1 \geq 0,\ x_2 \geq 0,\ x_3 \geq 0,\ \ldots,\ x_n \geq 0$$

Linear objective function
Linear constraints (structure - 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: 1xn vector series
A: mxn matrix with elements aij
b: mx1 column vector with bi elements

*Example of Linear Programming*

*200 products of type 1 and 2 should be produced. Determine the production of each product type in order to maximize the profit.*

| Product | 1 | 2 |
|---|---|---|
| Working hours | 9 | 6 |
| Raw material requirements (kg) | 12 | 16 |
| Profit (€) | 350 | 300 |

***Available***
*1566 working hours*
*2880 kg raw material*

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## 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 type 1 products

$X_2$ = number of type 2 products

**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

$1X1 + 1X2 \leq 200$ } total production

$9X1 + 6X2 \leq 1566$ } working hours

$12X1 + 16X2 \leq 2880$ } raw material

Non-negativity constraints

$X1 \geq 0$

$X2 \geq 0$



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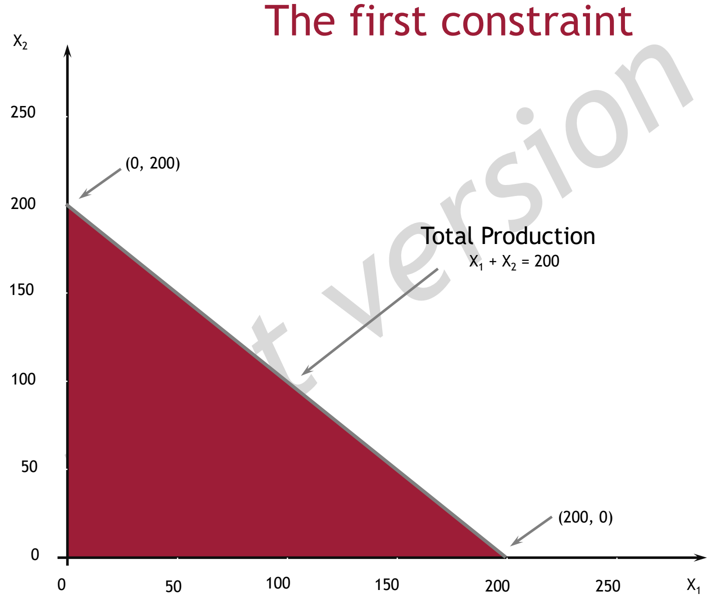
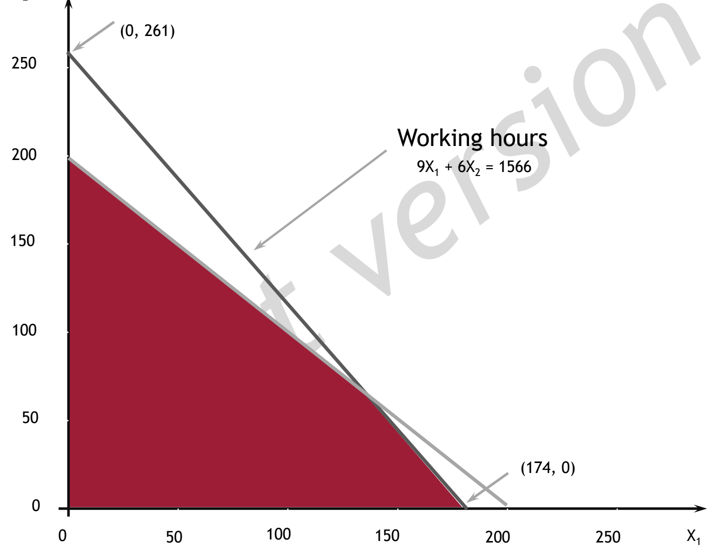
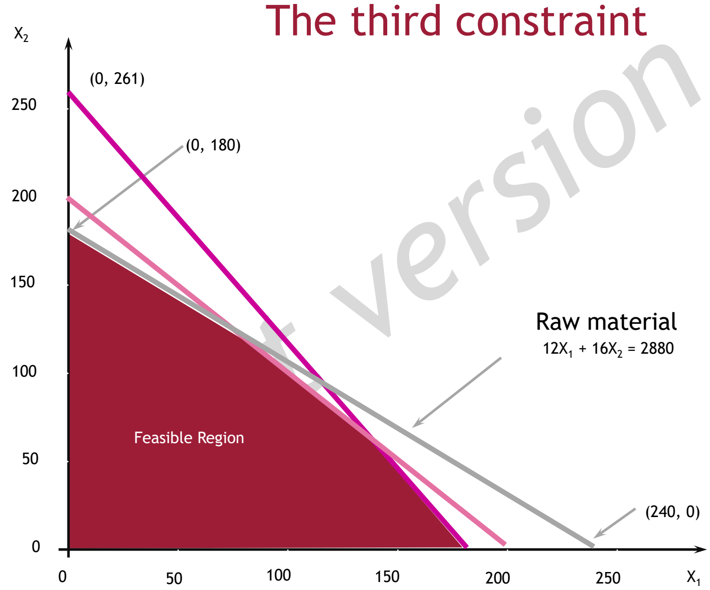
## The first constraint



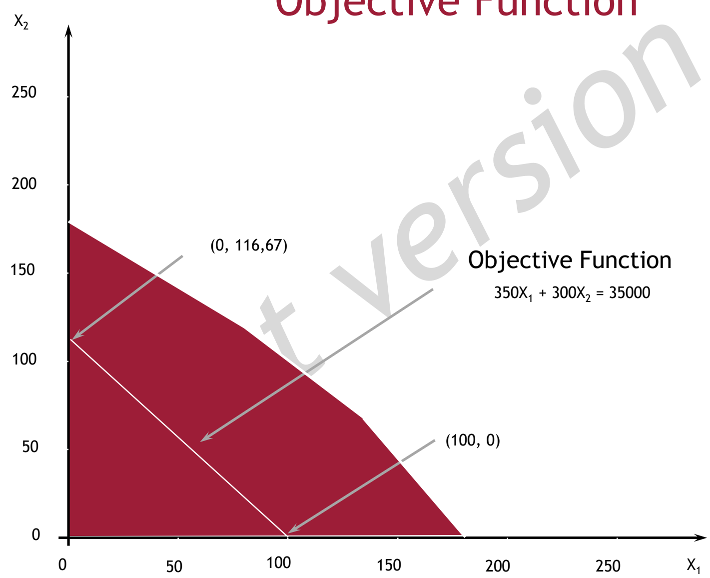
## The second constraint



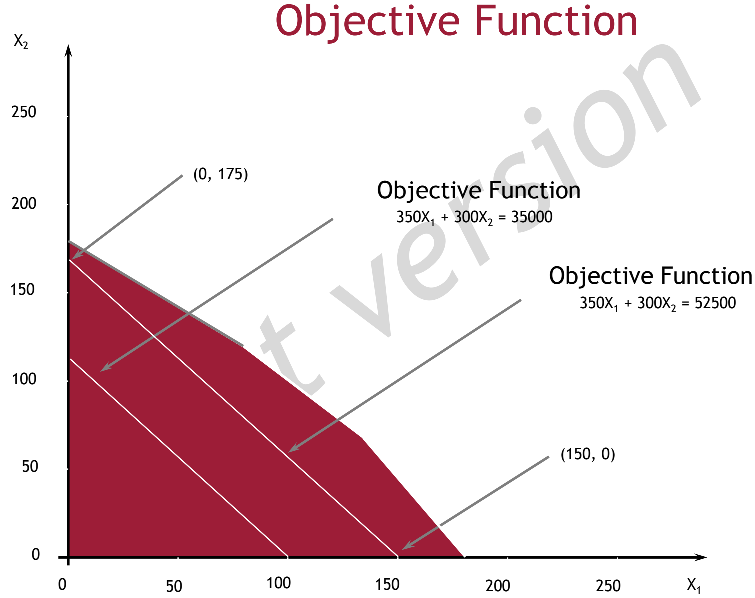

## The third constraint



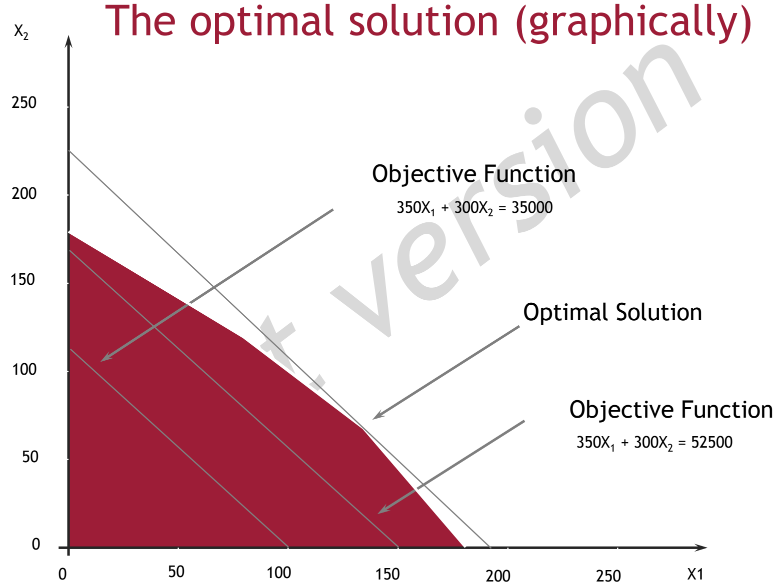
# Objective Function




# Objective Function



## The optimal solution (graphically)






## Estimating the optimal solution

The optimal soloution 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

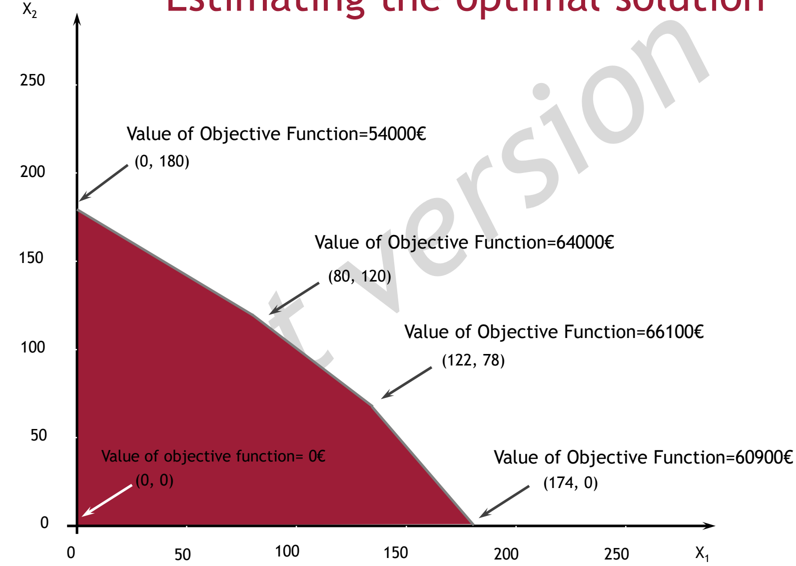
$9X_1 + 6(200 - X_1) = 1566$

$X_1 = 122$

$X_1=122$, $X_2=200-X_1=78$

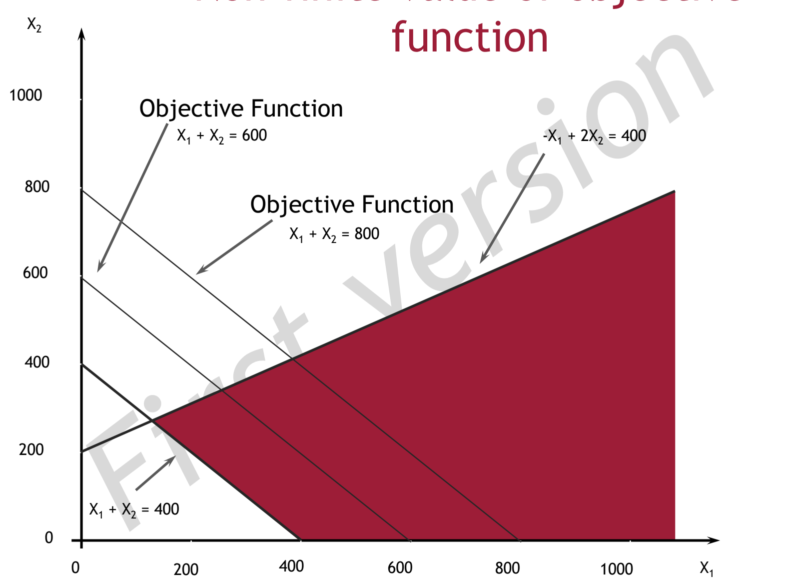
Total profit= 350*122 + 300*78 = 66100€

## Estimating the optimal solution

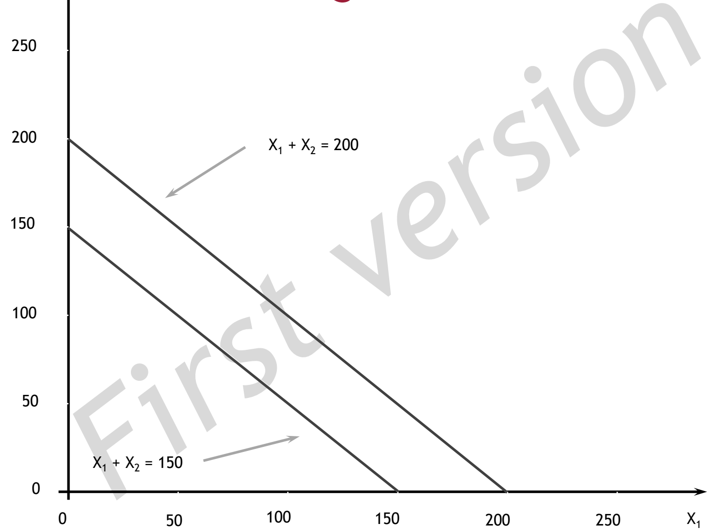





## Non-finite value of objective function



## 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.

*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.

# Linear Programming (LP)

*200 products of type 1 and 2 should be produced. Determine the production of each product type in order to maximize the profit.*

| Product | 1 | 2 |
|---|---|---|
| Working hours | 9 | 6 |
| Raw material requirements (kg) | 12 | 16 |
| Profit (€) | 350 | 300 |

*Available*
*1566 working hours*
*2880 kg raw material*

*MAX:* $350X_1 + 300X_2$ *} Profit*

*Subject to:*

$1X_1 + 1X_2 \leq 200$ *} Products*

$9X_1 + 6X_2 \leq 1566$ *} Working hours*

$12X_1 + 16X_2 \leq 2880$ *} raw material*

$X_1, X_2 \geq 0$ *} Non-negativity constraints*

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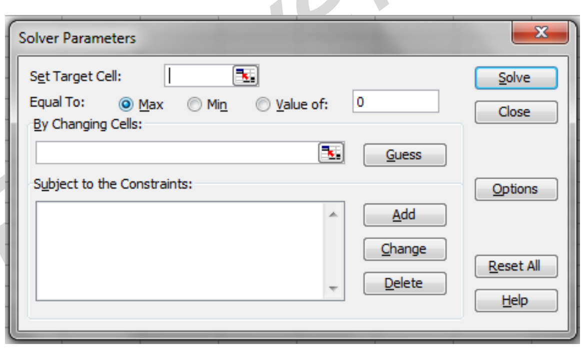
# How is the model depicted by Solver?

- Set Target Cell: insert the cell that corresponds to the objective function
- Equal 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



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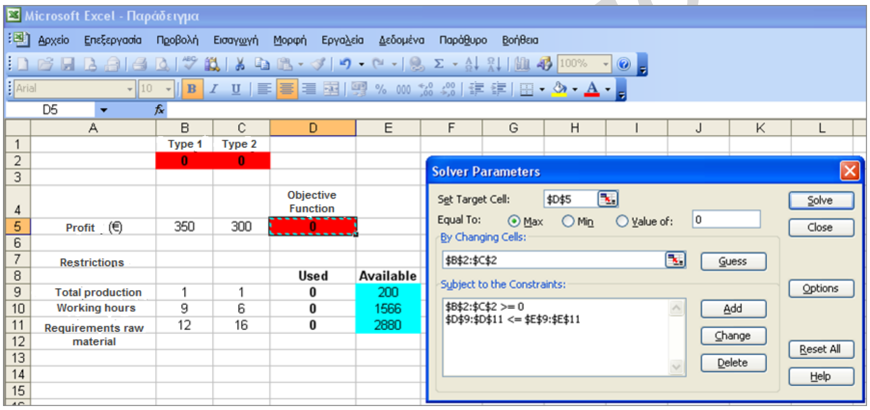
# Example of Linear Programming (continue)

*Example*




*EXCEL - LP - Example*

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# Linear Programming

## Make vs. Buy problem

### Defining the Decision Variables

M1 = Number of model 1 slip rings to make in-house
M2 = Number of model 2 slip rings to make in-house
M3 = Number of model 3 slip rings to make in-house
B1 = Number of model 1 slip rings to buy from competitor
B2 = Number of model 2 slip rings to buy from competitor
B3 = Number of model 3 slip rings to buy from competitor

### Defining the Objective Function

Minimize the total cost of filling the order:
MIN: 50M1 + 83M2 + 130M3 + 61B1 + 97B2 + 145B3

### Defining the constraints

*Demand constraints:*

M1 + B1 = 3000

M2 + B2 = 2000

M3 + B3 = 900

*Resource constraints:*

2M1 + 1.5M2 + 3M3 ≤ 10000

1M1 + 2.0M2 + 1M3 ≤ 5000

*Non negativity constraints:*

M1, M2, M3, B1, B2, B3 ≥ 0

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# Linear Programming

## A transportation problem



### Defining the Decision Variables

$X_{ij}$ = # of products shipped from node i to node j

Specifically, the nine decision variables are:

X14 = products shipped from node 1 to node 4
X15 = products shipped from node 1 to node 5
X16 = products shipped from node 1 to node 6
X24 = products shipped from node 2 to node 4
X25 = products shipped from node 2 to node 5
X26 = products shipped from node 2 to node 6
X34 = products shipped from node 3 to node 4
X35 = products shipped from node 3 to node 5
X36 = products shipped from node 3 to node 6

### Defining the Objective Function

Minimize the total number of miles.

MIN: 21X14 + 50X15 + 40X16 + 35X24 + 30X25 + 22X26 + 55X34 + 20X35 + 25X36

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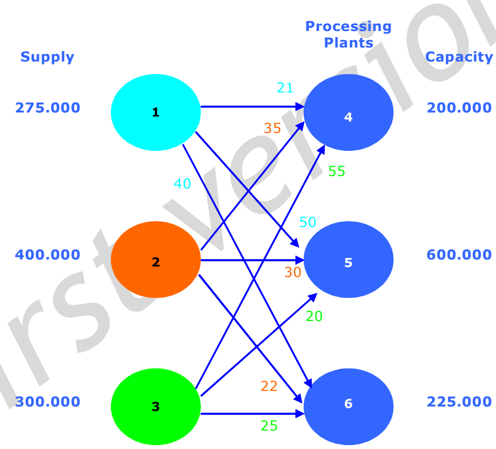
# Linear Programming

## A transportation problem





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# Linear Programming

## A transportation problem

### Defining the Constraints

Capacity constraints

$X14 + X24 + X34 \leq 200{,}000$
$X15 + X25 + X35 \leq 600{,}000$
$X16 + X26 + X36 \leq 225{,}000$

Supply constraints

$X14 + X15 + X16 = 275{,}000$
$X24 + X25 + X26 = 400{,}000$
$X34 + X35 + X36 = 300{,}000$

Non negativity conditions

$X_{ij} \geq 0$ for all i and j



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# Linear Programming

## An investment problem

### Defining the Decision Variables

X1 = amount of money to invest in A
X2 = amount of money to invest in D
X3 = amount of money to invest in E
X4 = amount of money to invest in M
X5 = amount of money to invest in O
X6 = amount of money to invest in P

### Defining the Objective Function

Maximize the total annual investment return:
MAX: .0865X1 + .095X2 + .10X3 + .0875X4 + .0925X5 + .09X6

### Defining the Constraints

| | |
|---|---|
| Total amount is invested | $X1 + X2 + X3 + X4 + X5 + X6 = 750{,}000$ |
| No more than 25% in any one investment | $Xi \leq 187{,}500$, for all i |
| 50% long term investment constrain. | $X1 + X2 + X4 + X6 \geq 375{,}000$ |
| 35% constrain on D, E, and O. | $X2 + X3 + X5 \leq 262{,}500$ |

Nonnegativity conditions: $Xi \geq 0$ for all i

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# Linear Programming

## An employee scheduling 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.



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# Linear Programming

## An employee scheduling problem

Linear minimization model of the total production and storage costs for the three months March –April- May.

*Decision Variables*

X3K: Regular hours in March — X3Y: Overtime in March — (3rd month, R regular)
X4K: Regular hours in April — X4Y: Overtime in April — (3rd month, O overtime)
X5K: Regular hours in May — X5Y: Overtime in May

Storage at the end of March: $2X_{3K} + 2X_{3Y} - 3800$

Storage at the end of April: $2X_{3K} + 2X_{3Y} + 2X_{4K} + 2X_{4Y} - 3800 - 4200$

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 $10\ (X_{3K} + X_{4K} + X_{5K}) + 15\ (X_{3Y} + X_{4Y} + X_{5Y}) +$
$K\ (2X_{3K} + 2X_{3Y} - 3800) + K\ (2X_{3K} + 2X_{3Y} + 2X_{4K} + 2X_{4Y} - 3800 - 4200)$

*constraints*

$X3K \le 2000 \quad X3Y \le 600$
$X4K \le 1800 \quad X4Y \le 500$
$X5K \le 2000 \quad X5Y \le 700$
Available regular hours and overtime

$2X_{3K} + 2X_{3Y} \ge 3800$
$2X_{3K} + 2X_{3Y} + 2X_{4K} + 2X_{4Y} \ge 8000$
$2X_{3K} + 2X_{3Y} + 2X_{4K} + 2X_{4Y} + X_{5K} + 2X_{5Y} = 12600$
Fulfil demand without delay
Storage March - April: ≥ 0
Storage May: zero

Non negativity constraints
$X_{3K}, X_{3Y}, X_{4K}, X_{4Y}, X_{5K}, X_{5Y} \ge 0$

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# Linear Programming

## A production planning 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 8%, 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 x1 and x2 are the production rates (in units / min) of products 1 and 2 respectively. The problem is to determine the values of x1 and x2 that optimize the linear model

Objective function $\quad$ Max Z = 3 x1 + 5 x2

constraints

$$\begin{array}{lll} x_1 & \le 4 & \text{(Laboratory 1)} \\ 2x_2 & \le 12 & \text{(Laboratory 2)} \\ 3x_1 + 2x_2 & \le 18 & \text{(Laboratory 3)} \end{array}$$

$x_1 \ge 0,\ x_2 \ge 0$



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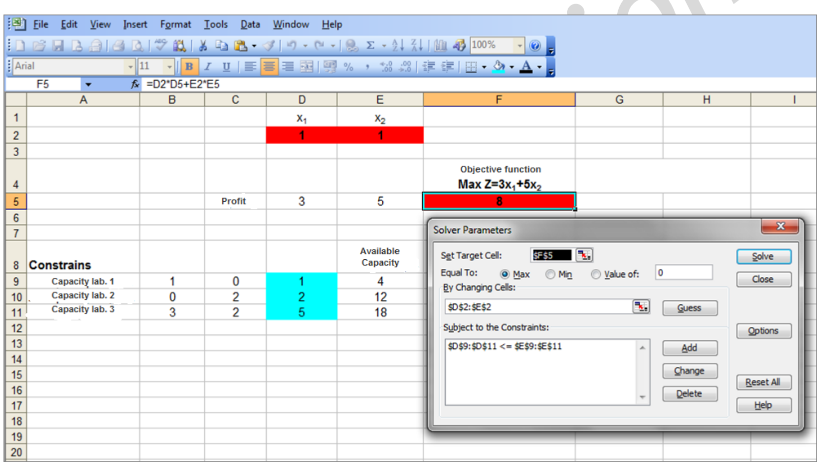
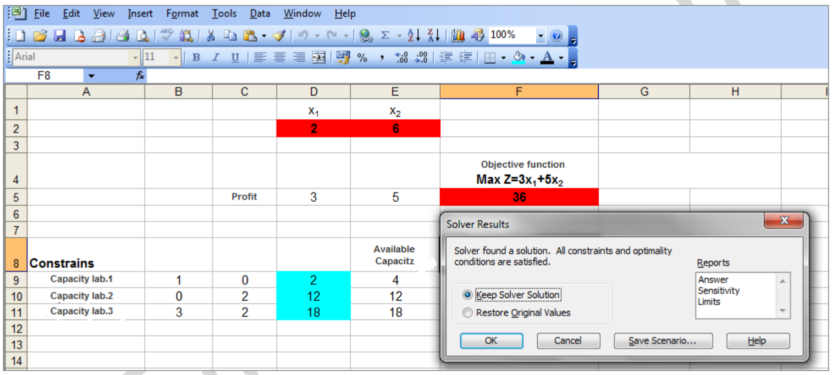
# Linear Programming

## A production planning problem



# Linear Programming

## A production planning problem




Best solution: x1 = 2, x2 = 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

*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 a.m. but for your company the airport allows TWO 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 - 11a.m. | 1 - 2 p.m. |
|---|---|---|---|
| Athens | 500 | 440 | 300 |
| Rhodes | 620 | 600 | 450 |
| Corfu | 420 | 350 | 310 |
| London | 780 | 650 | 550 |

Decision variables

XA1: flights from Thessaloniki to Athens at 8-9a.m

XA2: flights from Thessaloniki to Athens at 10-11a.m

XA3: flights from Thessaloniki to Athens at 1-2 p.m

XP1: flights from Thessaloniki to Rhodes at 8-9a.m

XP2: flights from Thessaloniki to Rhodes at 10-11a.m

XP3: flights from Thessaloniki to Rhodes at 1-2 p.m

XK1: flights from Thessaloniki to Corfu at 8-9a.m

XK2: flights from Thessaloniki to Corfu at 10-11a.m

XK3: flights from Thessaloniki to Corfu at 1-2 p.m

XL1: flights from Thessaloniki to London at 8-9a.m

XL2: flights from Thessaloniki to London at 10-11a.m

XL3: : flights from Thessaloniki to London at 1-2 p.m



## Linear Integer Programming (LIP)

### A transportation - scheduling problem

| Destination | 8 - 9 a.m. | 10 - 11a.m. | 1 - 2 p.m. |
|---|---|---|---|
| Athens | 500 | 440 | 300 |
| Rhodes | 620 | 600 | 450 |
| Corfu | 420 | 350 | 310 |
| London | 780 | 650 | 550 |

Objective Function:

$$500X_{A1} + 440X_{A2} + 300X_{A3} + 620X_{P1} + 600X_{P2} + 450X_{P3} + 420X_{K1} + 350X_{K2} + 310X_{K3} + 780X_{L1} + 650X_{L2} + 550X_{L3}$$

$X_{A1} + X_{A2} + X_{A3} = 1$ $\quad X_{A1} + X_{P1} + X_{K1} + X_{L1} \leq 2$

$X_{P1} + X_{P2} + X_{P3} = 1$ $\quad X_{A2} + X_{P2} + X_{K2} + X_{L2} \leq 2$ $\quad$ X: binary

$X_{K1} + X_{K2} + X_{K3} = 1$ $\quad X_{A3} + X_{P3} + X_{K3} + X_{L3} \leq 2$

$X_{L1} + X_{L2} + X_{L3} = 1$

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# Linear Integer Programming (LIP)

## A scheduling 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 more adequate coverage of the freight center.*



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# Linear Integer Programming (LIP)

## A transportation - scheduling problem

XA, XB, XC, XD 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: $X_A + X_B + X_C + 1{,}1X_D$

### Constraints

$X_C + X_D \geq 1$

$X_A + X_B \geq 1$

$X_A + X_D \geq 1$

$X_A + X_B + X_C \geq 1$

$X_B + X_C + X_D \geq 1$

$X_B + X_D \geq 1$

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# Software and applications - The SITATION software

Source: Mark S. Daskin, Department of IE/MS, Northwestern U., Evanston, IL





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## What is SITATION?

- Software to solve location problems
  - Set covering P-median
  - Maximal Covering Uncap. Fixed charge
  - P-center **Loc./Inv. Model**
  - Partial covering P-center
  - Partial Covering Set covering
  - Covering- Medial Tradeoff

## Options include:

- Forcing sites in/out of solution
- Different solution algorithms
  - Heuristic
  - Improvement
  - Lagrangian relaxation in branch and bound (optimal)
- Mapping
- Reporting
- Manual facility exchanges (for some objectives)

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## SITATION Software

### Main Menu

First you load the data

Set key parameters
coverage distance
cost per demand per mile

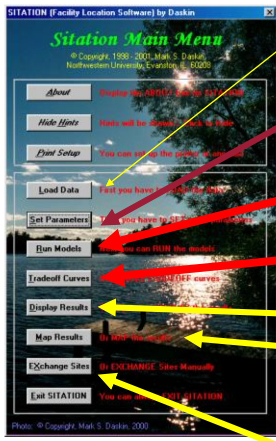
Run a single objective model

Or a multi-objective model

Tabular and graphical summaries

Map results

Exchange, delete, add sites manually



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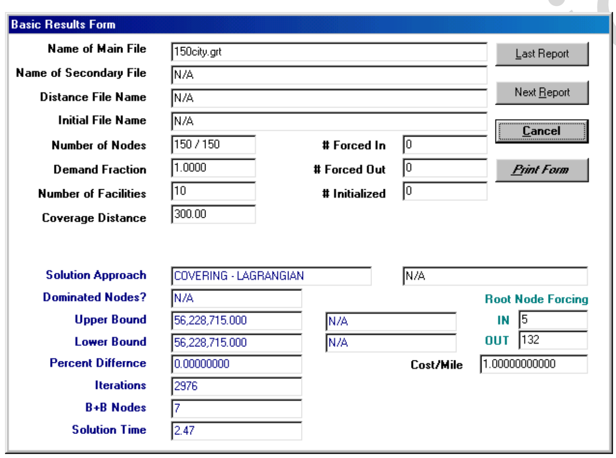
## SITATION Software

### Basic summary




Shows input values, problem selected, bounds, iterations, B&B nodes, seconds, etc.

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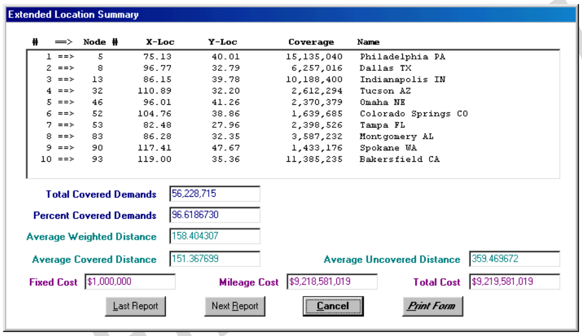
## SITATION Software

### Extended summary shows



Extended Location Summary

| # | ==> | Node # | X-Loc | Y-Loc | Coverage | Name |
|---|---|---|---|---|---|---|
| 1 | ==> | 5 | 75.13 | 40.01 | 15,135,040 | Philadelphia PA |
| 2 | ==> | 8 | 96.77 | 32.79 | 6,257,016 | Dallas TX |
| 3 | ==> | 13 | 86.15 | 39.78 | 10,188,400 | Indianapolis IN |
| 4 | ==> | 32 | 110.89 | 32.20 | 2,612,294 | Tucson AZ |
| 5 | ==> | 46 | 96.01 | 41.26 | 2,370,379 | Omaha NE |
| 6 | ==> | 52 | 104.76 | 38.86 | 1,639,685 | Colorado Springs CO |
| 7 | ==> | 53 | 82.48 | 27.96 | 2,398,526 | Tampa FL |
| 8 | ==> | 83 | 86.28 | 32.35 | 3,587,232 | Montgomery AL |
| 9 | ==> | 90 | 117.41 | 47.67 | 1,433,176 | Spokane WA |
| 10 | ==> | 93 | 119.00 | 35.36 | 11,385,235 | Bakersfield CA |

Total Covered Demands 56,228,715
Percent Covered Demands 96.6186730
Average Weighted Distance 158.404307
Average Covered Distance 151.367699
Average Uncovered Distance 359.469672
Fixed Cost $1,000,000
Mileage Cost $9,218,581,019
Total Cost $9,219,581,019

Last Report | Next Report | Cancel | Print Form

Shows locations, coverage, average distance, total cost, etc.

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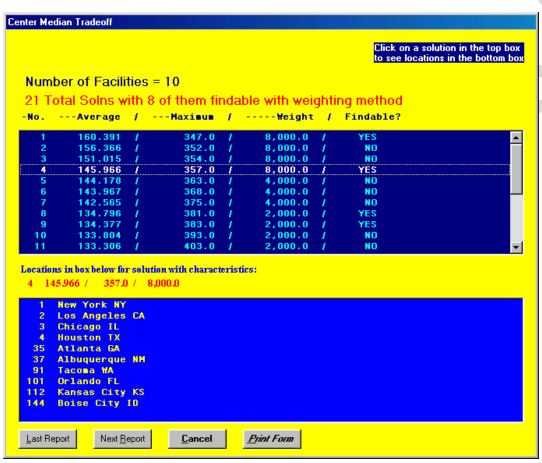
## SITATION Software

### Tradeoff summary info



Center Median Tradeoff

Click on a solution in the top box to see locations in the bottom box

Number of Facilities = 10

21 Total Solns with 8 of them findable with weighting method

| -No. | ---Average | / | ---Maximum | / | -----Weight | / | Findable? |
|---|---|---|---|---|---|---|---|
| 1 | 160.391 | / | 347.0 | / | 8,000.0 | / | YES |
| 2 | 156.366 | / | 352.0 | / | 8,000.0 | / | NO |
| 3 | 151.015 | / | 354.0 | / | 8,000.0 | / | NO |
| 4 | 145.966 | / | 357.0 | / | 8,000.0 | / | YES |
| 5 | 144.178 | / | 363.0 | / | 4,000.0 | / | NO |
| 6 | 143.967 | / | 368.0 | / | 4,000.0 | / | NO |
| 7 | 142.565 | / | 375.0 | / | 4,000.0 | / | NO |
| 8 | 134.796 | / | 381.0 | / | 2,000.0 | / | YES |
| 9 | 134.377 | / | 383.0 | / | 2,000.0 | / | YES |
| 10 | 133.804 | / | 393.0 | / | 2,000.0 | / | NO |
| 11 | 133.306 | / | 403.0 | / | 2,000.0 | / | NO |

Locations in box below for solution with characteristics:
4 145.966 / 357.0 / 8,000.0

| | |
|---|---|
| 1 | New York NY |
| 2 | Los Angeles CA |
| 3 | Chicago IL |
| 4 | Houston TX |
| 35 | Atlanta GA |
| 37 | Albuquerque NM |
| 91 | Tacoma WA |
| 101 | Orlando FL |
| 112 | Kansas City KS |
| 144 | Boise City ID |

Last Report | Next Report | Cancel | Print Form

Center-median shows solution values, whether findable using weighting method, penalty for distances greater than max distance, and locations

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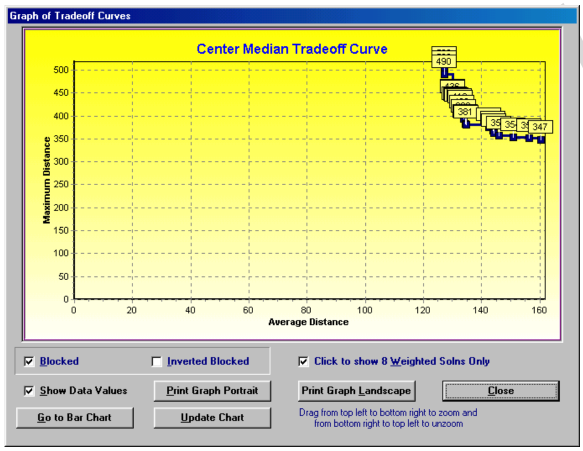
## SITATION Software

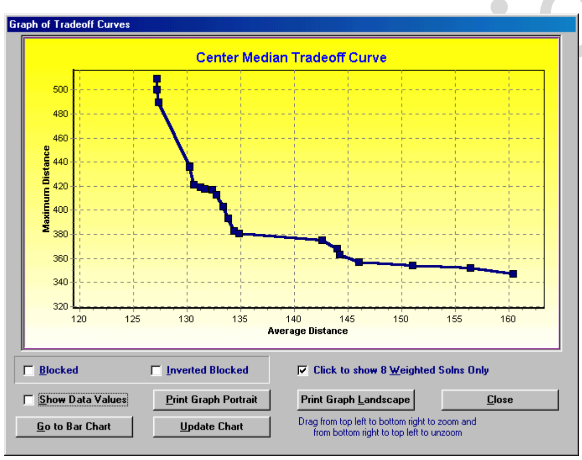
### Graph of tradeoff






## SITATION Software

### Alter how graph is displayed



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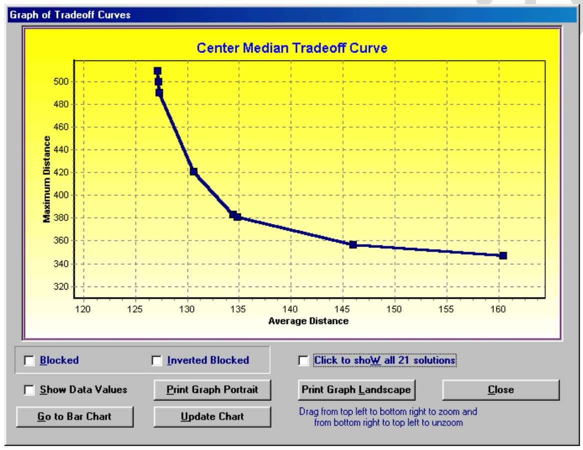
## SITATION Software

### Show only solutions findable using weighting method

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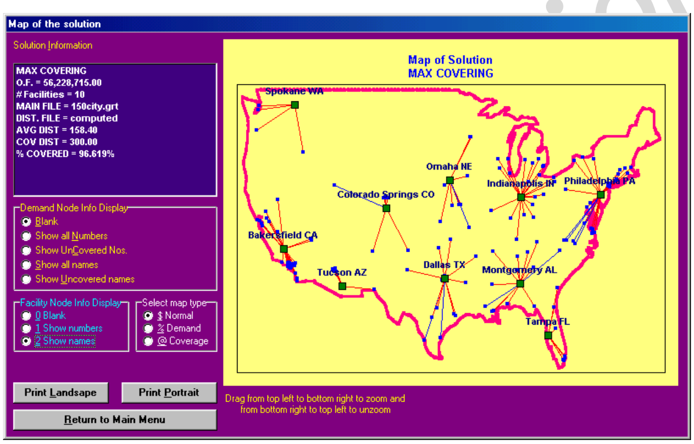
## SITATION Software

### Map with site names

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# SITATION Software

## Summary of basic location/inventory costs

**Summary of Location/Inventory Costs**

**Costs by category**

| | |
|---|---|
| Fixed Cost | $1,600,000.00 |
| Local Delivery Cost | $1,835,165.71 |
| Safety Stock Cost | $570.20 |
| Order Cost | $6,503.88 |
| Fixed Shipment Cost | $2.60 |
| Variable Shipment Cost | $116,393.06 |
| Working Inventory Cost | $6,506.48 |
| Total DC Working Inv Cost | $129,406.03 |
| Total Cost | $3,565,141.94 |
| Total Cost from Algorithm | $3,565,141.94 |

**Costs by Objective Function Term**

| | |
|---|---|
| Fixed Cost | $1,600,000.00 |
| Linear in Yij | $1,951,558.77 |
| Prop to SQRT(mean) | $13,012.97 |
| Prop to SQRT(var) | $570.20 |
| Total Cost | $3,565,141.94 |
| Total Cost from Algorithm | $3,565,141.94 |

Costs in Right Panel correspond to sum of similarly colored costs in Left Panel

Save Columns | Last Report | Next Report | Print Report | Cancel

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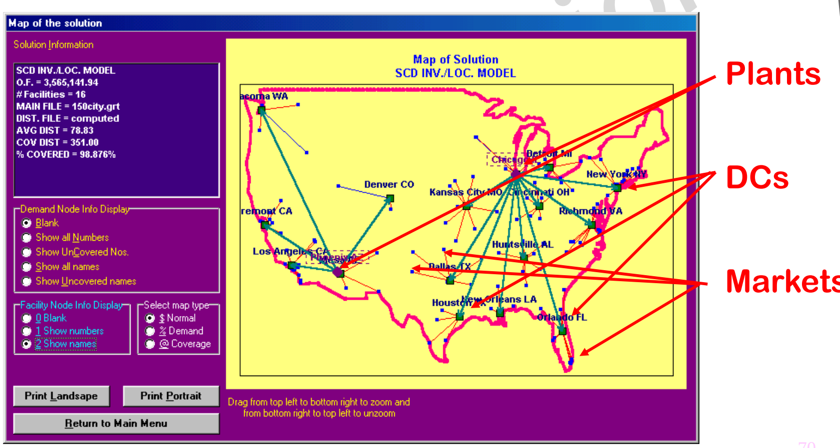
# SITATION Software

## Map of location/inventory solution showing plants

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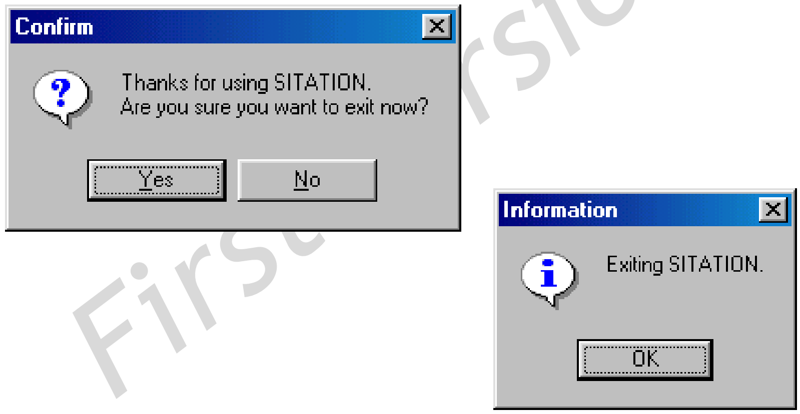
## SITATION Software








## Guidance to further knowledge acquisition

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*Thank you*
*for your attention*

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# Intelligent services for passenger transportation

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## Content

- Background — *General introduction to the topic*
- Theoretical methodologies — *Deepening knowledge of topic*
  - 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 — *Deepening the understanding of application (fields) and supporting the assessment of services*
- Exercise — *Application of learnings (put knowledge to work)*
- Additional suggested literature — *Further knowledge sources*

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# Background





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# Background

First version

- 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.<br><br>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.<br><br>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.<br><br>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 are necessary to achieve efficient operations.
- Providing travelers with updated information about routes, departure times, possible disturbances, and connecting services.



Cf. Berg Insight (2013).

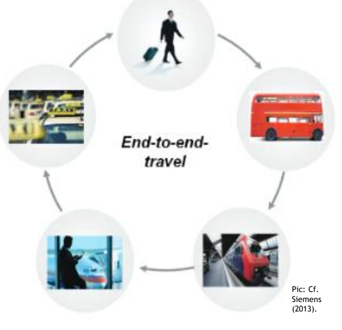


# Passenger transport modes (1/5)

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: Cf. Siemens (2013).

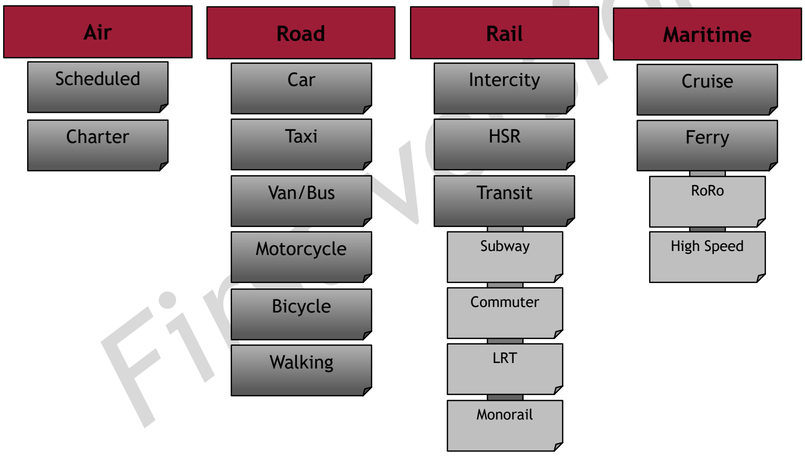
Multimodal integrated mobility platform:

- 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






Cf. Rodrigue, J.-P., et al. (2013): Main Passenger Modal Options.



# 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

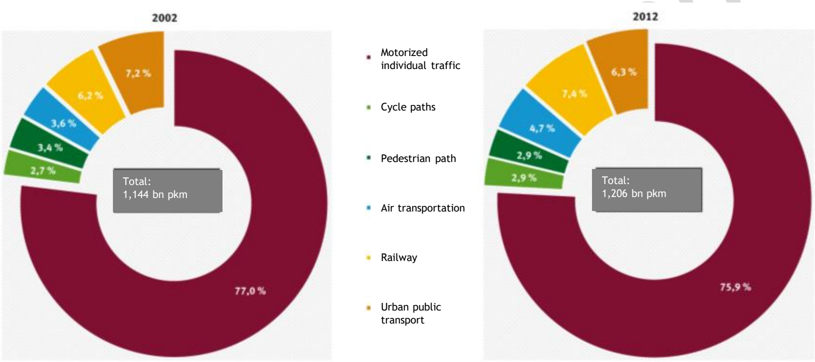


Cf. Rodrigue, J.-P., et al. (2013.



## Passenger transport modes (5/5)

Modal Split for passenger traffic (incl. not motorized traffic)




* passenger kilometer in billions

Cf. BMVI (2014/2015).

## 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



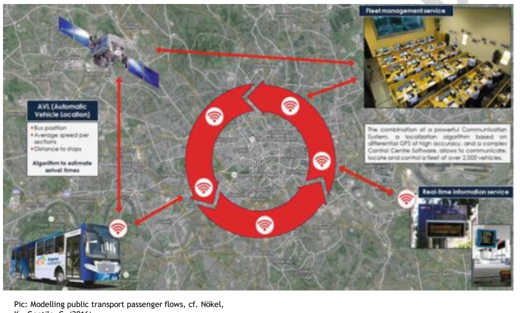
Cf. Nökel, K., Gentile, G. (2016).



## Information technology for passenger transport (2/4)

- Best way to monitor and PT 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: Modelling public transport passenger flows, cf. Nökel, K., Gentile, G. (2016).

- 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

Cf. Nökel, K., Gentile, G. (2016).

## Information technology for passenger transport (3/4)

Pic: Ticket counter in bus fleet in Craiova (Romania), cf. Nökel, K., Gentile, G. (2016).

- **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

Pic: Security camera system in San Sebastian (Spain), cf. Nökel, K., Gentile, G. (2016).

- **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).



## Information technology for passenger transport (4/4)

Pic: Bus lane and different types of signals for giving priority, cf. Nökel, K., Gentile, G. (2016).

- **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 times at traffic lights was reduced by 52 % with this kind of systems, at a comparatively low cost

↳ **This coordination is to facilitate the reliability in bus services**



Cf. Nökel, K., Gentile, G. (2016).

## 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).





## 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).

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# IT application fields



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# 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).

# 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: Ticket vending machine in Norwich, cf. Nökel, K., Gentile, G. (2016).


Pic: The Lisbon Smart Card, cf. Nökel, K., Gentile, G. (2016).

Cf. Nökel, K., Gentile, G. (2016).



# 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: Real-time information panel at a bus stop, cf. Nökel, K., Gentile, G. (2016).

Pic: Real-time smartphone app, cf. Nökel, K., Gentile, G. (2016).

Cf. Nökel, K., Gentile, G. (2016).

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## 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).



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## 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).

## 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: Interactive “aim4it-app”
  - 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

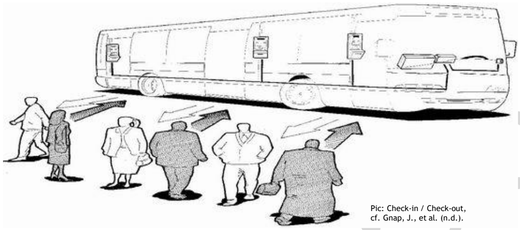
Cf. Austin, J. (2016).





## Applications – Case study

# Possibilities for the use of smart cards



Pic: Check-in / Check-out,
cf. Gnap, J., et al. (n.d.).

| Getting on by all doors | Check-in / Check-out | Walk-in / Walk-out |
|---|---|---|
| ➢ Central computer in vehicle and of one or two terminals located at each door<br>➢ System is more suitable for a larger number of passenger<br>➢ Disadvantage of this system is that it requires a frequent control of passengers through inspectors<br>➢ System requires a high investment for the processing equipment and also the records about getting off at stops is not accurate<br>➢ Driver is not able to have an overview of if passengers validated their tickets | ➢ Passenger is getting on the vehicle and the advance fare is deducted to the final stop from the electronic wallet<br>➢ When the passenger is getting off, the actual price is calculated and appears on the terminal<br>➢ Method provides the accurate statistical information about the number of passengers getting on and off using the smart cards at each stop<br>➢ Disadvantage is that it requires a high investment for the processing equipment and a problematic passengers control | ➢ Card is automatically registered when the passenger is getting on or off the vehicle<br>➢ During getting off the appropriate price is calculated<br>➢ System is suitable in the case of large number of passengers<br>➢ Detailed review about the passengers, the numbers of passengers at each stop, entry and exit and accurate records about the fare<br>➢ Disadvantage is the higher investment for providing the processing devices |

Cf. Gnap, J., et al. (n.d.).

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# 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.).

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## 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.).

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## Exercise

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## Exercise 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

Cf. Austin, J. (2016).





## Guidance to further knowledge acquisition

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# 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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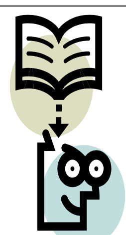
# Information systems for intermodal freight transport

Dipl.-Wirt.-Inform. Oliver Meier
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



## Learning goals



- Basic understanding of information systems in logistics
- Selection, classification and application of information systems
- Description and analysis of information structures and information flows
- Selection and application of information systems for logistical tasks
- What is big data and knowledge discovery

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# Content

- Roles of information in logistics
- Definition
- Information needs
- Data
- Information systems





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## Description of the logistics performance with the 6+2 R rule of logistics

| 6+2 R | | Question | Needs... |
|---|---|---|---|
| 1 | The right object | What | Identification |
| 2 | In the right quantity | How much | Counting, measuring |
| 3 | In the right place | where | localisation |
| 4 | At the right time | When, how often, how long | Time stamp, timing |
| Processes | | | |
| 5 | With the right costs | how (low costs) | Valuation of the logistics process in relation to effectiveness and efficiency |
| 6 | With the right quality | how + (in line with quality requirements) | Valuation of the quality and security aspects of the object |
| +1 | Ecological right | how ++ (in line with environmental requirements) | Valuation of ecological aspects |
| +1 | With the right information | how +++ (right information) | Valuation of completeness and correctness of the information |

## Characteristics of logistics according to Fleischmann

- Every logistics system needs a information and communication system
- Logistics has a comprehensive view on all processes
- Logistics is about physical systems and processes. The planning and controlling of logistics systems includes technical and economical tasks as well as information systems

[Fleischmann, 2008, S. 3 f.]

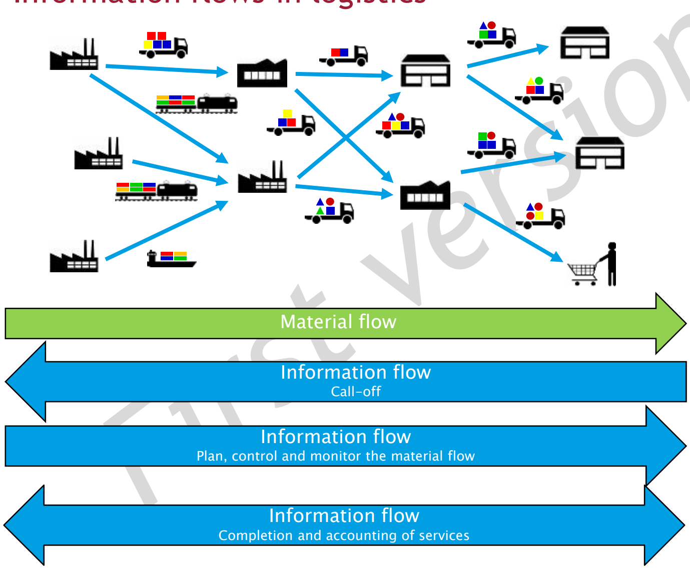
**To find information fast and easy in the company is a decisive sucsess factor.**







## Information flows in logistics




i. A. a. [Schenk et al. 2015, S. 99]

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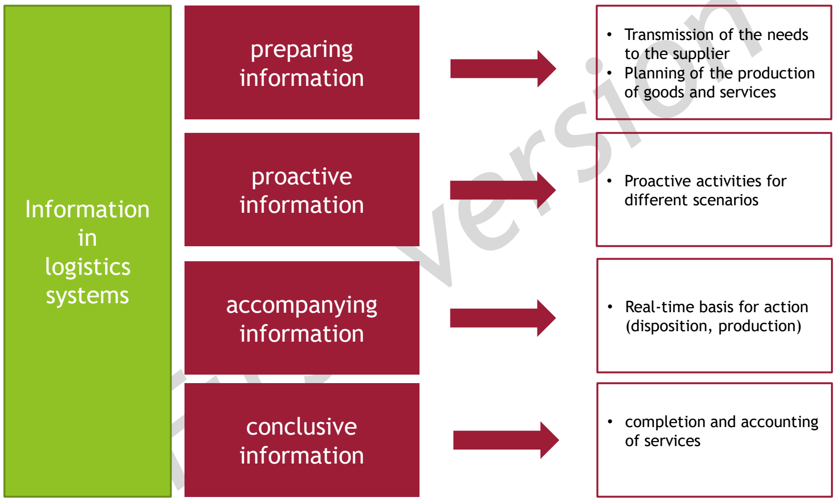
## Types of information




i. A. a. [Schenk et al. 2015, S. 100]



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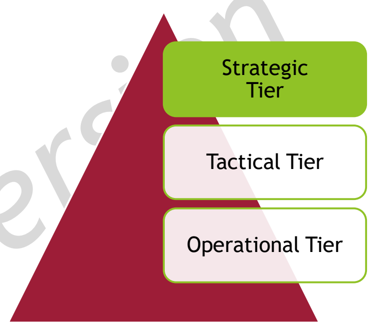
## Strategic logistics management

**Strategic Tier**

- Tasks
  - Business planning
  - Development of strategies
  - Program planning
  - Marketing
  - Sales
  - procurement
  - Accounting
  - Human resources
  - Controlling
- Characteristics
  - Tasks from the management
  - Demand of the markets
  - Uncertain information
  - Long decision times (hours, weeks)



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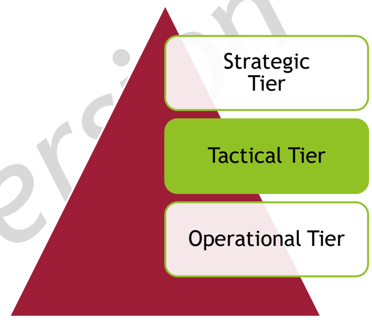
## Strategic logistics management

**Tactical Tier**

- Tasks
  - Scheduling of orders
  - Administration of orders
  - Production planning
  - Work preparation
  - Inventory management
  - Disposition of replenishments
  - Disposition of resources and equipment
  - Order tracking
  - Monitoring of all processes
- Characteristics
  - External orders
  - Requirements of the administration
  - Requirements of disposition strategies
  - Relatively secure information
  - Middle decision time (minutes, hours)





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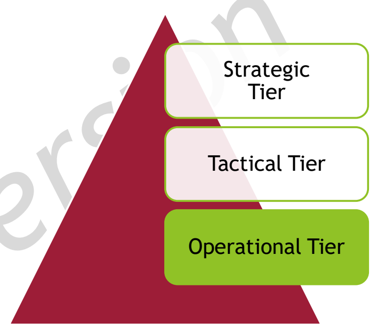
## Strategic logistics management

**Operational Tier**

- Tasks
  - Trigger processes
  - Control transactions
  - Regulate the processes
  - Monitor the processes
- Characteristics
  - Internal orders
  - Requirements of the disposition
  - Secure information
  - Short reaction time (seconds, minutes)



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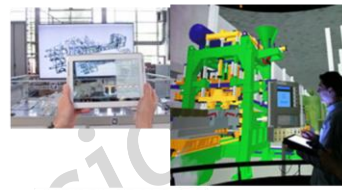
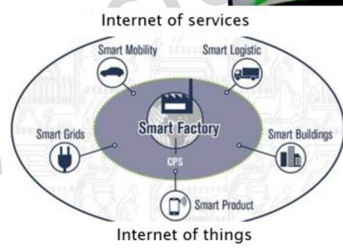
## Industry 4.0

- Strong individualization of products under the conditions of a highly flexible production.
- Customers and business partners are directly integrated in business processes.
- Companies and complete supply chains should be controlled and optimized in nearly real-time with the help of intelligent monitoring and decision processes.
- Merge of the real (physical system) with the digital world (cyber system) to a cyber-physical-system (CPS).






**Industry 4.0:**
„technical integration of CPS in the production and logistics as well as application of the internet of things and services in industrial processes“ [Kagermann et al., 2013, S.18]





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## Content

- Roles of information in logistics
- Definition
- Information needs
- Data
- Information systems

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## Definition – message, data, character


**CHARACTER**

… are the basic elements for the form of presentation of information

**DATA**

… are the form of presentation of information.

A **MESSAGE**

… is the specific type of notification of the (abstract) information.

… can only be presented in the form of data.

… can convey information.

… a information is conveyed by a message and its meaning for the recipient.

=> an information needs a message, but a message don't have to contain a information.





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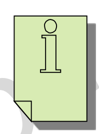
## Definition – information, knowledge



**INFORMATION is (in this context of production and logistics)**

**… a description of circumstances in the past, present or future, if they are understandable and usable for specific recipients and if they are used by at least one recipient.**

**KNOWLEDGE is**

**… the requirement to recognize and describe circumstances as well as to make decisions.**

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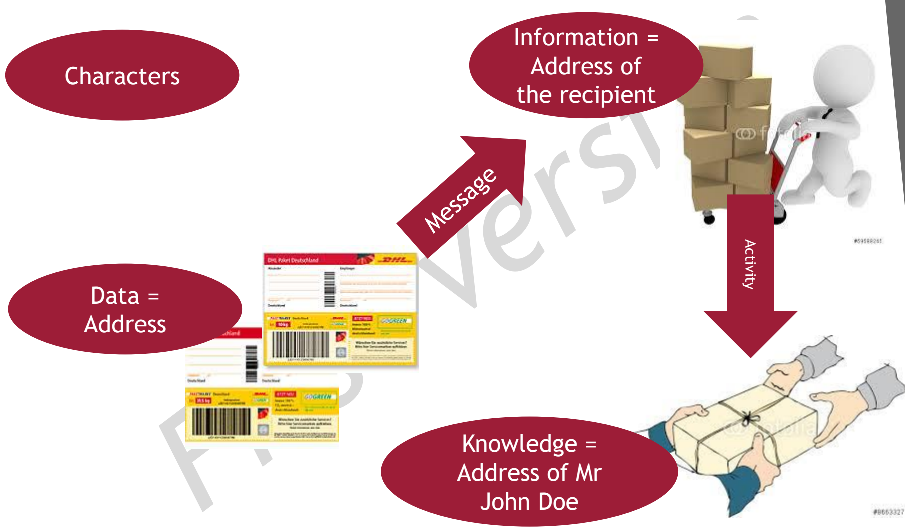
## Example



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## Content

- Roles of information in logistics
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## Analyses of the information needs

### Starting point:
### Roles, tasks, decisions:

- Who needs the information? — Recipient
- What information is needed? — Content
- How often is the information needed? — Frequency
- In which form is the information needed? — Form
- How should the information be transported? — Medium
- How important is the information? — Value
- Are their any security issues about that information? — Security
- Has the information to be stored? — Need for storage
- How long has the information to be stored? — Duration of storage





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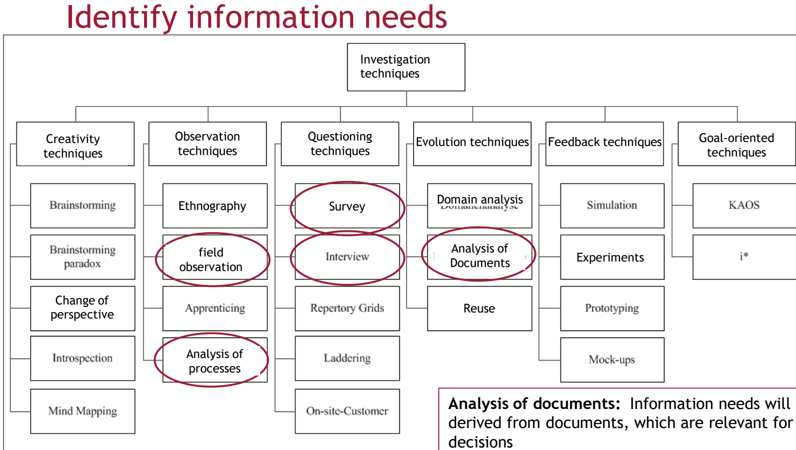
## Identify information needs




nach [Partsch, 2010, S. 40]

**Analysis of documents:** Information needs will be derived from documents, which are relevant for decisions

**Questioning** (interviews, surveys): Information needs will be derived from reports of decision makers

**Analysis of tasks:** Information needs will be derived from the relevenat taks

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## Principles of synchronisation

**Hierarchical principle**
- Higher (central) instance activates the considered unit

Activation

**Predecessor principle**
- Following instance activates the unit

Activation

**Sucessor principle**
- Preciding instance activates the unit

Activation



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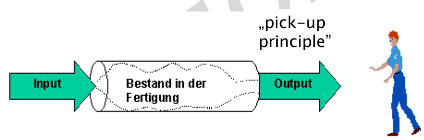
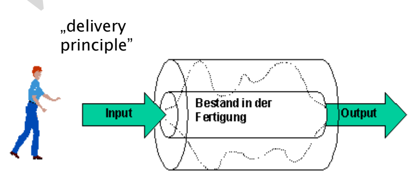
## Basic principles

**Pick-up principle**
activ for the recipient
= I have to collect information
= activation by recipient




**Delivery principle**
passiv for the recipient
= I would be informed
= Activation by triggering event
(e.g. arrival of a messenger, arrival of an e-mail etc.)



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# Content

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## Types of data

**DATA**
… are the form of presentation of information.

| Characteristic | Type of data | | |
|---|---|---|---|
| Type of character | numeric | alphabetic | alphanumeric |
| Formatting | formatted | unformatted | |
| Structure | structured | unstructured | |
| Handling process | input data | output data | |
| Duration | master data | transaction data | |
| Time-relevance | active | passive | |
| Status transition | status data | event data | |

version

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## Types of data – types of characters, formatting, structure

| Characteristic | Type of data | | |
|---|---|---|---|
| Type of character | numeric | alphabetic | alphanumeric |
| Formatting | formatted | unformatted | |
| Structure | structured | unstructured | |

- Address data
- Text
- graphics (CAD, etc.)
- Picture data (from scanner, film camera, camera, etc.)
- Digital tone sequences



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## Types of data – handling process

**Input data**

- orders
- Actual stock
- Supplier data
- Customer data
- …

Information system

**Output data**

- Prepared data: repots, lists, indicators
- …

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## Types of data - duration

**Master data**

- Describes physical or nominal stocks, which are related to the present or future, but can not activate processes
- Represent attributes of more or less unchangeable objects; e.g. personnel master data, resource data, basic data, etc.
- Do not change for longer times

**Stock data**

- Are related to a stock
- Warehouse stock, working time account, etc.
- Change over time

**Transaction data**

- Change very often
- Can trigger processes
- Current status of a order





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## Types of data - duration

**Active data**

- Are used in the current working process
- E.g. modification data for master data

**Passive data**

- Are not needed for the current process
- Archive data: history data

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## Types of data – status transition

**Current status:**

- The current status of a logistical object is described by actual values of predefined attributes (e.g. position)

**Event:**

- An event is the modification of the value of an attribute.

status

| ID | Time | Location |
|---|---|---|
| ULD033 | 23:47:00 | Dolly17 |
| ULD033 | 23:47:03 | warehouse |

event

| ID | Time | Location 1 | Location 2 |
|---|---|---|---|
| ULD033 | 23:47:03 | Dolly17 | warehouse |





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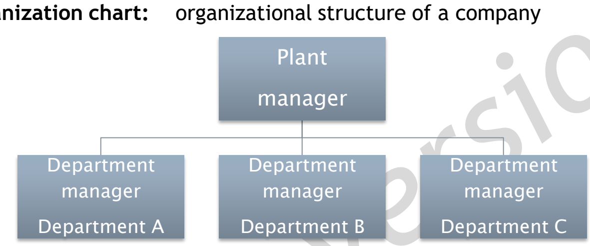
## Basic data in companies I – master data

**Organization chart:** organizational structure of a company




- **Procedures:** standard procedures in the company are defined and documented in the quality manual
- **Parts lists:** structure and quantity of products and parts in a graphical form and as a table

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## Basic data in companies II – master data

- **Work plan:** define sequence and duration of work processes as well as needed resources
- **Testing plan:** type, scale and documentation of quality control
- **Workplaces:** Organizational entity for working
- **Product and material master data**
- **Personnel master data:** person-related and workplace-related data
- **Basic resource data:** Machine type, year of construction, investment





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## Content

- Roles of information in logistics
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## Information systems

- The information system supports the information flow.
- Subject of operational information systems for the production is the operational, chronological and quantitative planning, controlling and monitoring of all processes, which are needed for the production of products and goods.
- Information systems for the production contains methods, models and software for the planning, controlling, monitoring and accounting of the production as well as the needed hardware for the data collection, data transmission, data backup, data processing and data output.





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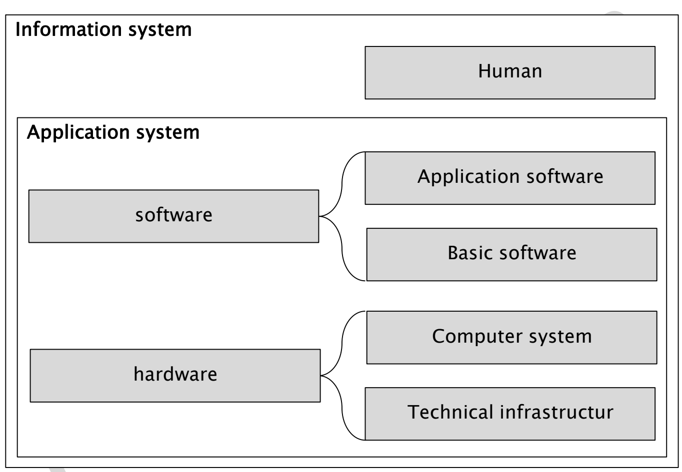
## Parts of a information system




nach [Vieweg et al., 2012, S. 74] und [Weber, 2012, S. 4]

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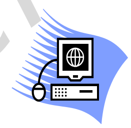
## Elements of the information system

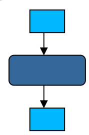
An Information system consists of three components:

1. **Humans**, decision maker and worker

2. **Equipment** (hardware, software, technical infrastructure etc.)



3. Used **methods**.







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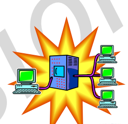
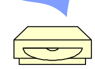
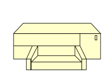
## Technical infrastructure for information systems

Technical infrastructure for the data flow:

- (mobile) data collection and data preparation
- Data transmission (-anlagen),
  e.g. (local) networks,
- Data security,
  e.g. access control, identification technology,
- Data processing,
  e.g. computer, control devices
- Data storage,
  e.g. (mobile) data medium, database
- Data output,
  e.g. monitor, printer etc.







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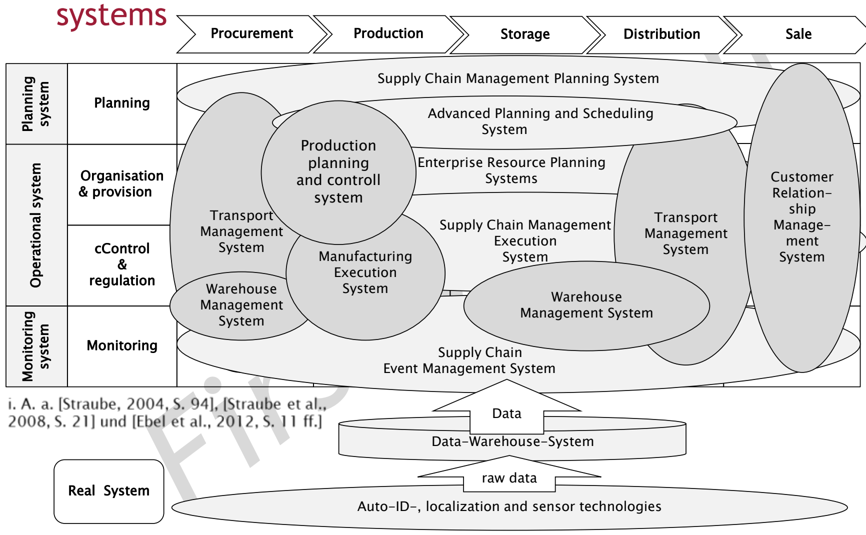
## Classification of common logistical information systems




i. A. a. [Straube, 2004, S. 94], [Straube et al., 2008, S. 21] und [Ebel et al., 2012, S. 11 ff.]

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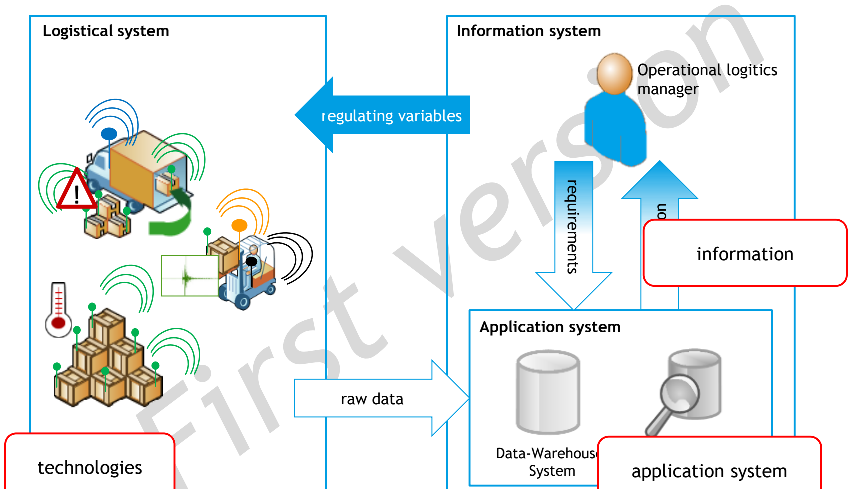
## Example – Operational logistics management

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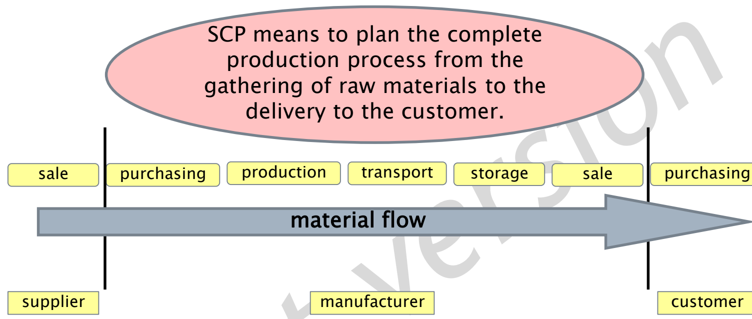
## Supply Chain Planning




- In the past, companies were considered as closed systems. An optimization happened only internally.
- Now, the potentials of business processes between companies will be used and improved.
- The goal of supply chain management is to significantly shorten delivery time and reduce stocks.





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## Planning tiers of SCP systems

| Tier | Description | Function |
|---|---|---|
| Supply-Chain-Configuration<br>**SCC** | Design of structures of production and logistics systems | • modelling of supply chains<br>• design and structure of supply chain objects (storage, production, transport) |
| Supply-Chain-Planning<br>**SCP** | Planning of stocks, quantity flows and capacities | • planning of sales and distribution<br>• planning of production<br>• Machine scheduling<br>• simulation of customer orders<br>• planning of transport<br>• failure management<br>• controlling and monitoring |
| Supply-Chain-Execution<br>**SCE** | Initiation and feedback of orders | • order management<br>• production order management<br>•Execution of the transport order |

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## Technologies for the monitoring of logistical objects and data collection



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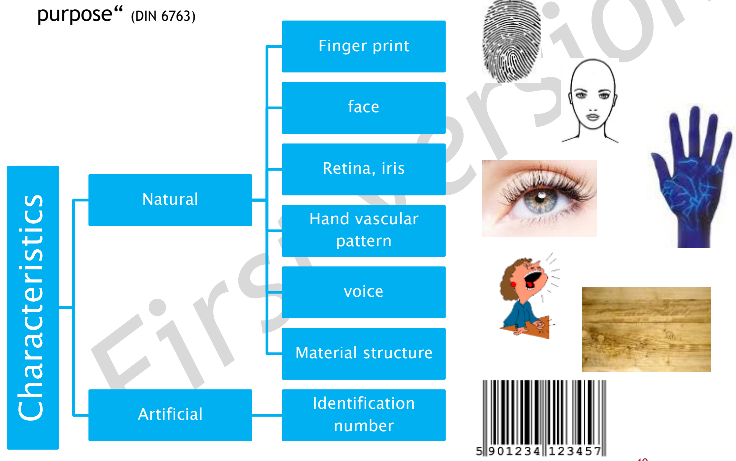
## Identification - ID

- „... The unique recognition of an object on the basis of characteristics (identification characteristics), with a defined accuracy for the intended purpose“ (DIN 6763)



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## Automatic identification systems - ID

- Automatic identification: recognition of objects without human participation

| procedure | | |
|---|---|---|
| | optic | Barcode, OCR, Video |
| | biometric | Automatic recognition of biometric identifiers |
| | galvanic | Chip cards |
| | electromagnetic | RFID |

[Schenk et al., 2012, S. 110-121]





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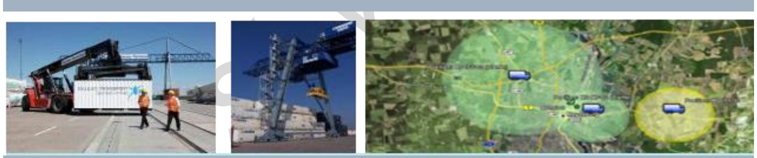
## Radio technologies

**Radio technology**

**Identification: RFID wristband; RFID gate**



**Localization: RTLS; GNSS**

Fraunhofer IFF

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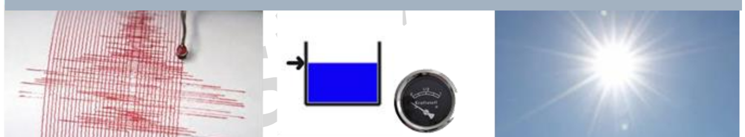
## Sensor technologies - conditions

### Sensor technologies

Condition measurement: temperature, humidity, pressure



Acceleration, fill level, light incidence



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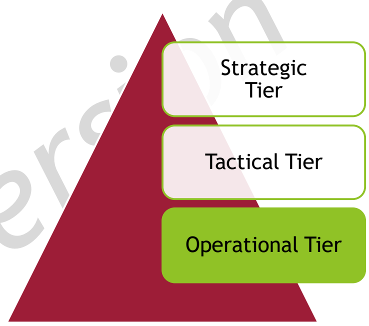
## Strategic logistics management

**Operational Tier**

- Tasks
  - Trigger processes
  - Control transactions
  - Regulate the processes
  - Monitor the processes
- Characteristics
  - Internal orders
  - Requirements of the disposition
  - Secure information
  - Short reaction time (seconds, minutes)



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## DATA WAREHOUSE SYSTEM





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## Requirements to the architecture of a data warehouse system

- Independence between data source and analyzing systems
- permanent provision of integrated and diverted data (persistence)
- Reusability of the data
- execution of any desired analysis
- individual views
- expandability
- automated procedures
- Clearness of data structures, access authorization and processes (transparency)

- design oriented to the purpose of the data analysis
  - support of decision making

nach [Köppen et al., 2014, 17f.]

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## FASMI-Requirements

- FAST: short response time
- ANALYSIS: appropriate interface (ad hoc queries)
- SHARED: several users
- MULTIDIMENSIONAL: multidimensional data model
- INFORMATION: complete information provision





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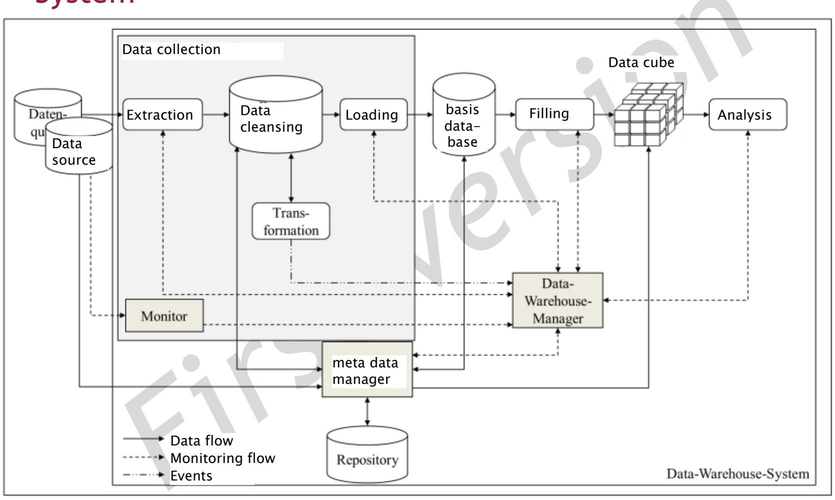
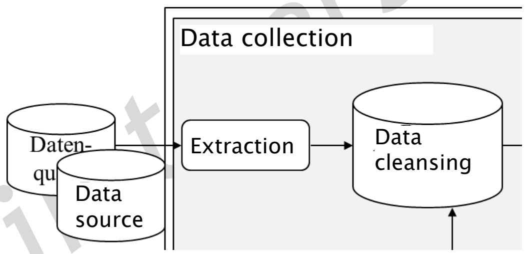
## Reference architecture of a Data Warehouse System




[Köppen et al., 2014, S. 36]

## Extraction

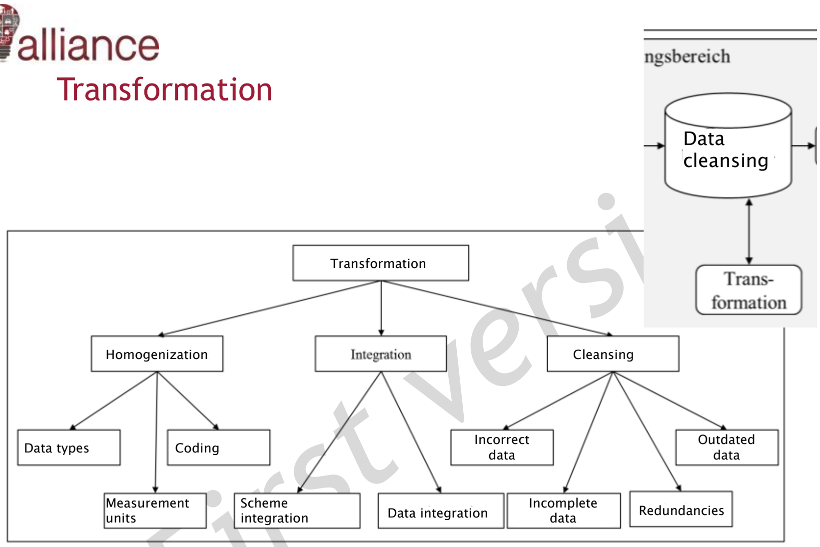
- Transfer of the raw data from the source to the data cleansing
- Important questions
  - What data shall be extracted into the DWS?
  - When?




nach [Köppen et al., 2014, S. 27]



## Transformation




nach [Köppen et al., 2014, S. 28]

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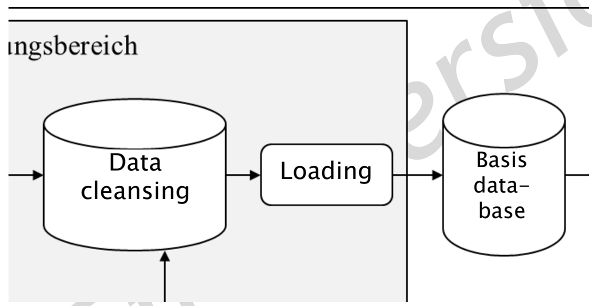
## Loading

- Transfer the prepared data to the basis database




nach [Köppen et al., 2014, S. 29]





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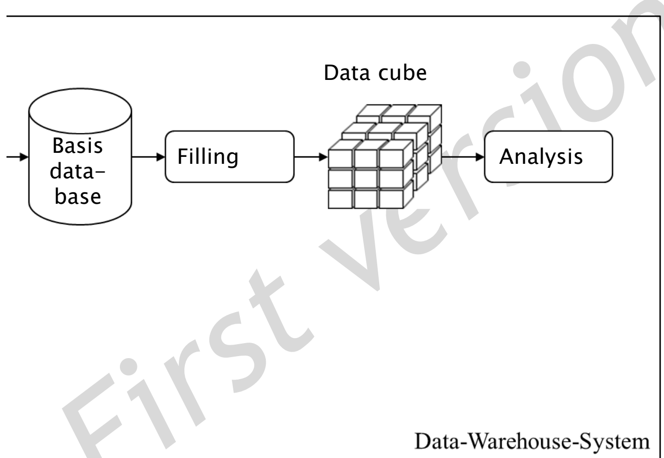
## Filling – data cube - analysis



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# Case study

Tracking and Tracing of chemical goods in the EU-project "ChemLog"

Method description:

Demonstration of the results of a research project of several central European countries. In this course the focus will be at the results of a pilot test with several tracking and tracing systems.





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# Design of passenger transport interchanges

University of Thessaly, Greece

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## Content

- Background
- Basic concepts
- Interchange zones
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- Transport and transfer
- Understanding the interchange
- Facilities and retailing
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- Facilities at different types of interchanges
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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:
  - Process coordination and management
  - Accessibility to all
  - Quality to traveller
  - Safety
  - Design
- The design of interchanges should ensure that transport system is:
  - Seamless
  - Smart
  - Clean
  - Safe
  - Accessible by all users

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# Theoretical methodologies





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# Basic concepts

| | |
|---|---|
| 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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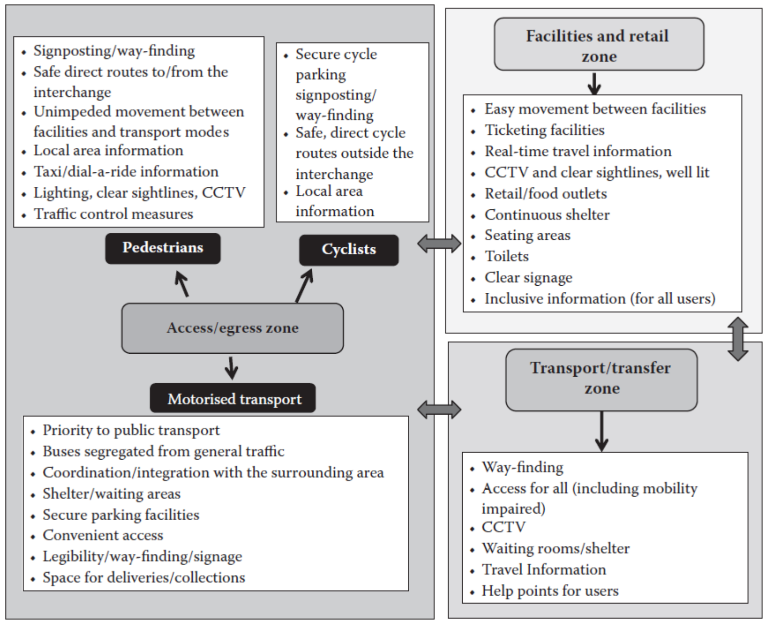
# Interchange zones (1/2)




*Source: CITY-HUBs, 2015*



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# Interchange zones (2/2)

- 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/retail zone:
  - Users having more time available to spend
  - Shops, food outlets, toilets, seating areas, ticketing facilities and real-time information should be available

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# Interchange design

- 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





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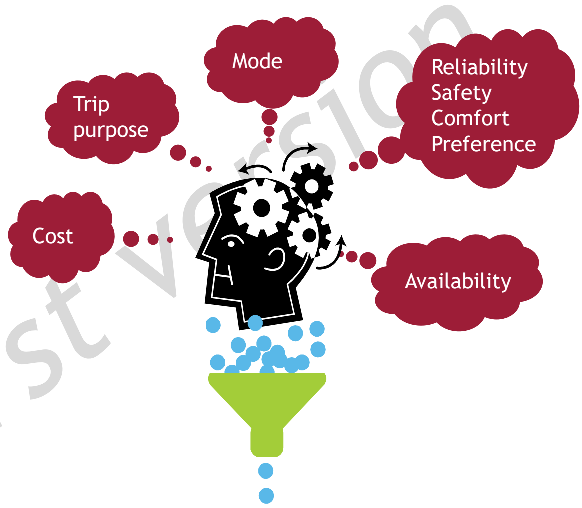
# Users

- 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



# 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-lime 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



# Problem stating and solution approach

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# 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



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# 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: CITY-HUBs, 2015*

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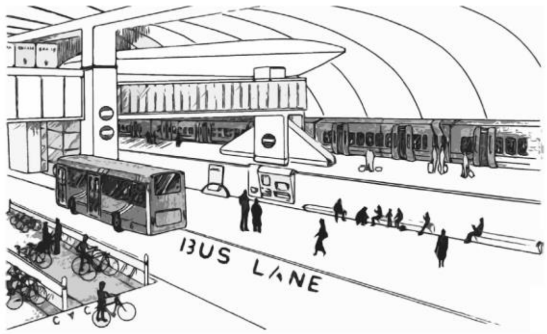
## alliance Transport & transfer

- Distances between different modes should look to emulate similar distances where possible




*Source: CITY-HUBs, 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

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## alliance Understanding the interchange

- **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

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# 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

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# 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



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## 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.



# 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 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: Köbánya-Kispest interchange, Hungary**

In this interchange, signs and information are accessibly 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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## 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

# alliance 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





# alliance Facilities at different interchanges (1/2)

| 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: CITY-HUBs, 2015*

# alliance Facilities at different interchanges (2/2)

| 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: CITY-HUBs, 2015***



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# Applications

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## Case study #1

Understanding travelers' perceptions in issues such as:

- Is the interchange environment convenient?
- Is the interchange modern and dynamic?
- How do you spend your time when not traveling?

Railway station, Volos, Greece

versus

Intercity bus station, Volos, Greece

*Source: Adamos et al., 2014*



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# The interchanges

### Railway

- **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

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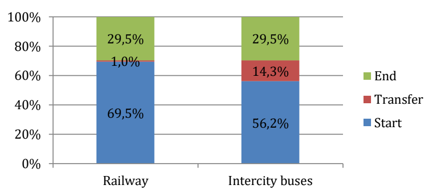
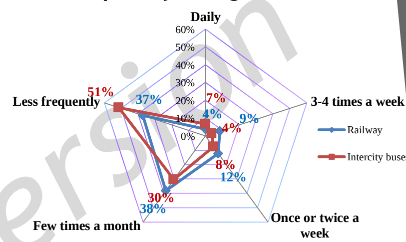
# Trip characteristics

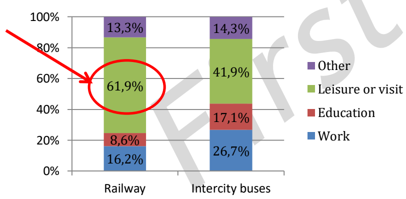
## Trip status



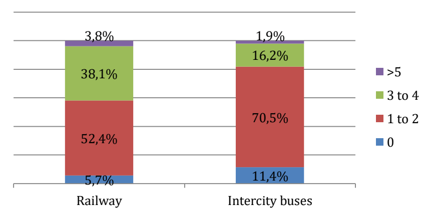

## Frequency using the station




## Trip purpose




## Total number of transfers

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# 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

1 Strongly dissatisfied — 5 Strongly satisfied

| 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

1 Strongly dissatisfied — 5 Strongly satisfied

| 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 mashines | 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%*

First version

# 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%*

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# Main findings

- Even if the Intercity Bus station had a higher score in the majority of indicators assessed, the Railway station seems to satisfy slightly more the users when rating the overall satisfaction level
- This is explained by the fact that there are specific characteristics of the station and the relevant services provided, which strongly affect travelers' opinion and finally modal choice
- 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

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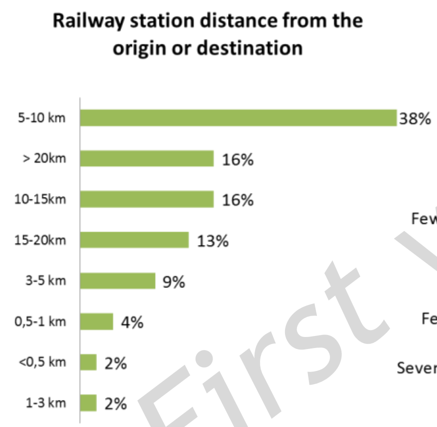
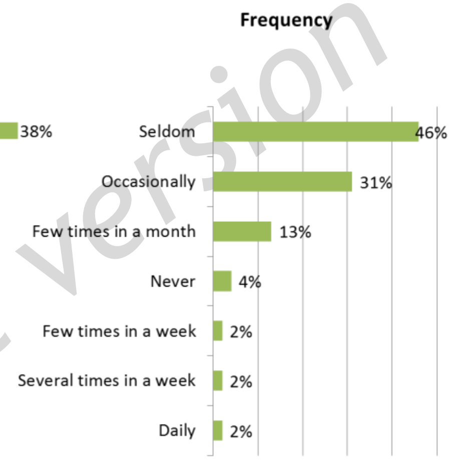
# Trip characteristics





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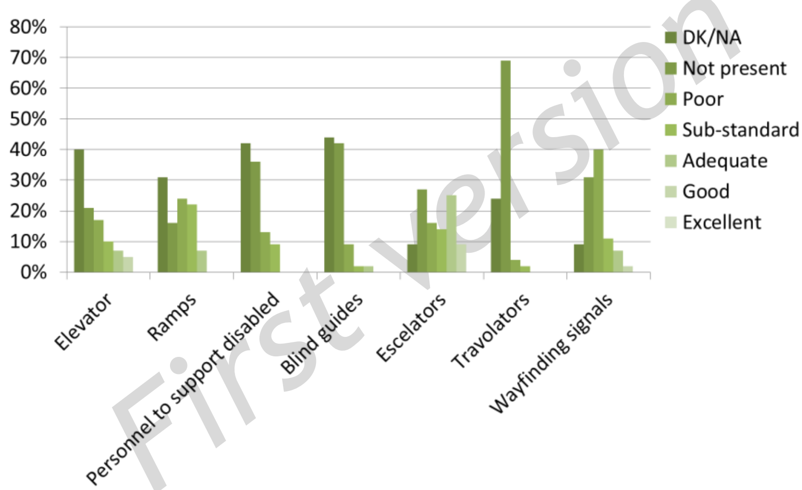
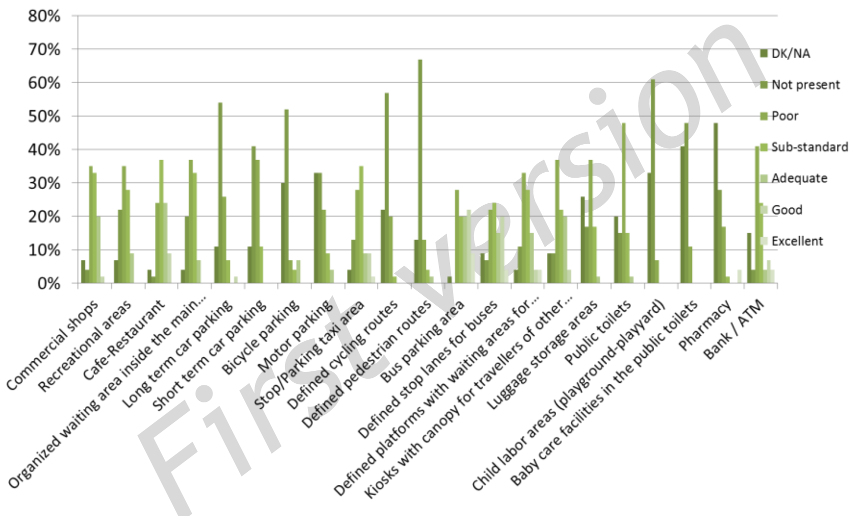
# Accessibility



## Interchange design

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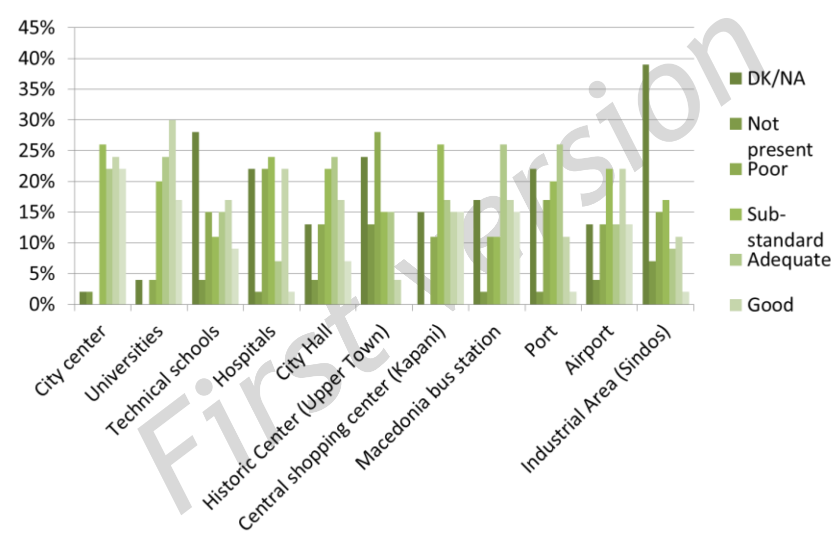
## Station connectivity

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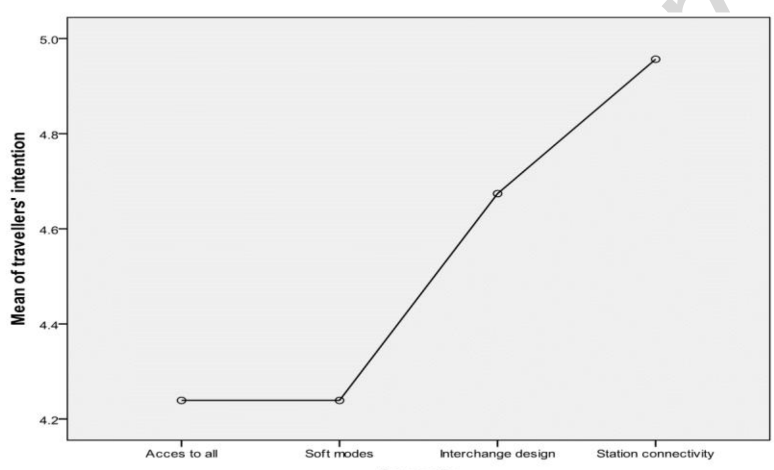
# Testing alternative scenarios

| 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 |

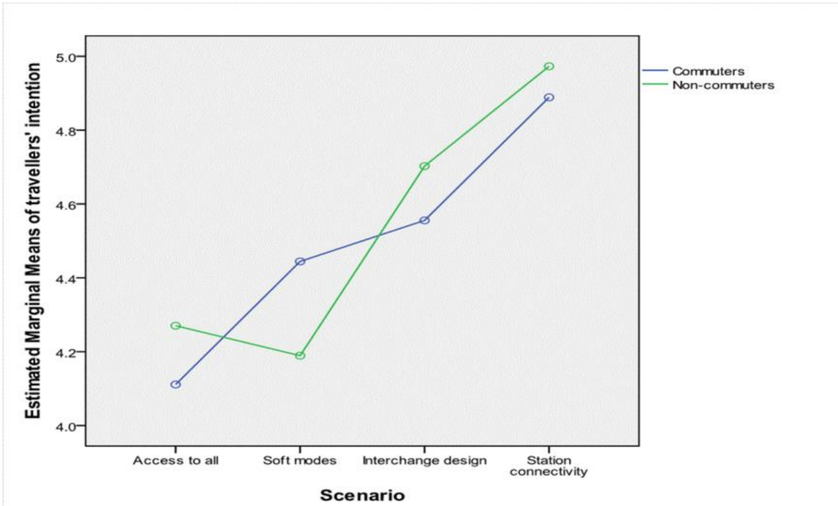




# Mean values of travelers' intention to increase their movements

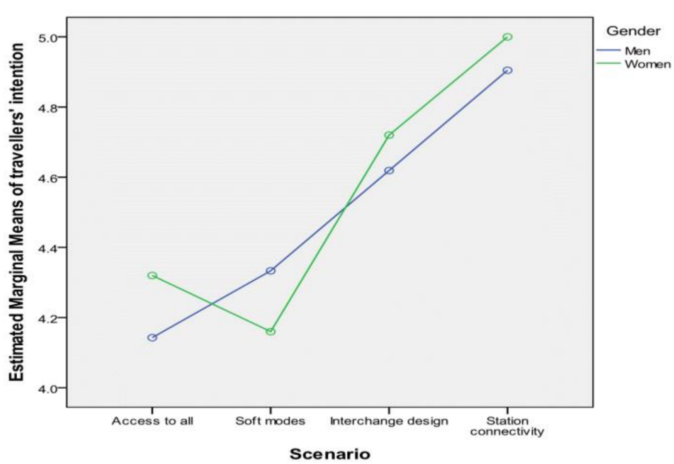


## Commuters versus non-commuters

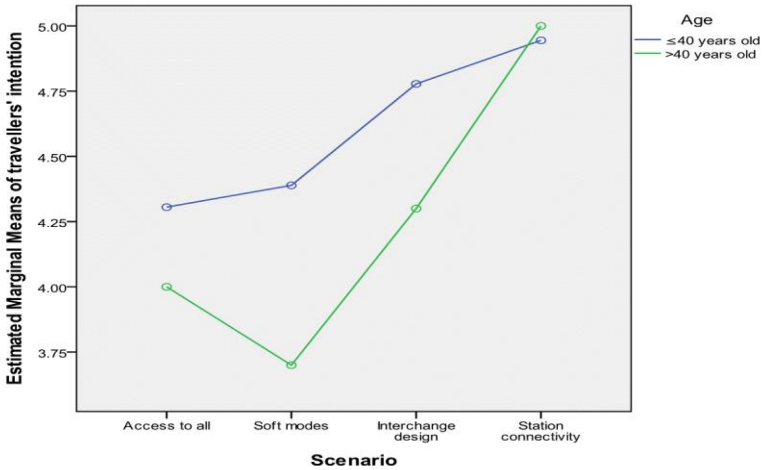





## Men versus women



# 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


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# Design of freight transport interchanges

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



## Content

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# Background



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# Background

- Freight transport interchanges are fully geographically determined areas, managed by one public and/or private body, and where all activities including transport, handling and distribution of cargo are operated by several enterprises, i.e. transport and logistics providers or users, established in the interchanges.

**Source (Gogas & Nathanail, 2014)**

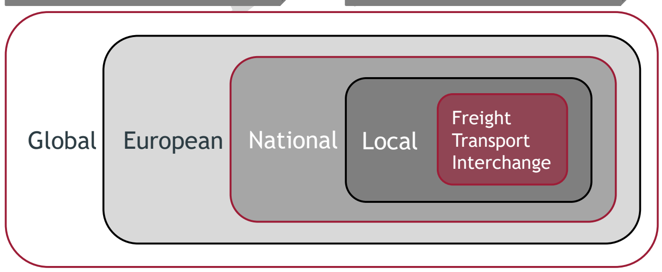
| Categories | City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|---|
| Transport modes | Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>Road-rail-sea/air |

# Background

## Elements of Freight Transport Interchanges

**Freight transport interchanges**

| Accessibility | Infrastructure |
|---|---|
| • Connection with other transport interchanges<br>• Connection with the regional transport system | • Cover the needs of handle and tranship of freight<br>• Provide material and technical equipment to serve current and future trends |






# European legal framework for industrial building

# 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 transhipment 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;*

**'multimodal transport':** *the carriage of passengers or freight, or both, using two or more modes of transport;*

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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 11**- Railway Transport Infrastructure/ **Article 11**- Infrastructure components

• Railway transport infrastructure shall comprise, in particular:
▶ freight terminals and logistic platforms for the transhipment 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.

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## alliance 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;





## alliance 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 transhipment of freight exceeds, for non-bulk cargo, 800 000 tonnes 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 point (a) in a NUTS 2 region, 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.





## 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 passenger transport: interconnection between rail, road, air and, as appropriate, inland waterway and maritime infrastructure of the comprehensive network;

▶ 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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# Categories of Freight Transport Interchanges

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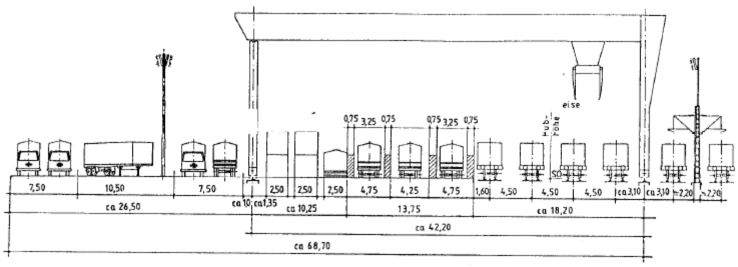
# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>Road-rail-sea/air |



Cargo Mover (Module Trains)
Vertical loading set up for intermodal transport



(Lechner, 2014)



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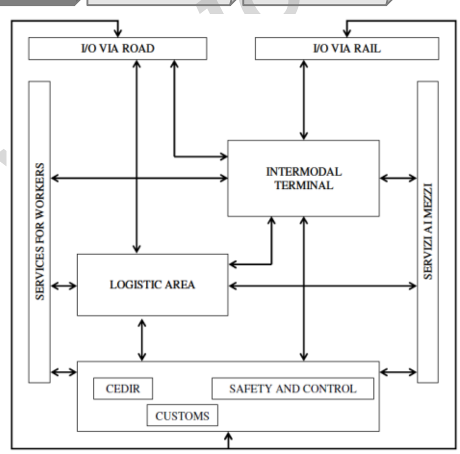
# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>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)

# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
| --- | --- | --- | --- |
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>Road-rail-sea/air |

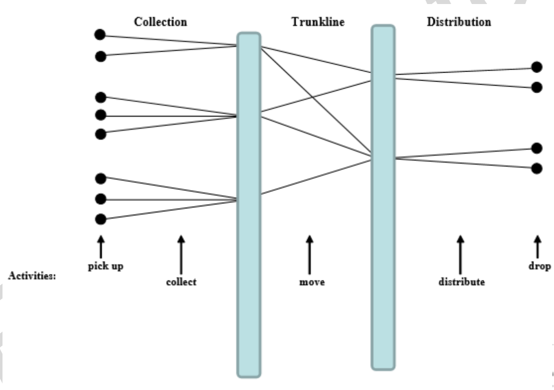
(SYSTEMA LTD, 2007)

Promachon freight village - Border between Greece and Bulgaria



# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
| --- | --- | --- | --- |
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>Road-rail-sea/air |




Intermodal capability for Logistics Parks (Visser et al., 2009)

# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>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
- City distribution centre
- Transhipment 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).

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# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>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 and so on

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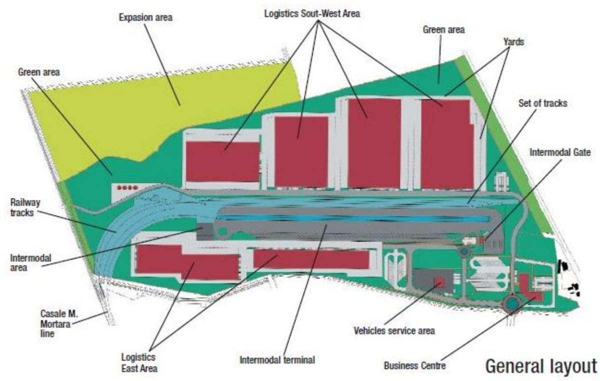
# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>Road-rail-sea/air |




General layout of a Logistic Park (Visser et al., 2009)



# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>Road-rail-sea/air |

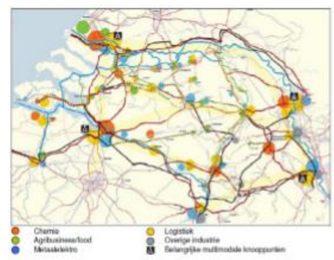
- Logistic Centers that operate in areas of other facilities related to freight.
- Apart from the basic services provided, these centers operate supportively, in cooperation with the freight interchange (port, airport, etc.) which are installed and 'belong' to.
  - Advantage: take advantage of the electromechanical equipment & logistics freight hubs
  - Disadvantage: often their services are determined based on the activities undertaken in the freight hubs

# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>Road-rail-sea/air |

Special Logistic Area: Road at seaports or inland ports

- Rotterdam seaport (NL)
  - ▶ Distripark Eemhaven specialised in high-quality products
  - ▶ Distripark Botlek specialised in chemicals
  - ▶ Distripark Maasvlakte focuses on containers
- Inland ports: Venlo and Borne



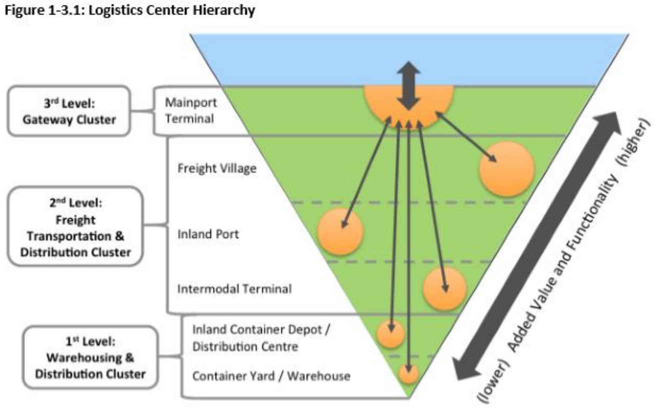




# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>Road-rail-sea/air |

**Figure 1-3.1: Logistics Center Hierarchy**




Source: MITL, 2011

(Source: Smith M., 2013)

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# Categories

| 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 |


(Source: Visser et al., 2009)

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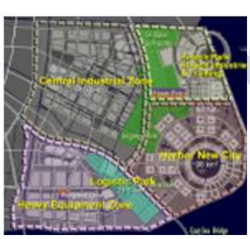
# Categories

| 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 |

Dalian International Logistic center



Shanghai Lingang Logistic center

(Source: Visser et al., 2009)

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# Categories

| City Terminal | Freight Village | Industrial & logistic park | Special logistic area |
|---|---|---|---|
| Road-road<br>Road-rail | Road-rail (barge) | Road-road<br>Road-rail | Road-sea/air<br>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 Shenzen airport

(Source: Visser et al., 2009)





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# Case studies

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# Port of Rotterdam

Satellite photo of port

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# Port of Rotterdam

Aerial photo of port

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# Port of Rotterdam

Container station of port




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# 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 and Hong Kong)
  - 10th 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

## Port of Rotterdam

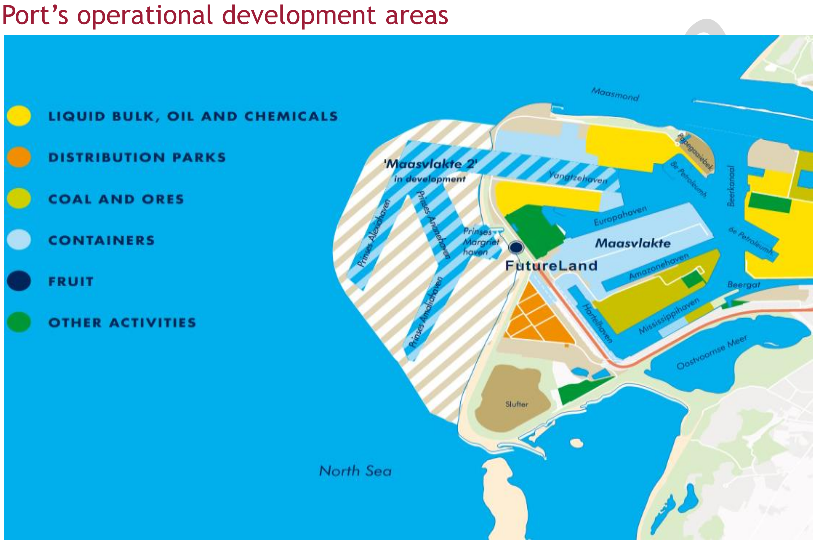
- Operational elements
  - 50 square kilometers for freight development activities (planned direct expansion of 20%)
  - Total length of the wider port area: 40 km
  - port agency jobs: 1200 (500 € annual turnover)
  - Total number of posts: 90000
  - Volume of goods and commodities (2010): 430 million. 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 €





## Port of Rotterdam

Port's operational development areas



## Port of Rotterdam

- Video (Loading at Port of Rotterdam)

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## Manchester Airport – World Freight Terminal


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# Manchester Airport –
## World Freight Terminal

Aerial photo of the terminal

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# 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



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# Manchester Airport – World Freight Terminal

Airplane loading

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# Manchester Airport – World Freight Terminal

- Video (Container air cargo loading)


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# Guidance to further knowledge acquisition



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# Suggested literature


- 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.
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# Smart Technologies for Efficient Logistics

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## Course Overview

This course will provide basic information on and experience with advanced information and communications technologies relevant to the shipping industry.

✓ It addresses basic ICT such as:

- Auto-ID technologies,
- Image processing,
- Image based localization, and
- 3D scanning systems.

✓ It provides an overview of typical applications.



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# Course Overview

The course is divided into three modules:

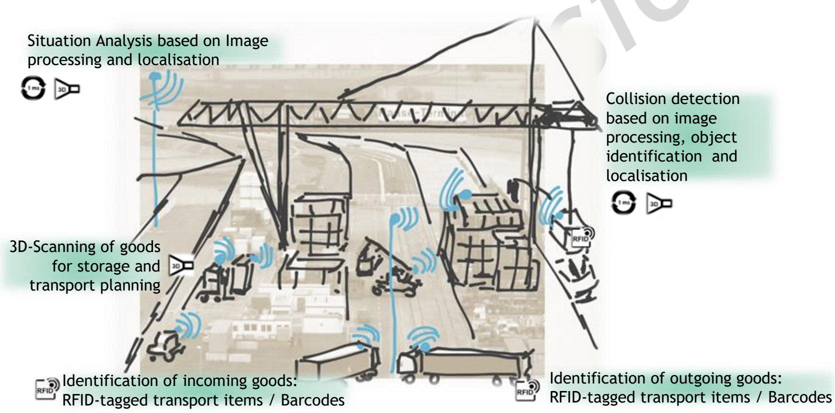
1. Lecture on ICT and typical applications
   – Auto-ID and IT infrastructure
   – Radio and image-based positioning
   – 3D scanning
   – Condition monitoring
2. Brief demonstration and hands-on training
   – RFID scanning
   – 3D scanning
3. Questions and Discussion





# Course Overview

The technologies discussed are relevant to the basic logistics processes in logistics operation – e.g.:



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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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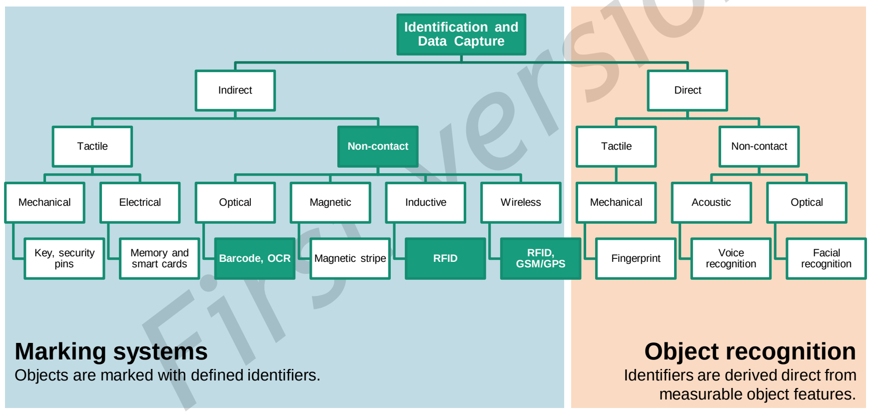
# AUTO-ID Basics

## Overview of Auto-ID Technologies





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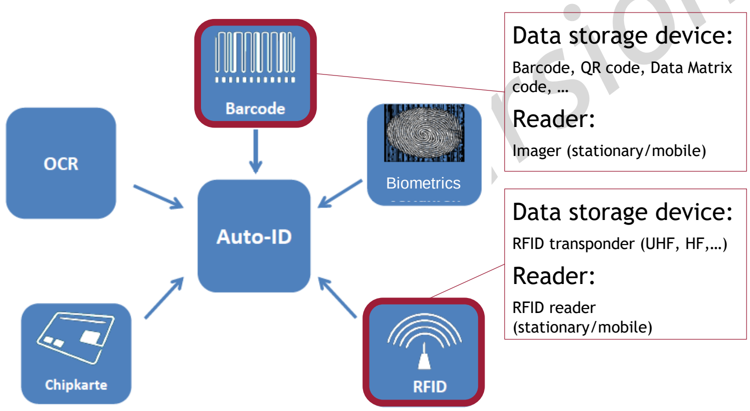
# AUTO-ID Basics

## Overview of Auto-ID Technologies



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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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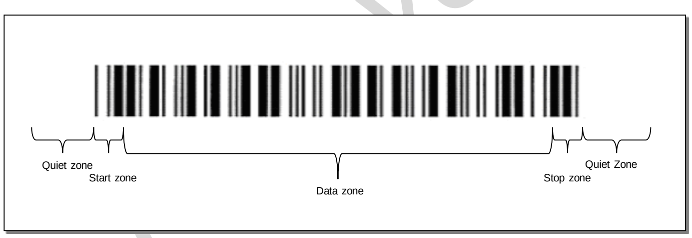
# AUTO-ID Basics

## 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




First version

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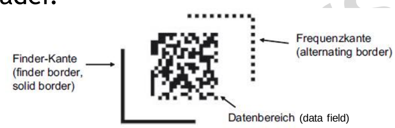
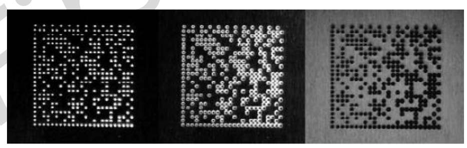
# AUTO-ID Basics

## 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

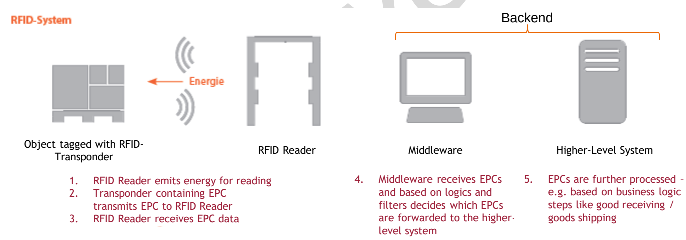
## RFID Overview

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





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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.

| *Merkmal* | *Barcode-Technologie* | | *RFID-Technologie* | |
|---|---|---|---|---|
| | *1D-Codes* | *2D-Codes* | *Aktiv* | *Passiv* |
| **Übertragung** | optisch | | elektromagnetisch | |
| **Datenkapazität** | sehr gering | gering | hoch | |
| **Sichtverbindung** | erforderlich | | nicht erforderlich | |
| **Form und Größe** | festgelegt | | individuell anpassbar | |
| **Einfluss von Richtung und Lage** | gering | sehr gering | sehr gering | |
| **Schädliche Umwelteinflüsse** | Schmutz, Feuchtigkeit, Hitze | | Metalle, Flüssigkeiten | |
| **Lesegeschwindigkeit** | gering | mittel | hoch | |
| **Datensicherheit** | sehr niedrig | niedrig | sehr hoch | |
| **Informationen** | statisch | | dynamisch | |
| **Kosten für Datenträger** | sehr gering | | sehr hoch | hoch |
| **Kosten für Lesegeräte** | hoch | | gering | |
| **Pulkerfassung** | nicht möglich | | möglich | |
| **Lesedistanz** | gering (wenige cm) | | sehr hoch (bis ~15m) | hoch (bis ~5m) |
| **Fälschbarkeit** | leicht | | schwierig | |
| **Verbreitung in der Industrie** | sehr hoch | mittel | gering | |

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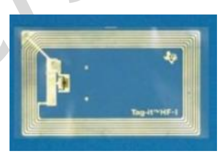
# AUTO-ID Basics

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

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>Energieversorgung</td><td colspan="2">Aktiv</td><td colspan="2">Semiaktiv/ -passiv</td><td colspan="2">Passiv</td></tr>
<tr><td>Frequenzbereich</td><td>LF<br>(kHz)</td><td colspan="2">HF<br>(MHz)</td><td colspan="2">UHF<br>(MHz)</td><td>SHF/MW<br>(GHz)</td></tr>
<tr><td>Reichweite</td><td colspan="2">Close-Coupling</td><td colspan="2">Remote-Coupling</td><td colspan="2">Long-Range</td></tr>
<tr><td>Datenhaltung</td><td colspan="3">Data-on-Tag</td><td colspan="3">Data-on-Network</td></tr>
<tr><td>Speicherkapazität</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 |

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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



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## 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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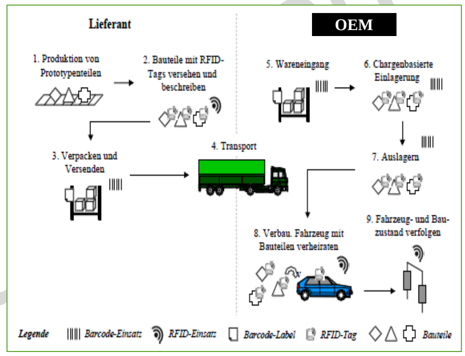
## AUTO-ID Basics

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.**





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## 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

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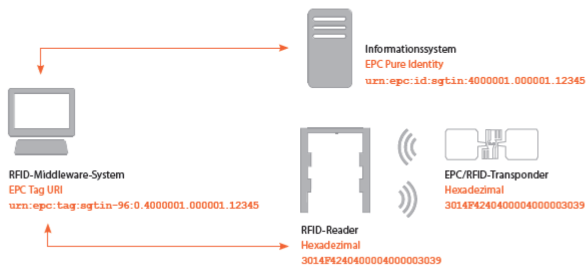
# AUTO-ID Basics

## 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 process 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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# 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 UIIDs
  - 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)<br>• Serialized Global Trade Item Number (SGTIN) | • Serial Shipping Container Code (SSCC)<br>• Global Shipping Identification Number (GSIN)<br>• Global Identification Number for Consignment (GINC) | • Global Location Number (GLN)<br>• Serialized Global Location Number (SGLN) | • Global Individual Asset Identifier (GIAI)<br>• Global Returnable Asset Identifier (GRAI) | • Global Service Relation Number (GSRN)<br>• Global Document Type Identifier (GDTI)<br>• Global Coupon Number (GCN) |

**CAPTURE**
GS1 Automatic Identification and Data Capture Standards

GS1 Barcodes: EAN/UPC, GS1-128, IFT-14, GS1 DataBar, GS1 DataMatrix, GS1 QR code, GS1 composite barcode

EPC/RFID: Passive EPC HF, Passive EPC UHF

**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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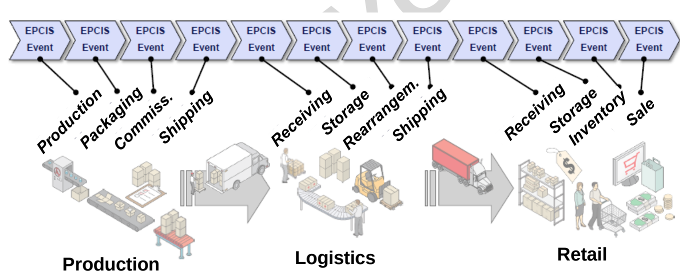
# AUTO-ID Basics

## 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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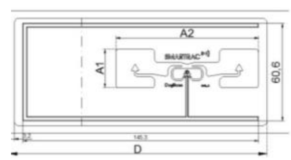
# AUTO-ID Basics
## Outlook

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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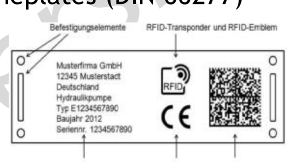
# AUTO-ID Basics
## Outlook

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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# Image Processing





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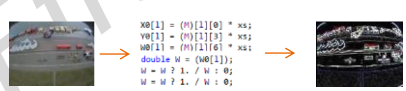
## Image Processing

Introduction

Image processing is the generation, transmission and analysis of images in order to extract information on concrete objects.

Generation Transmission Analysis

Image processing is the processing of images.



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# Image Processing

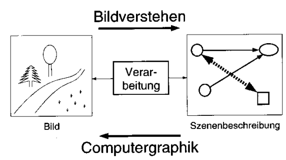
## Introduction



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.

Image editing/photo manipulation



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# Image Processing

## Imaging



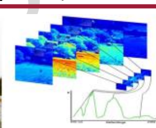
Illustrative: An image is the outcome of optical imaging (photo).


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).

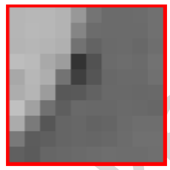
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 181 | 183 | 183 | 179 | 152 | 116 | 107 | 107 | 108 | 112 |
| 181 | 184 | 183 | 179 | 133 | 108 | 107 | 107 | 107 | 112 |
| 180 | 182 | 180 | 176 | 114 | 099 | 106 | 107 | 104 | 110 |
| 189 | 186 | 169 | 157 | 051 | 082 | 107 | 109 | 107 | 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

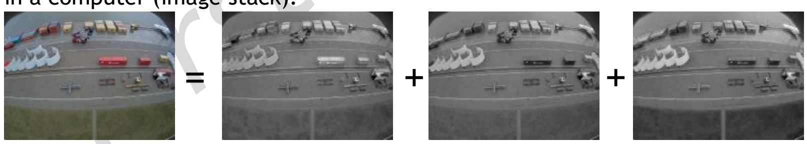
## Image Channels

- 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).





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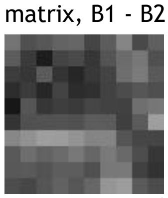
# Image Processing

## 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 |

$B_1 - B_2$

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 |
| 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 |
| 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 |
| 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 |
| 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 |
| 000 | 000 | 001 | 000 | 000 | 000 | 000 | 000 | 000 | 000 |
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| 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 |
| 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 |

→ Differential imaging detects objects’ movements.

## 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

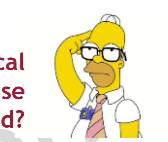

Obstructions





## Image Processing
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


First version

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# Image-Based Localization





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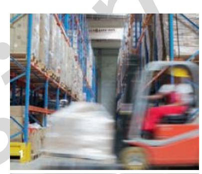
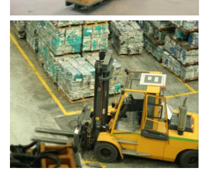
## Image-Bases Localization

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-Bases Localization

## Introduction

| Camera on vehicle | Camera to vehicle |
|---|---|
| **Advantages**<br>– Cost efficient if only a few vehicles are located in a particular area<br>– Only a small amount of data has to be sent through the network | **Advantages**<br>– No electronic devices on vehicles<br>– Cost efficient if many vehicles are located in a particular area<br>– Combinable with other image processing systems (documentation, visualization, object detection) |
| **Disadvantages**<br>– Electronic devices on vehicle<br>– Not combinable with other image processing systems (documentation, visualization, object detection) | **Disadvantages**<br>– Not cost efficient if only a few vehicles are located in a particular area<br>– 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-Bases Localization

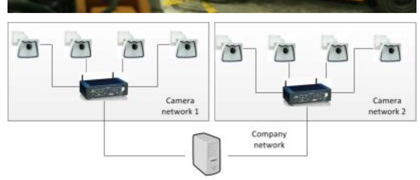
## System Overview

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-Bases 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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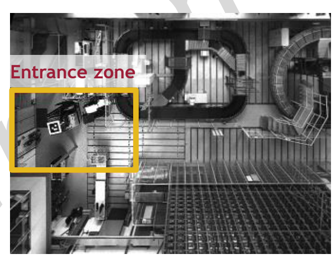
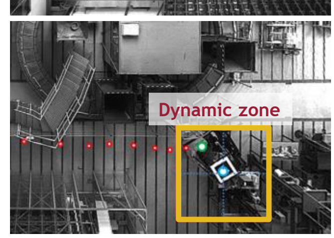
# Image-Bases Localization

## Marker Recognition

- Marker recognition entails searching top-view images generated by GPC 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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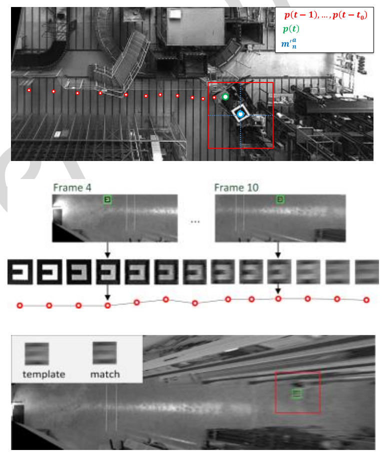
# Image-Bases Localization

## 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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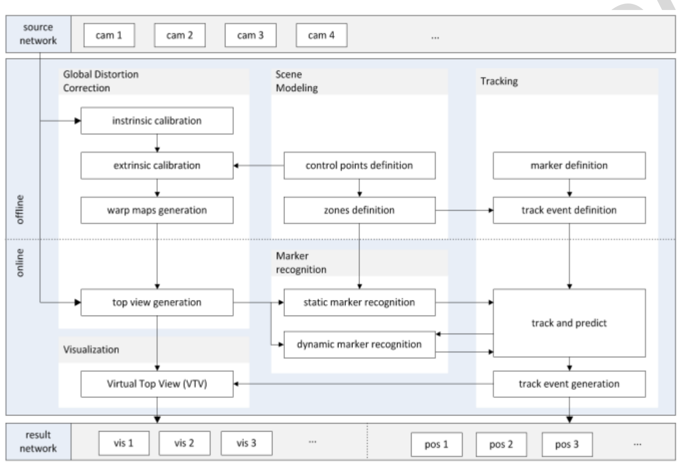
# Image-Bases Localization

## Implemented System



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# 3D Scanning



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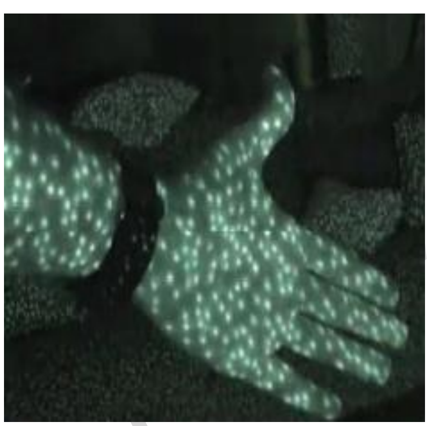
## 3D Scanning

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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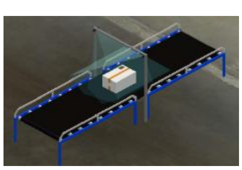
# 3D Scanning

## Use Cases in Logistics

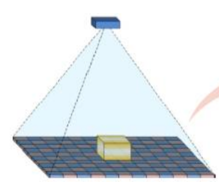
Interesting Uses in Logistics from the Transformation of Consumer Technology (e.g. Kinect Sensor)

**Volume recognition for single parcels/pallets**



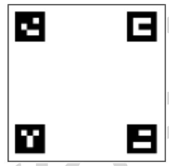
**Load volume detection**

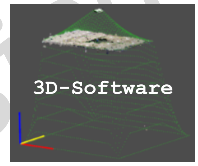

**Automated inventory**



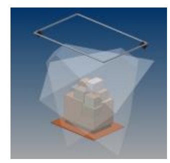
## 3D Scanning
Pallet Dimensioning

- 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



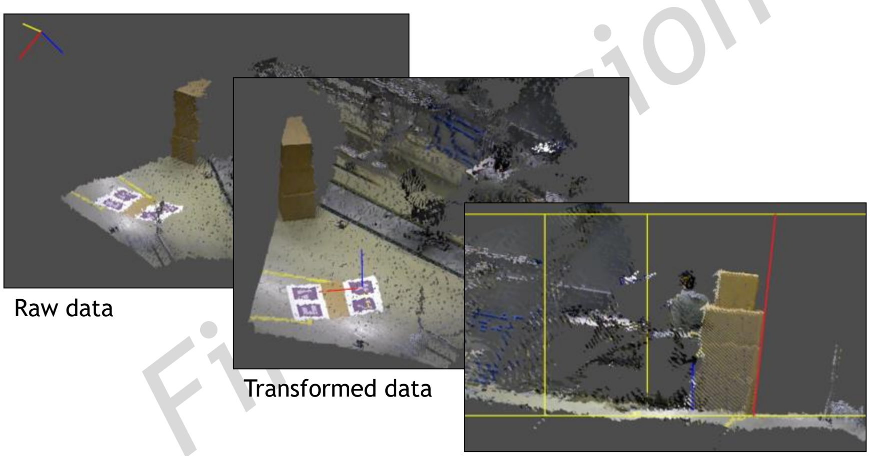








## 3D Scanning
Pallet Dimensioning



Raw data

Transformed data

Errors

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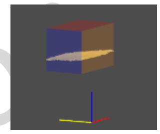
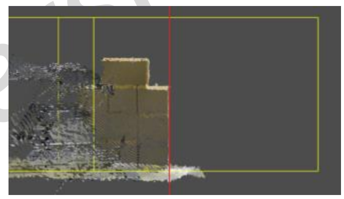
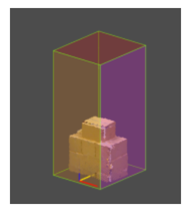
# 3D Scanning

## 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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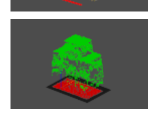
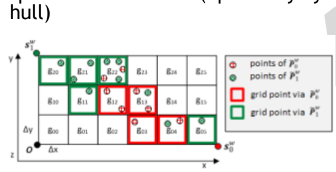
# 3D Scanning

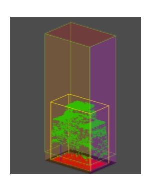
## Pallet Dimensioning

- 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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# Decision making methodologies

University of Thessaly, Greece



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## Content

1. Background
2. Multi-stakeholder Multi-criteria analysis
3. Weighing
4. Normalization
5. Cost benefit analysis
6. Adaptability and transferability analysis
7. Risk analysis
8. Example
9. Suggested literature

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# Background

3



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## Evaluation

- **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"

*[Nijkamp et al., 1990]*

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# Why do we evaluate?

- Decision Making
- Design
- Measuring Performance
- Monitoring



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# Why do we evaluate?

**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

Are we forgetting something?



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# Usual types of comparing

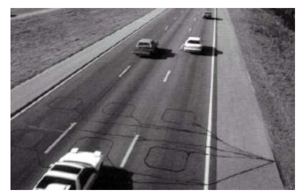
- ***Ex-post evaluation*** - how well project goals and objectives are being achieved after implementation.
- ***Ex-ante evaluation*** - how goals/objectives/plan are expected to be achieved when being implemented. It employs:
  - expert findings and knowledge (a qualitative assessment)
  - comparison with similar projects in other countries or cities (best practice);
  - modelling: the proposed solution is investigated by the microscopic or macroscopic simulation models.

# Impact assessment

## Impacts assessment for:

- Design and Evaluation (ex-ante)
  Inputs from Models/Simulation

- Monitoring (ex-post)
  Inputs from direct measures and Models/Simulation





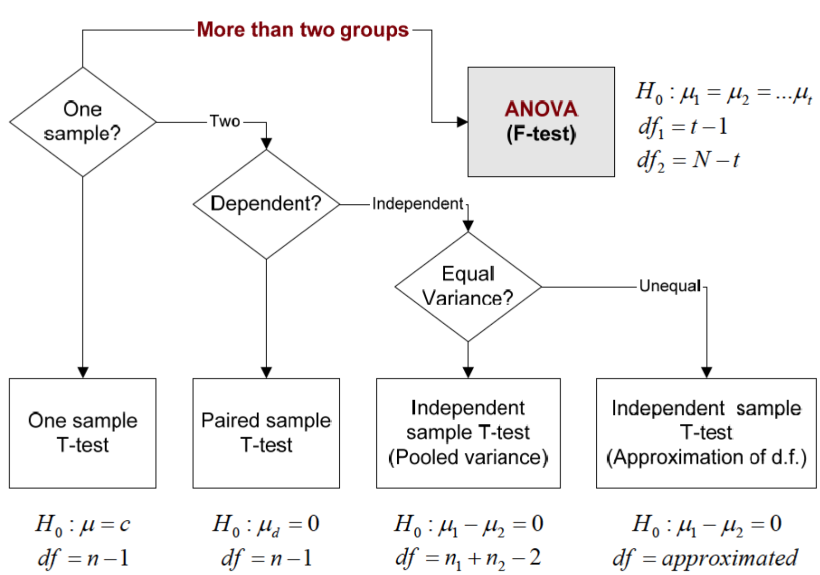
# Before – after studies

- **Traffic performance changes** owing to measure implementation
  1. measurements, which observe the change in the number of vehicle on a line or set of lines (cause of change not certain)
  2. surveys, where vehicle operators are asked to provide their opinions as regards the quality of service, and how it has affected their choices
  3. historical data (usually treated as meta-data)

# Inferential statistics

- Looking at two variables at a time to test hypotheses or to examine the strength of association (Logan, 2006)
- *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**





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# Multicriteria multistakeholder decision making





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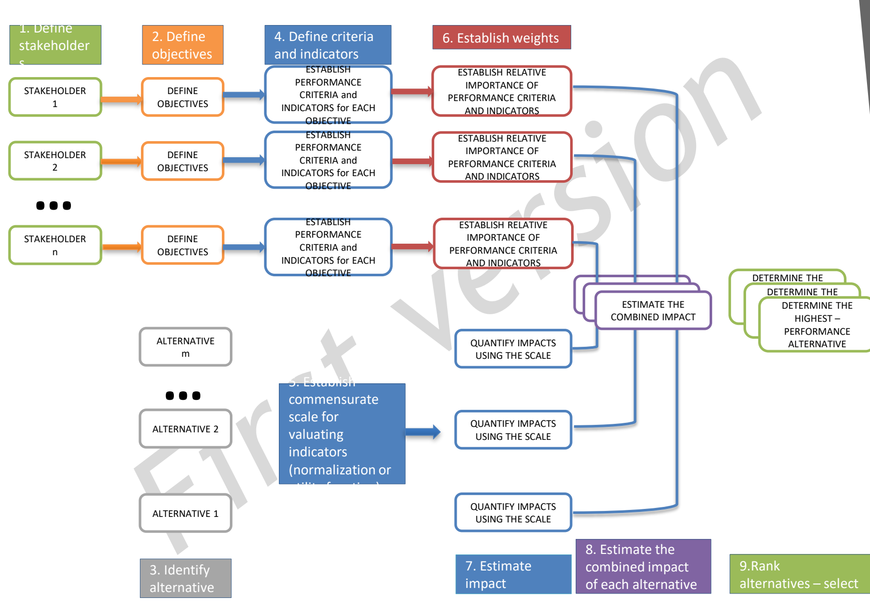

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# Multicriteria Decision Making Methodologies

- Analytic Hierarchy Process (AHP),
- Multi-Attribute Utility Theory (MAUT),
- Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE)
- ELimination Et Choix Traduisant la REalite (ELECTRE)
- Dominance-based Rough Set Approach (DRSA)
- Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)
- Simple Multi Attribute Rated Technique (SMART)
- Weighted Sum model (WSM)
- Weighted Product model (WPM)





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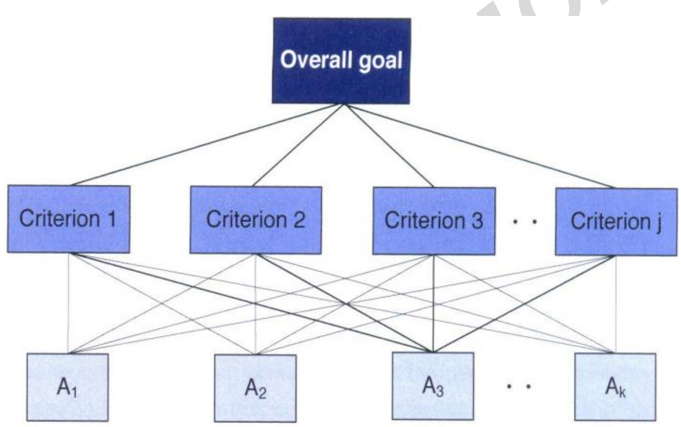
# Analytical Hierarchy Process (AHP) (Saaty, 1995)



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# AHP steps

- Define criteria
- Define indicators for each criterion
- Attribute comparative importance in pairs
- Select alternatives
- Estimate impacts = quantify measures
- Compare alternatives performance for each criterion



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# Measures of Performance (MoP) - Criteria

| | Criterion 1 | Criterion 2 | Criterion 3 | ... | Criterion m |
|---|---|---|---|---|---|
| Measure 1 | | | | | |
| Measure 2 | | | | | |
| Measure 3 | | | | | |
| | | | | | |
| | | | | | |
| Measure n | | | | | |

## Measures of Performance (MoP) - Criteria

| 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.p |

## Qualitative - Quantitative

| | Indicator 2.2 (rating) | Indicator 3.1 (qualitative) | 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 (qualitative) | 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 |
| … | | | | |

Difference = 6

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## Combination and Decision

Elimination criteria

- *Dominance analysis*
- *Conjunctive method*
- *Disjunctive method*
- *Mathematical Programming*

Ranking criteria

- *MaxMin and MaxMax*
- *Combined mathematical functions of Value, Utility, or Cost-Effectiveness (Weighed Sum, Weighed Product, Impact Index)*
- *Topsis, ELECTRE, AHP*

# 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

- 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

| 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 | $\frac{n(n-1)}{2}$ |

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# Comparison matrix

| | 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.

$$a_{ij} = \frac{1}{a_{ji}}$$



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Comparison matrix

| | A | B | C |
|---|---|---|---|
| A | 1 | 1/3 | 5 |
| B | 3 | 1 | 7 |
| C | 1/5 | 1/7 | 1 |

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## Priority vector

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 |



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## Priority vector

| | 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

| | 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**

$$\lambda_{\max} = \frac{21}{5}(0.2828) + \frac{31}{21}(0.6434) + 13(0.0738) = 3.0967$$

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# 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: $\lambda_{max} = n$

$$CI = \frac{\lambda_{max} - n}{n - 1} = \frac{3.0967 - 3}{2} = 0.0484$$



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# CI Comparison

- 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 |

## CI Comparison

- 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)

$$CR = \frac{CI}{RI} = \frac{0.0484}{0.58} = 8.3\% < 10\%$$

## 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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# MAUT concepts



rigorously measure value vj

- identify what is important (hierarchy)
- identify RELATIVE importance (weights wk)
- identify how well each alternative does on each criterion (score $s_{jk}$)
- can be linear $v_j = \Sigma\, w_k\, s_{jk}$
- or nonlinear $v_j = \{\prod(1+Kk_j s_{jk}) - 1\}/K$

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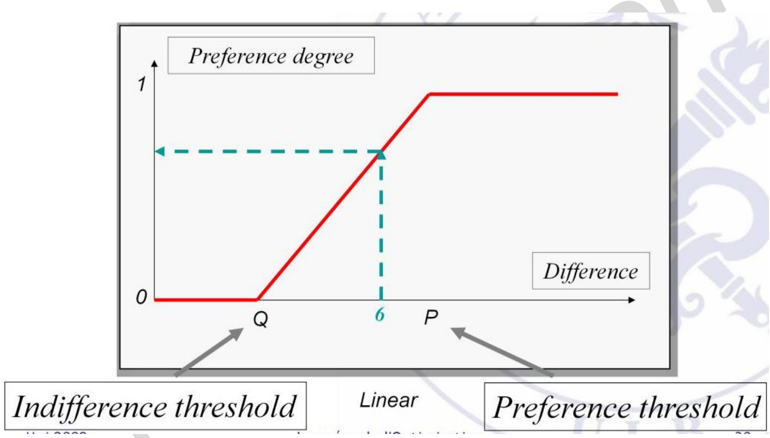
# Preference function



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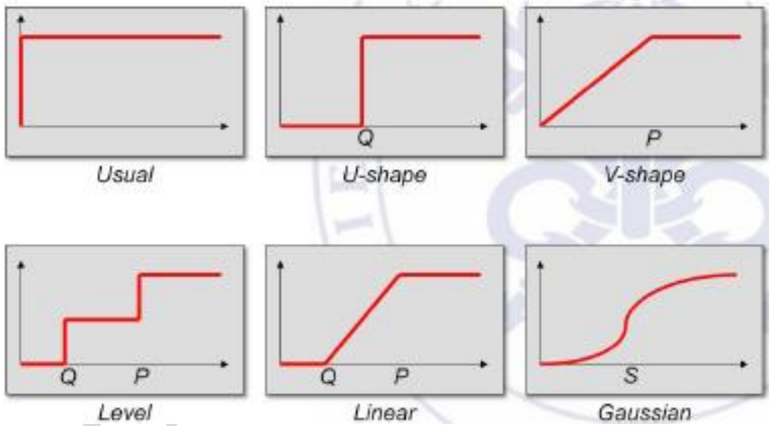
## More preference functions

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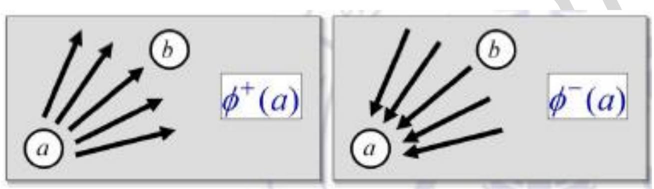
## Preference flows




- Leaving flow: (strength) $\phi^{+}(a) = \frac{1}{n-1}\sum_{b \in A} \pi(a,b)$
- Entering flow: (weakness) $\phi^{-}(a) = \frac{1}{n-1}\sum_{b \in A} \pi(b,a)$
- Net flow: $\phi(a) = \phi^{+}(a) - \phi^{-}(a)$

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# 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.

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# Normalization techniques (1/3)

- Normalization by comparison with the best alternative

$$\bar{r}_{ij} = \frac{I_{ij}}{max_j I_{ij}}$$

- Classic normalization

$$\bar{r}_{ij} = \frac{I_{ij}}{\sum_{j=1}^{m} I_{ij}}$$





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# 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

$$\bar{r}_{ij} = exp^{-z^2/2}, \text{where } z = \frac{(I_{ij} - I_i^0)}{\sigma_i}$$

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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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# Cost benefit analysis and social cost benefit

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## Net Present Value

$$= B_0 - C_0 + \frac{B_1 - C_1}{(1+r)} + \frac{B_2 - C_2}{(1+r)^2} + \ldots + \frac{B_t - C_t}{(1+r)^t} + \ldots + \frac{B_n - C_n}{(1+r)^n}$$

$$= \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)^t}$$

where:
Bt = benefits in year t
Ct = costs in year t
r = interest rate
n = target year



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## Internal Rate of Return (IRR)

$$B_0 - C_0 + \frac{B_1 - C_1}{(1+IRR)} + \frac{B_2 - C_2}{(1+IRR)^2} + \ldots + \frac{B_t - C_t}{(1+IRR)^t} + \ldots + \frac{B_n - C_n}{(1+IRR)^n} = 0$$

where:
Bt = benefits in year t
Ct = costs in year t
IRR = interest rate that sets equation to zero
n = target year

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# Cost-Benefit Ratio

$\Sigma(B_i/(1+r)^i)/\Sigma\ (C_i/(1+r)^i)$, for i = 0 to n

where:
Bt = benefits in year t
Ct = costs in year t
r = interest rate
n = target year

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# SCBA indicators (1/3)

<table>
<tr><th>Indicator</th><th>Measurement</th></tr>
<tr><td rowspan="2">External air pollution cost</td><td>$$B_{AC} = \sum_{i,j=1}^{m,n} CAP_{ij} \cdot \left(N_{ij} - N'_{ij}\right) \cdot DAVE$$<br>where:<br>$CAP_{ij}$ – air pollution costs generated by vehicle $i$ and Euro norm $j$<br>$m$ – number of analyzed types of vehicles, m = 16 for LDV petrol, LDV diesel, rigid HGV (8 load categories), articulated HGV (6 load categories)<br>$n$ – number of analyzed Euro norm, n = 7 for Euro 0 - Euro 6<br>$N_{ij}$ – numer of vehicles of type $i$ and Euro norm $j$ before introduction the measurement<br>$N'_{ij}$ – estimated numer of vehicles of type $i$ and Euro norm $j$ after introduction the measurement<br>$DAVE$ – vehicle's average distance in analysed area before introduction the measurement</td></tr>
<tr><td>$$B_{AC} = CAPAVE \cdot (VKM - VKM')$$<br>$$CAPAVE = \frac{\sum_{i,j=1}^{m,n} CAP_{ij} \cdot N_{ij}}{N}$$<br>$$VKM = N \cdot DAVE$$<br>$$VKM' = N' \cdot DAVE'$$<br>where:<br>$CAPAVE$ – average air pollution costs generated by vehicles in analysed area (euroct/vkm)<br>$VKM$ – total vehiclekilometers in analysed area before introduction the measurement<br>$VKM'$ – total vehiclekilometers in analysed area after introduction the measurement<br>$N$ – number of vehicles in analyzed area before introduction the measurement<br>$N'$ – estimated number of vehicles in analyzed area after introduction the measurement<br>$DAVE'$ – estimated vehicle's average distance in analysed area after introduction the measurement<br>$DAVE$ – as above</td></tr>
</table>

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# SCBA indicators (2/3)

| Indicator | Measurement |
|---|---|
| Congestion costs | $$B_{CON} = \sum_{k=1}^{2} CON_{ijk} \cdot (VKM_k - VKM'_k)$$<br>where:<br>$CON_{ijk}$ – 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)<br>*k* – number truck types, k=2 for rigid truck and articulated truck<br>$VKM_k$- vehiclekilometers of truck *k* before introduction of the measurement<br>$VKM'_k$- vehiclekilometers of truck *k* after introduction of the measurement |
| | $$B_{CON} = \sum_{k=1}^{2} (CON_{ijk} - CON_{ij'k}) \cdot VKM_k$$<br>where:<br>*j* – type of congestion before introduction of the measurement (over capacity or near capacity)<br>*j'* – type of congestion after introduction of the measurement (free flow) |

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# SCBA indicators (3/3)

| Indicator | Measurement |
|---|---|
| Marginal external noise costs | $$B_N = \sum_{ijk=1}^{mno} CN_{ijk} \cdot \frac{VKM_{ijk} - VKM'_{ijk}}{1000}$$<br>$CN_{ijk}$ –noise costs of truck *i* (i=2 for LDV and HGV) in the time of the day *j* and traffic type *k*.<br>$VKM_{ijk}$ – vehiclekilometers of truck *i* travelled in the time of the day *j* and traffic type *k* before introduction of the measurement.<br>*m* – number of truck types *m*=2 for LDV and HGV<br>*n* –time of the day (n=2 for day and night)<br>*o* – number of traffic types, k=2 for dense and thin traffic<br>$VKM_{ijk}$ – vegiclekilometers of truck *i* travelled in the time of the day *j* and traffic type *k* before introduction of the measurement. |
| | $$B_N = \sum_{i=1}^{m} \cdot (CN_{DDi} - CN_{NTi}) \cdot \frac{N_i \cdot DAVE}{1000}$$<br>where:<br>*m* – number of truck types *m*=2 for LDV and HGV<br>$CN_{DDi}$ – noise cost of truck type *i* in day time and in dense traffic<br>$CN_{NTi}$ – noise cost of truck type *i* in night time and in thin traffic<br>$N_i$ – numer of vehicles of type *i*<br>$DAVE$ – vehicle's average distance in analysed area before introduction the measurement |

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# Adaptability and transferability

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## Adaptability and transferability

- Identification of factors defining the approach for the UFT measures implementation process.
- Preparation of assumptions for the goal identification in UFT implementation.
- Preparation of the assumptions for proper selection of measures to be adapted.
- Establishing the requirements for utilization of adaptability index for the evaluation of implementation of good practices

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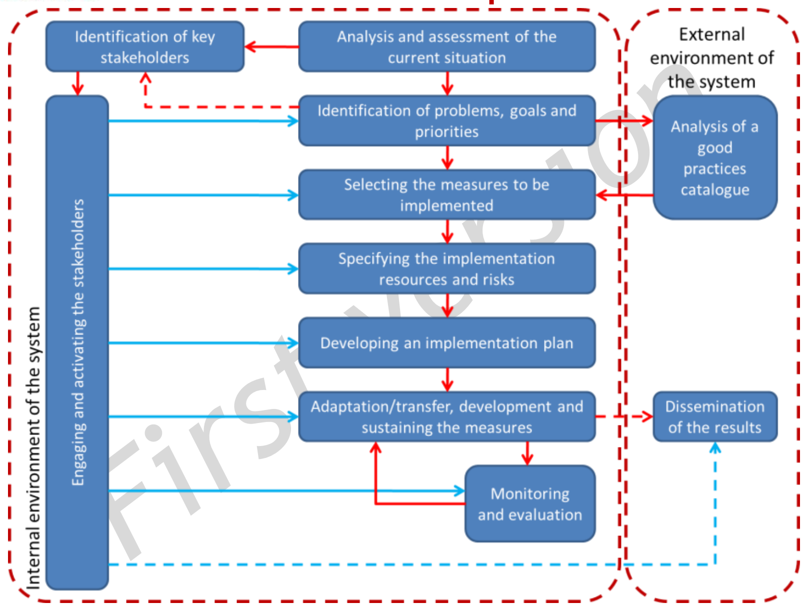
# General concept




General concept for adaptative approach for measures implementation



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# Adaptability and transferability (1/7)

- Analysis of qualitative indicators;
- Analysis of quantitative indicators;
- Creating a radar adaptability diagram showing the quality of the implementation process which is underway, taking into account the maximum and current indicators of fulfilling the qualitative and quantitative indicators;
- Calculating the Adaptability Indicator, which is a percentage specifying the level to which the current indicator of fulfilling the qualitative and quantitative indicators covers the maximum indicator of fulfilling the qualitative and quantitative indicators.

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# Adaptability and transferability (2/7)

- The proposed method is based on a **series of questions asked to stakeholders**, followed by determining a parameter named an **Adaptability Index**.
- The questions have been divided into two groups:
  - corresponding to the **external factors**,
  - corresponding to the **internal factors**.
- The questions should be prepared based on pre-determined qualitative indicators.
- The questions are asked **separately for each** of the assessed good practices.



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# Adaptability and transferability (3/7)

The example of questions' set for CAI analysis

| No | Question | E/I |
|---|---|---|
| 1. | What are the current political and public pressures for taking measures to implement a given solution? | E |
| 2. | What is the current research level for the purposes of a given solution? | I |
| 3. | How realistically was the implementation process planned? | I |
| 4. | What is the engagement of the individual stakeholders in the current implementation phase? | E |
| 5. | Were the benefits for the major stakeholders, resulting from the potential solution implementation, correctly specified? | I |
| 6. | What is the cross-party engagement of politicians in the implementation activities? | E |
| 7. | Was the integration with the key internal/external schedules of the stakeholders taken into account? | E |
| 8. | Were the duties and competencies adequately assigned within a given solution? | I |

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# Adaptability and transferability (4/7)

The example of questions' set for CAI analysis

| No | Question | E/I |
|---|---|---|
| 9. | What is the level of the currently presented, first outcomes and successes obtained for a given solution? | I |
| 10. | To what extent is transparent and regular communication between the stakeholders ensured? | I |
| 11. | Are the stakeholders willing to learn and exchange knowledge? | E |
| 12. | As a stakeholder, to what extent do you feel jointly responsible for the outcomes of the project and do you identify with it? | E |
| 13. | How tangible and visible are the potential outcomes of the project and how perceptible is its impact? | I |
| 14. | How do you assess the current possibilities of financing the solution implementation and its further functioning? | I |
| 15. | What is the current level of legislative support for a given solution? | E |

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# Adaptability and transferability (5/7)

Summing up the results of all the responses (for one measure)

| Measure / Questions | Weight ($W_m$) | Result () | Grade ($O_m$) |
|---|---|---|---|
| Question 1 | | | |
| Question 2 | | | |
| … | | | |
| Question M | | | |
| $FI_{max}$ | | | |
| FI | | | |
| AI (%) | | | |

$W_m$ - the weight for the *m-th* question regarding the measure

$\overline{x_m}$ – the arithmetic mean of the obtained stakeholders' responses to the *m-th* question regarding the measure

$O_m$ - the weighted arithmetic mean of the obtained responses to the *m-th* question regarding the measure

$$O_m = \overline{x_m} * W_m\ ,\ \ m \in \{1, \dots, M\}$$

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# Adaptability and transferability (6/7)

Summing up the results of all the responses (for measures' set)

- The weights are calculated for individual questions in relation to the each measure and being numbers from the range ⟨0,1⟩:

$$W_{m,n} \approx \sqrt{\left(r_{m,n} QR_m\right)^2 + \left(r_{m,n} MR_n\right)^2} * 10\,, \begin{matrix} m \in \{1, \dots, M\} \\ n \in \{1, \dots, N\} \end{matrix}$$

- where:
  - 10 is the scale factor (experimentally established)

…



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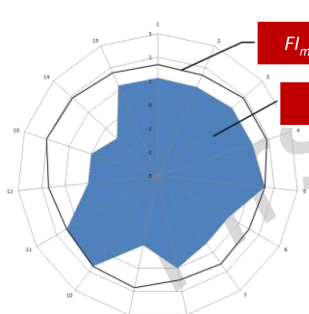
# Adaptability and transferability (7/7)

An adaptability diagram - web analyzer

In the geometrical interpretation, the level of fulfilling the qualitative and quantitative indicators is the **area being the surface area of the polygon shown on the radar diagram** where the **number of axes corresponds to the number of indicators**.



$FI_{max}$ – maximum fulfilling the qualitative and quantitative indicators

$FI$ – current fulfilling the qualitative and quantitative indicators

The steps mentioned at previous slides are realized separately for both quantitative and qualitative indicators (according to the tables in the toolbox).

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# Risk analysis

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## Risk analysis (1/5)

- **Functionality 1**: Identification of risks in UFT measures implementation (analysis of potential risks in UFT measures implementation, classification of risks both external and internal).
- **Functionality 2**: Preparation of the assumptions and requirements for the risks assessment (establishment of tool sets for risks assessment - quantitative analysis, preparation of qualitative indicators, such as probability, consequences, susceptibility/sensitivity and early detection indicators).
- **Functionality 3**: Identification of the corrective actions - 4 general strategies, which will make possible to:
  - prevent change project plan in order to eliminate risks or impact.
  - mitigate: change project for reduction of risk probability or impact.
  - transfer the ownership of a risk to a third party for a certain price.
  - tolerate: the risk cannot be avoided, treated or transferred.

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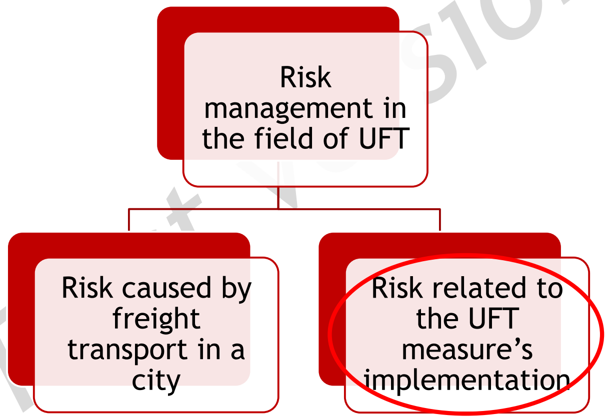
# Risk analysis (2/5)

## Risk management in the field of UFT



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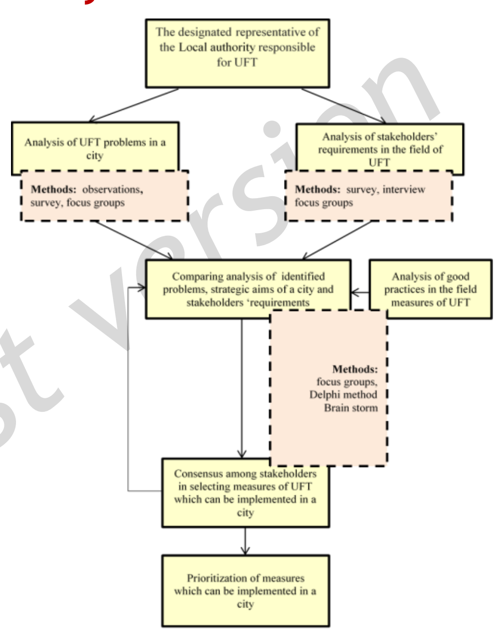
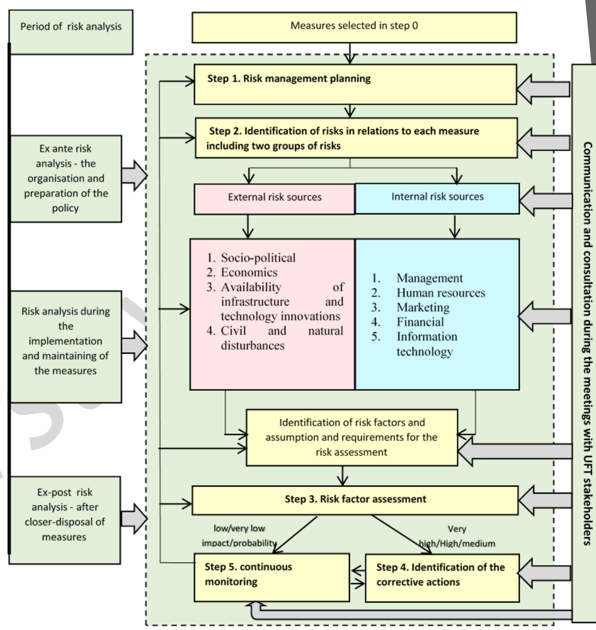
# Risk analysis (3/5)

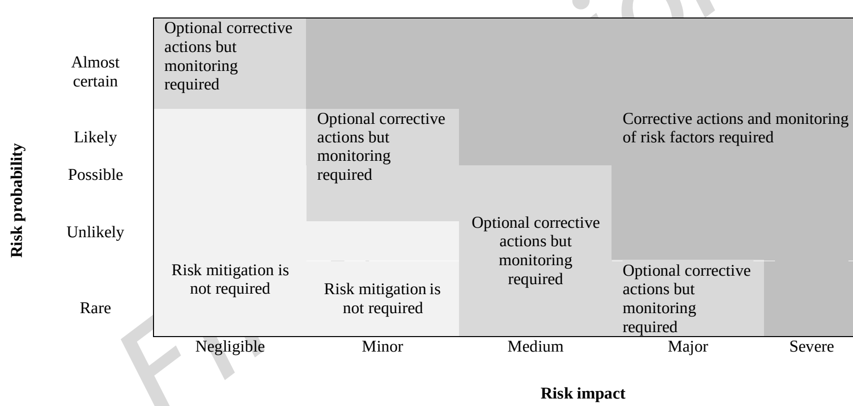


# Risk analysis (4/5)




# Risk analysis (5/5)

## Risk matrix



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# Example

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# City logistics

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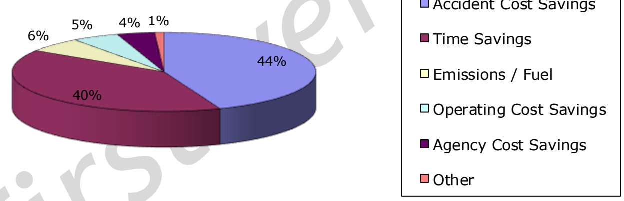
# Estimating impacts



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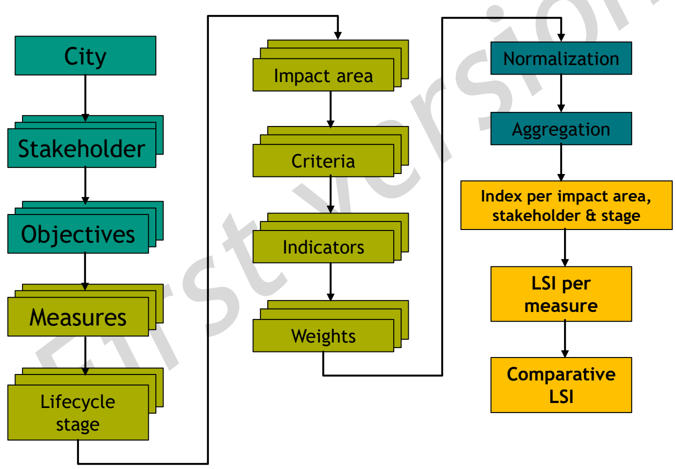
# The sequence of actions



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# Cities

- Athens
- Turin
- Graz
- Rome
- Barcelona
- Mechelen
- Emilia Romagna Region
- Gothenburg
- Venice
- Copenhagen
- Pisa
- London borough of Barking



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# Stakeholders

- Stakeholders → 3 groups → 10 subgroups
- Stakeholder match → Stages, Impact areas, Criteria, Indicators

| 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 |

## Objectives

- Objectives → City based
- For example: Athens objectives

| Pilot Title | Integrated rail-road system for urban deliveries |
|---|---|
| City's main objectives | Economic<br>• increase LSP's economic sustainability (revenues vs cost)<br>• increase logistics services quality<br>Environmental<br>• reduce CO2 emissions<br>• reduce noise emissions<br>Social<br>• change behaviour towards sustainable UFT<br>• reduce congestion |
| City's second level objectives | • introduce/adopt ICT/ITS<br>• increase delivery load factor<br>• adopt new business models<br>• provide evidence/incentives for further adoption |

## Measures

- Measures → 22
- Measure suggestion
- Measure selection (City planning)

| 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 |

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# Impact areas

Life cycle stage match → Impact Areas (7), Measures (22), Criteria (26), Indicators (137), Stakeholders (10)

| 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 |

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| | Criterion | KPI | Data/unit | Stakeholder category<br>Supply chain stakeholders<br>Public authorities<br>Other | | | LCSA MODULE APPLICABILITY | | |
|---|---|---|---|---|---|---|---|---|---|
| Economy and energy | Fuel | Fuel consumption | Liters | Supply chain stakeholders | | | SCBA | | |
| | Energy | Energy consumption | kW | Supply chain stakeholders | | | SCBA | | |
| | | Logistics cost | EURO - € (or other monetary unit) | Supply chain stakeholders | | | SCBA | | |
| | Competitivenes s | Business development | Number or percentage (%) | Public authorities | Oher stakeholders | | IA | RA | |
| | | Product cost | EURO - € (or other monetary unit) | Supply chain stakeholders | Oher stakeholders | | IA | SCBA | |
| | | Total benefit | EURO - € (or other monetary unit) | Supply chain stakeholders | | | IA | SCBA | |
| | Benefits | Strength and diversification of local economy | Level (high, medium, low) | Public authorities | Oher stakeholders | | IA | RA | |

**LCSA MODULES**
IA: Impact Assessment
SCBA: Social Cost Benefit Analysis
A&T: Adaptability and Transferability
RA: Risk Analysis

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## Weighing

Weights per **impact area, criterion and composite indicator → Pairwise comparison**

## Normalization

$$\overline{r}_{ij} = \frac{r_{ij}}{\max_j r_{ij}} \qquad \overline{r}_{ij} = \frac{\min_j r_{ij}}{r_{ij}}$$



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## Sustainability Index

- Disaggregation of **sustainability disciplines** (key indicators):
- Economy and energy
- Environment
- Transport and mobility
- Society

and **applicability enablers**

- Policy and measure maturity
- Social acceptance
- Users' uptake

## alliance Aggregation

- Weighted Sum Method (WSM)
- The assumption that governs this model is the additive utility assumption

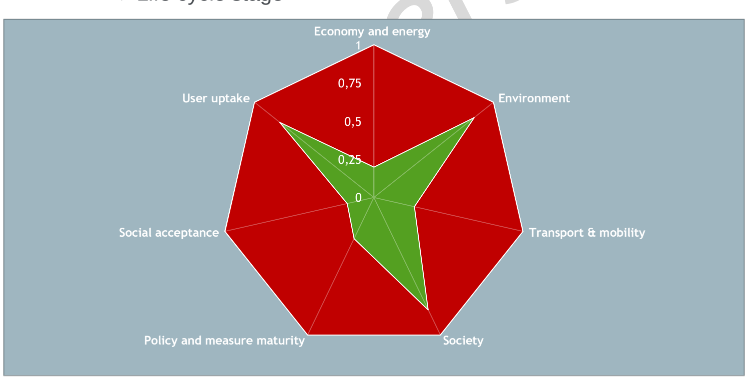
$$V_i = \sum_{j=1}^{n} w_j \bar{r}_{ij} \qquad i = 1, \ldots, m$$

Where: $r_{ij}$ is the normalized value of indicator $j$ for alternative $i$



## alliance Graphic outcome (1/2)

- Indicators are normalized to a dimensionless scale
- LSI for valuating overall measure performance, and also index per:
    - ➢Stakeholder
    - ➢Impact area and criterion
    - ➢Life cycle stage



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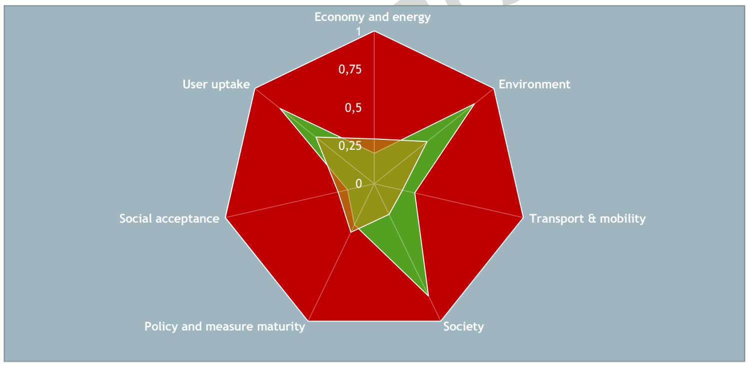
# Graphic outcome (2/2)

- 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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# Data collection methods: Surveys

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



## Content

Qualitative data collection methods

- Setting up a survey
- Sampling
- Data collection methods
- Data collection techniques
- Research designs strengths and weaknesses of each method
- Statistical analysis
- Suggested literature

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# Introduction





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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 |
| 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 | e.g. interview, group discussion, observation | e.g. test, experiment, observation |

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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
  - ▶ 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

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# 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



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# 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.

First version

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# Sampling





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# 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.

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# Sampling

- **Sampling Methods**
  - Sampling by groups
  - Sampling by layers
  - Sampling based on choices of commuters

- **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 )





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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 | $\sigma^2$ | $S^2$ |

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# Sampling

- The standard error tends to zero when N → v.
- in practice, however, we usually have large populations and small sample, so:

$$\frac{\mathrm{N}-\nu}{\mathrm{N}} \cong 1$$

and: $$se(\bar{x}) = \frac{\mathrm{S}}{\sqrt{N}}$$

- then, we can calculate the sample size:

$$v' = \frac{S^2}{se(\bar{X})^2}$$

- for samples of finite size :

$$\nu' = \frac{\nu'}{1 + \frac{\nu'}{\mathrm{N}}}$$





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# Data collection methods & techniques

## 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

- 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



## Data collection methods

- Method of observing (Observational research)
(no interference with the subject(s) under study)

  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

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# Research design





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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





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# Strengths & Weaknesses

**Method of asking**

**Mail and self-administered questionnaires**

| Strengths | Weaknesses |
|---|---|
| • Relatively cheap to administer<br>• Produces reliable and valid information<br>• You can ask many things in one time<br>• Closed questions are easy to collect and it is easy to compare and analyse the results afterwards<br>• Open questions can be used to collect more detailed information<br>• Anonymity of questionnaires may improve response rate | • Requires specialist knowledge<br>• Questionnaires can limit response rates by being perceived as 'boring'<br>• A low response rate can result in a biased sample<br>• Risk of incomplete Questionnaires<br>• No signals available as to the honesty of respondents' answers<br>• Literacy skills required for responding can exclude some individuals |

**Interviews**

| Strengths | Weaknesses |
|---|---|
| • Yield richest data, details, new insights, provide opportunity to explore topics in depth<br>• Allow interviewer to explain or clarify questions<br>• Allow interviewer to be flexible in administering interview<br>• Small samples, if interviewed in-depth, can provide a large range of views | • Expensive and time consuming<br>• Need well-qualified, highly trained interviewers<br>• Interviewee may distort information through recall error<br>• Researcher's presence may bias responses<br>• Large gap between the respondent's knowledge and that of the interviewer<br>• Special equipment to record interview |

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# Strengths & Weaknesses

## Method of asking

### Telephone interviews

| Strengths | Weaknesses |
| --- | --- |
| • You can quickly reach many people across long distances<br>• More expensive than a mail questionnaire but less expensive than face-to-face interviews<br>• Less time consuming than face-to face interviews | • Limited interview length.<br>• Respondents without telephone are impossible to reach.<br>• The call may come at an inconvenient time<br>• Open-ended questions are difficult to use, also questions requiring visual aids |

### Face-to-face interviews

| Strengths | Weaknesses |
| --- | --- |
| • Very high response rate<br>• Possibility to observe the surroundings, nonverbal communication and make use of visual aids<br>• Good approach to gather in-depth attitudes, beliefs, and anecdotal data<br>• 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<br>• It requires time and a quiet area to conduct interviews<br>• Requires special equipment to record and transcribe interviews |

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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<br>• Information concerning causes, reasons, best approaches from an 'insider' point of view<br>• Advice/feedback increases credibility of study | • Time required to select and get commitment may be substantial<br>• Informants may interject own biases and impressions<br>• 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 groups

| 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<br>• Produces a lot of useful ideas from the target groups themselves<br>• Participants are not required to read or write<br>• 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<br>• Discussion can be hindered if some participants are seen to be 'experts'<br>• The data collected could tend to have low validity due to the unstructured nature of the discussion<br>• Discussions' analysis can be time consuming and relatively expensive |

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# Strengths & Weaknesses

## Method of asking

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# Strengths & Weaknesses

## Method of asking

### On-line focus group

| Strengths | Weaknesses |
|---|---|
| • Anonymity can be useful when discussing a sensitive topic<br>• Using the Internet can overcome the expense and other logistical complications<br>• On-screen displays lessen the influence of the interviewer's personal characteristics<br>• 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<br>• Restricted participation for those who cannot type quickly<br>• Requires a skilled facilitator to keep discussions on topic<br>• Difficult to explore individual comments in  more detail<br>• Technology may overshadow the purpose of the discussion or even interrupt the discussion |

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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<br>• Excellent techniques to discover, observe, and evaluate actual behaviour of participants in a natural setting.<br>• Provide direct information about behaviour of individuals and groups.<br>• Provide good opportunities for identifying unanticipated outcomes and unusual aspects<br>• Permit evaluator to enter into and understand the situation/context<br>• Researcher can record information as it is revealed<br>• 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<br>• Need well-qualified, highly trained observers<br>• Observers may encounter difficulties determining gender, age and behaviour of participants. The data recorded is subjective<br>• Restricted viewing angles may obscure important details<br>• 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 |

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## Strengths & Weaknesses

### Method of document analysis

**Content Analysis**

| Strengths | Weaknesses |
|---|---|
| • As written evidence, it saves a researcher the time and expense of transcribing<br>• Useful for determining value, interest, positions, political climate, public attitudes, historical trends or sequences<br>• An unobtrusive source of information<br>• Audio/visual material allows participants to share their 'reality' | • Analysis may be time consuming<br>• Requires transcribing or optically scanning for computer entry<br>• The documents may not be authentic or accurate<br>• 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**

| Strengths | Weaknesses |
|---|---|
| • An unobtrusive source of information - can be accessed at a time convenient to the researcher<br>• Can be used to collect baseline data<br>• 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<br>• In order to obtain reliable and good quality results, a large amount of data is needed<br>• It is often difficult to determine the accuracy of secondary data<br>• Equivalence reliability can also be a problem |

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# Statistical analysis



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# 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..."

(Professor 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<br>• Do not allow us to make conclusions beyond the data we have analyzed or reach conclusions regarding any hypotheses we might have made<br>• Enables us to present the data in a more meaningful way, which allows simpler interpretation of the data<br>• 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<br>• Are techniques that allow us to use these samples to make generalizations about the populations from which the samples were drawn<br>• methods of inferential statistics are:<br>(1) the estimation of parameter(s), and<br>(2) testing of statistical hypotheses |

(Source: Laerd Statistics)

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# Guidance to further knowledge acquisition





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# Suggested literature


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- 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.
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# Data collection methods: Historical and observed data

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## Content

- Introduction
- Quantitative data collection methods
- Data collection
- Data sources and open data
- Survey design and ethical issues
- Data analysis and visualization
- Big data
- Big data in transport

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## Introduction

- The integration of digital into the real world has found its way into logistics and production systems and is called the fourth industrial revolution (Industrie 4.0)
- The annual global data volume will increase tenfold in the next few years and be only manageable if information systems can process this purposefully. 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.
- In order to fully exploit the information potentials of the state data for the operational monitoring and control of the logistics processes, interdisciplinary modeling and analysis concepts have to be developed, which take into account both the viewpoints of logistics as well as those of computer science.

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## Introduction

- Decision making is the core of management of organisational systems
- 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
- Decision problems and situations in logistics are different from other functional areas of an organisation

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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 organisation but also among the organisation and its supply chain partners
- logistics operations and necessity to communicate and collaborate with other organisations

- higher complexity of some decision making situations
- increase level of uncertainty in decision making
- …





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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 |
| 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 data collection methods

- Quantitative and qualitative techniques provide a tradeoff between breadth and depth, and between generalizability and targeting to specific (sometimes very limited) populations
- Data collected through quantitative methods are often believed to yield more objective and accurate information
- they were collected using standardized methods, can be replicated, and, unlike qualitative data, can be analyzed using sophisticated statistical techniques





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## Quantitative data collection 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.

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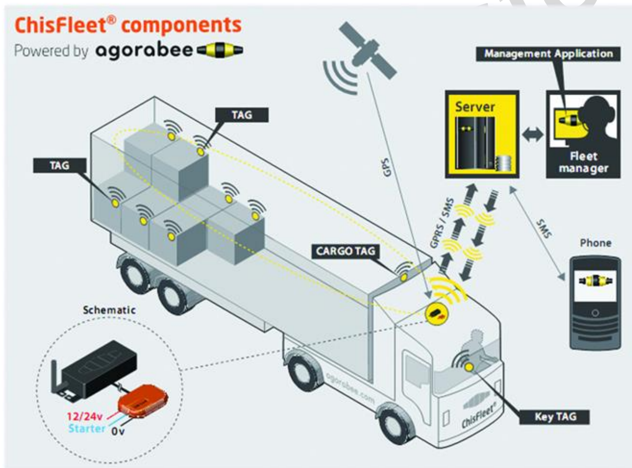
## Data sources

- After data collection, evaluation and preparation has been explained, it is important to explain the origin of the data.

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## Data sources

- Bluetooth ®:
  Is a wireless technology standard for exchanging data over short distances (using short-wavelength UHF radio waves in the ISM band from 2.4 to 2.485 GHz) from fixed and mobile devices, and building personal area networks (PANs). Invented by telecom vendor Ericsson in 1994.

- GPS:
  Also known as Navstar is a global navigation satellite system (GNSS) that provides location and time information in all weather conditions, anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. The GPS system operates independently of any telephonic or internet reception, though these technologies can enhance the usefulness of the GPS positioning information.

  Other systems arte the Russian equivalent (GLONASS), the Indian equivalent (IRNSS), other similar systems (GNSS), the Chinese equivalent (BeiDou-2tf), or the European equivalent (GALILEO).

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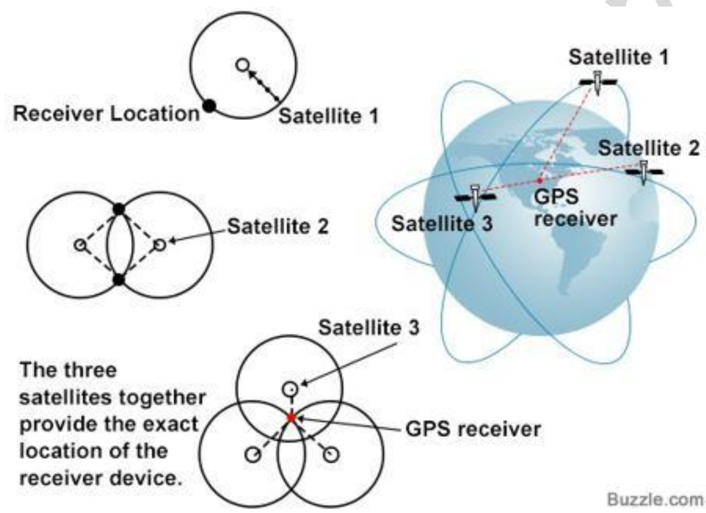
## Data sources

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## Data sources

GPS receiver receives real-time data from the satellite.
⇓
This data is transmitted to the cellular towers via wireless cellular communication.
⇓
This data is directly sent to clients on mobile devices.
⇓
Also, the location-based information is sent to the tracking server via GPRS/Internet.
⇓
The tracking server forwards the data onto the client terminal.
Special radio signals from the satellites are received by the GPS receiver, which further carries out mathematical calculations on them. For calculating the exact position, the GPS receiver should know:

- Distance of the tracked device from each of the satellite.
- Rough location of the device to be tracked.

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## Data sources

- RFID:
  Radio-frequency identification (RFID) uses electromagnetic fields to automatically identify and track tags attached to objects. The tags contain electronically stored information. Passive tags collect energy from a nearby RFID reader's interrogating radio waves. Active tags have a local power source such as a battery and may operate at hundreds of meters from the RFID reader.

- Sensors:
  Is an object whose purpose is to detect events or changes in its environment, and then provide a corresponding output. A sensor is a type of transducer; sensors may provide various types of output, but typically use electrical or optical signals.





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## Data sources

RFID tag placed on the material.
⇓
Material placed inside a vehicle.
⇓
Company receives location-based data from the tag via wireless communication.
⇓
Location-specific data stored in the company's tracking server.
⇓
Tracking information is sent to the mobile devices.

RFID tags are generally read-only, and contain the serial number that is fed into the local database for further reference. However, read/write tags are also available, into which specific user information can be stored by authorized personnel. This information is stored on non-volatile memory, so that it can be read even when the system is not powered.

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# Data sources

- Real-time Locating System:
  The RTLS system is used for location tracking of devices inside a confined area, like an industrial estate. Like RFID systems, RTLS also uses tags which transmit wireless signals.

  These signals are read by fixed-point readers, and thus, the location of the desired devices can be found. The technology uses RF signals to transmit location-based information. This location information does not contain details like the speed of the device or its spatial positioning. However, obstructions, like walls or gates, can cause a decline in data accuracy.



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# Data sources

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  Is an object whose purpose is to detect events or changes in its environment, and then provide a corresponding output. A sensor is a type of transducer; sensors may provide various types of output, but typically use electrical or optical signals.



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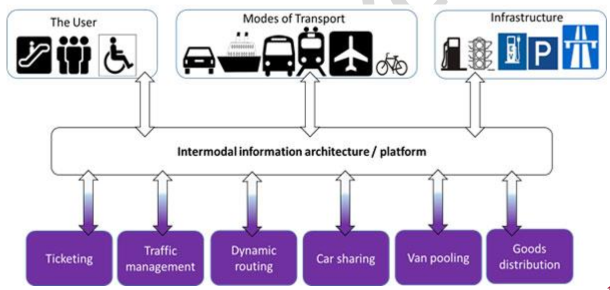
# Open Data Sources

- Traffic data in statistics
- Journals and studies
- Open data platforms
- Open maps



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# Data analysis and visualization

- An analysis of large amounts of data serves to recognize unknown connections or to confirm already known ones
- 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 CRoss Industry Standard Process 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.

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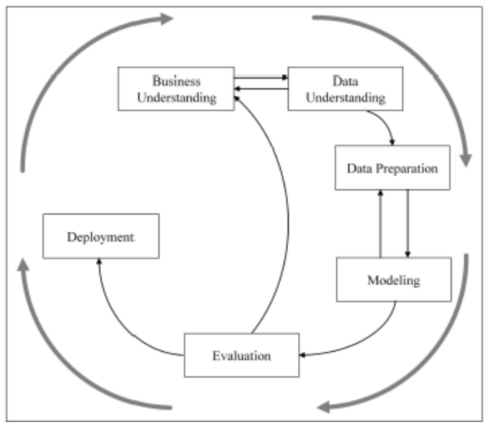
# Data analysis and visualization

- „Knowledge discovery in Databases is the nontrivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data“



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## Knowledge Discovery in Databases and Data Mining

- „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)

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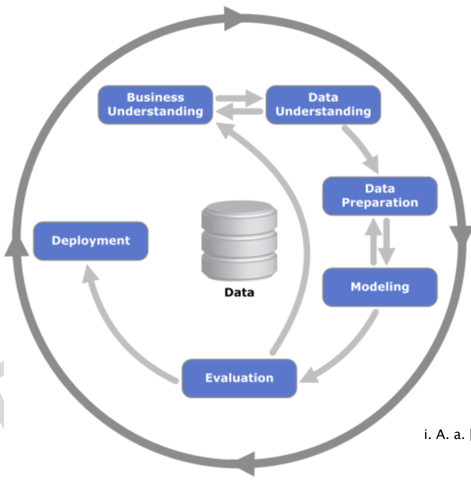
## Phases of the Cross Industry Standard Process for Data Mining (CRISP-DM)




i. A. a. [Chapman et al., 2000]



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## 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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## 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





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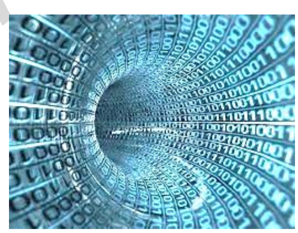
## Big Data

- „Big Data are large amounts of data, which are to big for traditional database systems. They have a long half-life time and their form do not comply with conventional database systems“ (Freiknecht, 2014, S. 9), (Dumbill, 2012)
- „Big Data is, when the data itself are part of the problem“ (Roger Magoulas von O´Reilly Media), (Freiknecht, 2014, S. 14)
- “More data are not necessarily better data!” (Koeppen et al., 2014, S. 10)



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## Development of the data volume

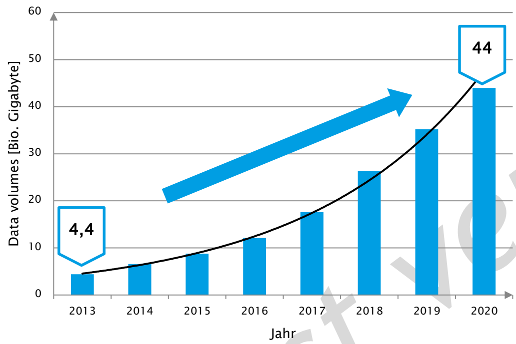


Abb. 1: development of data volume world wide, vgl. [Turner et al., 2014]

**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]



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## Characteristics of big data

- characteristics: 3 V from Gartner 2001 + 1 V from IBM
  - **Volume:**
    - definition how big is BIG depends on the hardware.
    - e.g. the loading of a 100 Megabyte CSV-file need 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.

(Freiknecht, 2014, S. 10-13)



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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





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## 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

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# Big data in transport

- Application example Freight airport

- In this first application example, 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.





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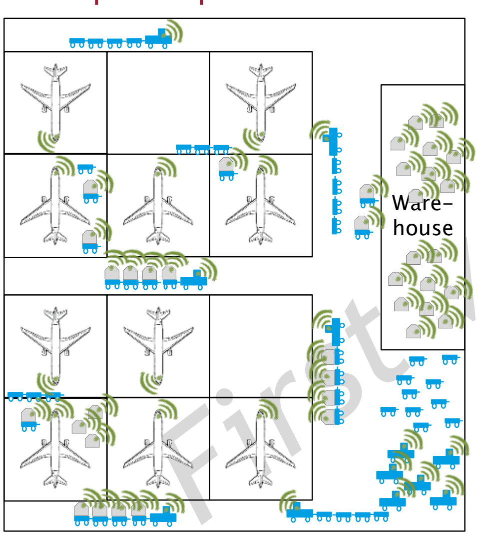
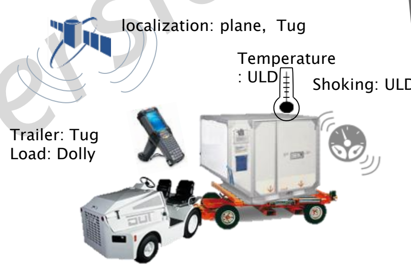
## Example: Airport



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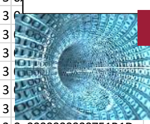
## Raw data - Examples

| LfdNr | Mandant | Device | Seriennummer | Zeit | Verarbeitet | Auftrag | TimeStamp |
|---|---|---|---|---|---|---|---|
| 50 | 1 | 61 | 74657874616720540002EEF7 | 2012-11-22 17:29:02.000 | -1 | 3 | 0x000000000000D34C |
| 61 | 1 | 62 | 746578746167205300006D761 | 2012-12-07 11:36:04.000 | -1 | 3 | 0x000000000751B06 |
| 62 | 1 | 62 | 746578746167205300006D77D | 2012-12-07 11:36:04.000 | -1 | 3 | 0x000000000751B07 |
| 63 | 1 | 62 | 746578746167205300006A952 | 2012-12-07 11:37:27.000 | -1 | 3 | 0x000000000751B08 |
| 64 | 1 | 62 | 746578746167205300006A952 | 2012-12-07 11:38:10.000 | -1 | 3 | 0x000000000751B09 |
| 65 | 1 | 62 | 746578746167205300006A987 | 2012-12-07 11:38:18.000 | -1 | 3 | 0x000000000751B0A |
| 66 | 1 | 62 | 746578746167205300006A984 | 2012-12-07 11:38:25.000 | -1 | 3 | 0x000000000751B0B |
| 67 | 1 | 62 | 74657874616720540002EEF7 | 2012-12-07 11:38:33.000 | -1 | 3 | 0x000000000751B0C |
| 68 | 1 | 62 | 74657874616720540002EF09 | 2012-12-07 11:38:37.000 | -1 | 3 | 0x000000000751B0D |
| 69 | 1 | 62 | 746578746167205300006A99F | 2012-12-07 11:38:42.000 | -1 | 3 | 0x000000000751B0E |
| 70 | 1 | 62 | 74657874616720540002EF4E | 2012-12-07 11:38:48.000 | -1 | 3 | 0x000000000751B0F |
| 71 | 1 | 62 | 74657874616720540002EEF2 | 2012-12-07 11:38:53.000 | -1 | 3 | 0x000000000751B10 |
| 72 | 1 | 62 | 74657874616720540002EEF5 | 2012-12-07 11:38:59.000 | -1 | 3 | 0x000000000751B11 |
| 73 | 1 | 62 | 746578746167205300006D77E | 2012-12-07 11:39:03.000 | -1 | 3 | 0x000000000751B12 |
| 74 | 1 | 62 | 746578746167205300006A986 | 2012-12-07 11:39:10.000 | -1 | 3 | 0x |
| 75 | 1 | 62 | 746578746167205300006A9A0 | 2012-12-07 11:39:16.000 | -1 | 3 | 0x |
| 76 | 1 | 62 | 746578746167205300006A989 | 2012-12-07 11:39:24.000 | -1 | 3 | 0x |
| 77 | 1 | 62 | 746578746167205300006A988 | 2012-12-07 11:39:35.000 | -1 | 3 | 0x |
| 78 | 1 | 62 | 746578746167205300006D758 | 2012-12-07 11:39:42.000 | -1 | 3 | |
| 79 | 1 | 62 | 746578746167205300006D728 | 2012-12-07 11:39:43.000 | -1 | 3 | |
| 80 | 1 | 62 | 746578746167205300006D760 | 2012-12-07 11:40:02.000 | -1 | 3 | |
| 81 | 1 | 62 | 746578746167205300006D777 | 2012-12-07 11:40:09.000 | -1 | 3 | |
| 82 | 1 | 62 | 746578746167205300006D76C | 2012-12-07 11:40:20.000 | -1 | 3 | |
| 83 | 1 | 62 | 746578746167205300006D74D | 2012-12-07 11:40:29.000 | -1 | 3 | |
| 84 | 1 | 62 | 746578746167205300006D76B | 2012-12-07 11:40:38.000 | -1 | 3 | 0x000000000751B1D |
| 85 | 1 | 62 | 746578746167205300006D75B | 2012-12-07 11:40:49.000 | -1 | 3 | 0x000000000751B1E |
| 86 | 1 | 62 | 746578746167205300006D782 | 2012-12-07 11:40:59.000 | -1 | 3 | 0x000000000751B1F |

> 50 data sets per minute



BIG DATA





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## Data protocol – structure of meta data

| ULD |
|---|
| ID |
| time |
| localizatio |
| 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 | 23:50:3 | | | | 0 |
| ULD055 | 23:51: | | | | 0 |
| ULD049 | 23:51: | | | | 0 |
| ULD043 | 23:51: | | | | 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 |

Aggregation of the raw data of the acceleration sensor

| Pool |
|---|
| ID |
| time |
| content |
| – |
| – |
| – |

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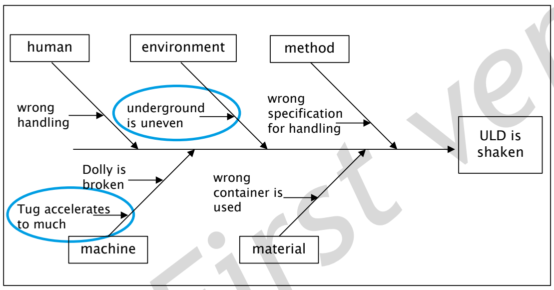
## Cause analysis

Detailed analysis




- 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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## Airport – association analysis

- Assoziation 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 |
| ULD12 | | | | | |
| 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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