

NODES

D5.3 Evaluation results and final recommendations as full data set

Version number	Version 1.3
Main author(s)	Luca Lucietti, Paola Cossu, Massimo Marciani
Work Package/Task	WP5/5.3
Deliverable	D5.3
Draft/Final	Final
Public/Confidential	Public
Date	30 July 2015



Revision and history sheet

Version history			
Version	Date	Main author	Modification
Format	27/04/2015	FIT	Table of contents
1.0	10/06/2015	FIT	First issue
1.1	03/07/2015	FIT, UITP, TUD, DTV, SWO	Second issue
1.2	15/07/2015	FIT, UITP, TUD, DTV, EPF, RBC	Third issue
1.3	23/07/2015	FIT	Revised according to the comments

Revision/Approval		
	Name partner	Date
Lead author(s)	Luca Lucietti, Paola Cossu, Massimo Marciani	15/07/2015
Task approval	Task 5.3 participants (UITP, TUD, DTV, RBC, SWO)	22/07/2015
EB approval	EB members	30/07/2015
Coordinator approval	Caroline HOOGENDOORN	30/07/2015

Authors (full list)

Task leader

FIT

Task participants

UITP
DTV
EPF
TUD
RBC
SWO

Workpackage leader

FIT



Project co-ordinator

Caroline Hoogendoorn, UITP
Rue Sainte-Marie 6
1080 Brussels, Belgium
Tel.: +32 2 788 01 11
Fax: +32 2 660 10 72
Email: caroline.hoogendoorn@uitp.org

**EUROPEAN COMMISSION
DG RESEARCH AND INNOVATION
NODES 'New tOols for Design and OpEration of Urban Transport InterchangeS'
SMALL OR MEDIUM-SCALE FOCUSED RESEARCH PROJECT
GRANT AGREEMENT N. 314618**

Table of Contents

Executive Summary	5
1. Introduction	6
1.1 Scope of the deliverable	6
1.2 Main needs and challenges for urban interchange.....	7
1.3 NODES Toolbox: integrated planning, design and management tools (toolbox)	9
Topic 1: Integrated land use and infrastructure planning.....	10
Topic 2: Design	14
Topic 3: Intermodality and ICT.....	19
Topic 4: Management and business models.....	26
Topic 5: Energy and Environment.....	33
Cross Topic Tools.....	35
2. Main barriers and enablers for successful implementation of the tools (toolbox).....	36
2.1 Process barriers in the reference sites.....	36
2.2 Process drivers (enablers) in the reference sites	37
3. Lessons learned and recommendations	38
3.1 Key lessons learned from the reference sites	38
3.1.1 Lessons learned of the tool implementation	39
3.1.2 Lessons learned for the usage of the toolbox.....	40
3.2 Transferable roadmap for efficient and sustainable urban interchanges	46
3.3 Final recommendations	51
4. Conclusions	67

Executive Summary

Starting from the results achieved either in task 5.1 and task 5.2 of the Work Package 5, the NODES project will outline a transferable roadmap including recommendations addressed to local authorities for integrated strategies, for planning and implementing efficient and sustainable interchange in cities.

The Deliverable D5.3 aims at analysing the project's results and impacts according to the project evaluation framework defined in the deliverable 5.1 (Evaluation plan) to indicate to what extent the application of the NODES Toolbox enables to enhance integrated planning, intermodality, safety, cost-effectiveness, energy-consumption reduction, etc. in urban interchange design and operation.

The Deliverable D5.3 synthesizes the overall results achieved in the reference sites, providing criteria for transferability, including lessons learned. The NODES Toolbox has been successfully tested in different sites (nine different reference sites across Europe) characterized by different local conditions and constraints, transport patterns, national / local regulatory framework, different types of interchanges as well as interchanges' lifecycle.

The NODES tools were identified in Work Package 3, tested and validated in Work Package 4 and the overall impacts were evaluated in Work Package 5 in terms of increasing accessibility and integration, enhancing intermodality and liveability, increasing safety and security, increasing economic viability and costs efficiency, stimulating local economy, increasing environmental and energy efficiency.

The selection and upscaling of the tools successfully tested in the different reference sites has been based on specific key drivers namely tools with high scores following the testing phase, the most useful and effective tools, the tools that have potential for transferability, impact-oriented tools, etc.

Transferable approaches for the project's results to a European dimension are described in the last part of this deliverable. These will help stakeholders in making urban transport interchanges more accessible, integrated, reliable, sustainable, energy-efficient and safer.

This includes targeted final recommendations for successful planning and implementation of integrated strategies and tools for efficient and sustainable urban transport interchanges.

The deliverable's objective is to build and promote integrated innovative approaches for planning and implementation inclusive and sustainable urban transport interchanges in Europe and beyond.

1. Introduction

The Deliverable D5.3 aims at analysing the project's results and impacts according with the project evaluation framework defined in the deliverable 5.1 (Evaluation plan) to indicate to what extent the application of the NODES Toolbox enables to enhance integrated planning, intermodality, safety, cost-effectiveness, energy-consumption reduction, etc. in urban interchange design and operation.

This section of the Deliverable 5.3 provides the presentation of its framework (deliverable structure) including the contents of the different chapters (chapter 1.1) as well as a brief description of the main needs and challenges from transport interchange stakeholders' prospective, covering the five NODES topics (chapter 1.2). The last chapter (1.3) finally summarizes the tools and methodologies successfully tested and validated in the reference sites to be transferred in other cities.

The tools description is provided through a standard framework enabling to synthetize main characteristics, usefulness, effectiveness, cost as well as potential to transfer, providing qualitative scale (low, medium, high) and reason of assessed qualitative values.

1.1 Scope of the deliverable

The NODES project aims at developing a Toolbox to support European cities, transport authorities and operators in the design and operation of new or updated urban transport interchanges.

The NODES Toolbox is a catalogue of integrated planning, design and management tools for new or upgraded urban interchange enabling to improve interchange planning, design and operation.

The Deliverable 5.3 aims at analysing the project's results and impacts according with the project evaluation framework defined in the Deliverable 5.1 (Evaluation plan) to indicate to what extent the application of the NODES Toolbox enables to enhance integrated planning, intermodality, safety, cost-effectiveness, energy-consumption reduction, etc. in urban interchange design and operation.

The Deliverable 5.3 synthesizes the overall results achieved in the reference sites, providing criteria for transferability of the project's results, including lessons learned.

After the description of main needs and challenges which are commonly faced by two key stakeholder's categories of urban interchanges (interchange end-users and interchange managers / promoters), the Deliverable 5.3 provides a practical synthesis of the most effective and useful tools successfully tested and validated in Work Package 4 and assessed in Work Package 5.

The selection and upscaling of the tools successfully tested in the different reference sites has been based on specific key drivers: higher score tools achieved during the testing phase, usefulness and effective tools, tools having potentials for transferability and impact-oriented tools.

Chapter 1 provides a description of the tools in a standard framework enabling to synthesize its main characteristics, when to be used, usefulness, effectiveness, cost as well as potential to transfer, providing qualitative scale (low, medium, high) and reason of assessed value.

The qualitative scale related to tool "financial feasibility" has to be considered opposite is compared with the scale of "usefulness", "effectiveness" and "potential to transfer". The qualitative scale "high" means high cost of the tool as well as the qualitative scale "low" means less cost of the tool as well.

Chapter 2 provides main results of the process evaluation, according the project evaluation framework defined in the Deliverable 5.1. This enables to gain insight into main barriers and drivers (enablers) during implementation and testing of the selected tools in the reference sites.

Chapter 3 initially provides key lessons learned based on the impact evaluation results in the reference sites according with the different evaluation areas as well as strategic evaluation objectives defined in the Evaluation plan and assessed in the Deliverable 5.2 (Data set for each reference site).

This analysis enables to further generalise the overall (impact and process) evaluation results achieved in the reference sites through the implementation of the NODES Toolbox allowing to define a transferable roadmap for efficient and sustainable planning, design and operation of urban transport interchanges.

Transferable approaches based on integrated strategies and tools for a more accessible, integrated, safer, reliable, sustainable and energy-efficient urban transport interchanges are finally described in chapter 3 of this deliverable. The last part of chapter 3 provides final recommendations for successful implementation of integrated strategies and tools (Toolbox) for efficient and sustainable urban transport interchanges. These recommendations are addressed to interchange manager / promoter-oriented stakeholders which include Local Authorities, Public Transport Operators, etc.

The aim of the recommendations is to get a successful and transferable pathway towards effective, innovative, performance-oriented and cost-effective integrated strategies and tools for supporting urban transport interchange planning, design and management.

Overall conclusions summarize the main results and experiences achieved during the tools testing and impacts evaluation, to build and promote integrated innovative approaches for planning and implementation inclusive and sustainable urban transport interchanges.

1.2 Main needs and challenges for urban interchange

A transport interchange is considered as the driver of urban development in the city. Larger interchanges can be seen as cities within cities, combining multiple functions. The users (travellers) need interchanges to be 1) easy to use, 2) accessible and 3) comfortable. The interchange experience adds to the quality of daily living. Main needs and requirements from the interchange stakeholders' perspective (travellers and interchange manager/promoter) are as follows:

- integrated planning,
- ease of access and transfer,
- reduced transfer time and distances,
- information provision and completeness,
- comfort and liveability,
- safety and security (inside and around interchange),
- cost efficiency,
- economic viability and profitability,
- environmental efficiency,
- energy saving.

1) Integrated land use planning with urban passenger infrastructure planning

Planning and design of interchanges should enable to reach continuity between the surrounding area (interchange zone) and the interchange. Accessibility to interchange by means of smooth transfers from one mode to another determines the attractiveness and enables high accessibility for all users.

Enhancing accessibility of an interchange (including interchange zone) should cover a range of different aspects of planning and design activities. Effective access to the interchange's transport services and facilities, allowing easy and fast movements within the interchange as well as the surrounding area, should be properly addressed through careful planning and design of the local built environment recognising the user needs and requirements.

The interchange should be located and build in an urban area into which the transport interchange has to be functionally and aesthetically integrated. The interchange should be effectively connected with the transport network and infrastructures around the station (functional integration) as well as its building and aesthetic should be integrated with the architecture of the surrounding urban area (aesthetic and urbanistic integration). Transport interchanges should be located in strategic positions within the city. It is important to locate the interchange in an attractive urban environment for users as well as conveniently integrated functionally and aesthetically in the urban environment.

Enhancing urban and mobility integration of interchanges (including interchange zone) should be properly addressed during the planning, design, (re-)design as well as construction of a transport interchange. Enhancing mobility integration of interchange should mean its effective connection with the arterial road network, feeder modes (e.g. buses, private vehicles, cycling, etc.) as well as the interchange's main public transport modes (e.g. commuter rail, metro, light rail, buses, etc.).

2) Innovative approaches relating to the design of new or updated transport interchanges

From the interchange design perspective, it is very important to design a **station that enables short transfers between the different transport modes, both in terms of time, distances and effort.**

Multi-level design can help to keep the interchange compact, allowing to reach higher comfort and speed of passenger flows. But it might have a negative impact on the "effort" taking much more effort to walk up stairs, for less mobile people elevators and escalators are required. An effective design of interchanges should also include needs and requirements of specific categories of users such as persons with reduced mobility, cyclists, impaired persons, etc.

High-level performance interchanges should properly cover a wide range of aspects, including design, furniture, vertical communication between floors and measures for the visually impaired, etc.

The design of open spaces, comfortable and sufficiently large waiting areas as well as the environmental quality management of the interchange - through proper ventilation, lighting, temperature and noise control - are important in reaching users' overall satisfaction. Increasing safety and security conditions also represents one of the main needs because every transport interchange faces a certain level of risk associated with various threats which might be the results of natural events, crime, accidents, system's failures, etc. Safety and security aspects need to be properly addressed during a new interchange design, interchange refurbishment as well as during operation in order to identify, evaluate and control the risk factors in and around the interchange.

3) Intermodal operations and information provision

For the intermodal operations and information provision, smart (e.g. smartcards, mobile applications, etc.), integrated ticketing, integrated as well as up-to-date / real-time information (covering all transport modes feeding interchange) are considered relevant key aspects.

Provision of both pre-trip information (e.g. information in advance for planning the optimal trip, find alternatives, make choices, etc.) and on-trip information (e.g. actual information, real-time, customer-related, etc.) as well as individual and collective information should allow to increase intermodal journeys properly using the available transport modes.

Transport interchanges should guarantee an effective intermodality to minimise distance and time taken between the different transport modes (both public transport and feeder modes) through integration of transport modes, information, signalling and ticketing integration.

Interchange users should receive clear, intuitive, easy and integrated information/signalling.

4) Management and business models

Interchanges need a specific management structure and strategy, both for larger and smaller stations. **Management and ownership of interchange need to be identified and managed separately.** Increasing economic viability and costs efficiency for interchange management is a key aspect. Practitioners need to reduce the operating costs of the different public transport modes that operate in the interchange, as well as of interchange's relevant services and systems.

In order to enhance economic viability of transport interchange management, the interchange manager/promoter should identify and set-up new and additional business opportunities, also offering complementary services (e.g. information points, commercial areas, business areas, leisure areas, etc.). The interchange manager/promoter should also address the question of how their interchange might stimulate the local economy, for example using local service providers or proposing new business opportunities in the interchange as well as in the surrounding area.

Building a new interchange in cities can be an incentive for the local economy. It can enhance the profitability of businesses (e.g. retailers) concentrated around the interchange.

5) Energy efficient and environmental friendly operations

The environmental footprint of interchanges is a key issue for environmental efficiency of interchange operations and local energy production for energy efficient operations.

Increasing **environmental and energy efficiency** during the interchange lifecycle (design, construction and operation) is a key objective of each interchange manager/promoter. Given that many interchanges are situated below ground level and can be used by modes of transport that emit harmful gases and increase ambient temperature, specific attention should be paid to the monitoring of environmental conditions in the interchange zone.

1.3 NODES Toolbox: integrated planning, design and management tools

The NODES Toolbox is a catalogue of integrated planning, design and management tools to support European cities in the design and operation of new or upgraded interchanges, as a way to provide greater support, services and satisfaction to travellers and users as well as to interchange operators.

The key question is as follows: “What should be transferred?”. This chapter identifies the tools and methodologies successfully tested and validated in the reference sites (WP4) included in the Toolbox that are to be transferred to other interchanges in different cities in Europe.

The selection and upscaling of the tools successful tested in the different reference sites has been based on specific key drivers as follows:

- higher average score tools achieved during the testing phase (from 16 to 25),

- usefulness and most effective tools from practitioners and users' prospective,
- tools having potentials for transferability,
- impact-oriented tools, including accessibility, intermodality, safety and security, etc.

The tools description is provided through a standard framework enabling to synthesize their main characteristics, when to be used, usefulness, effectiveness, cost as well as potential to transfer, providing qualitative scale (low, medium, high) and reason of assessed qualitative values.

The different tools descriptions and transferability are provided below, grouped per NODES topic

Topic 1: Integrated land use and infrastructure planning

Tool for a complete diagnosis and identification of priority areas

Tool name	Tool for a complete diagnosis and identification of priority areas
Tool number	1
Tool description	The 'Land-use transport integration diagnosis and identification of priority areas' tool is based on various types of indicators. The tool helps to understand the correlation between the components of the transport network, the structure of area surrounding the interchange, land use and other factors potentially influencing interchange zone.
Nature of the tool	Technical (Model / software)
Usefulness	high Relevant and useful, but requires a lot of data and analysis, besides IT skills are beneficial. Consumes a lot of time and resources.
Effectiveness	medium The tool consists of four tasks. Indicators can be calculated and measured. The areas for further investigation and potential interventions is indicated by using the tools as well.
Financial feasibility	medium
Potential to transfer	high Potentially interesting tool, but requires a lot of effort, depending on the level of detail taken into account and available data as input data.

Tool to evaluate strategic scenarios for a new interchange

Tool name	Tool to evaluate strategic scenarios for a new interchange
Tool number	2
Tool description	This tool is developed for a complete understanding and diagnosis of the public transport network, its integration, relationship with land use and the strategic role of a point within the whole network. The tool is in essence a methodology aiming to support the strategic evaluation of different location and connection scenarios. Moreover, this tool enables detection of present needs and prior areas for intervention and/or investment based on

	comparing scenarios.
Nature of the tool	Methodological
Usefulness	high The tool listed seems to provide a comprehensive list of considerations when deciding upon a location to construct a new interchange. Some elements such as Space Syntax methodology can be used to assess an existing station. If software, knowledge, skills and models are available, the value of this tool might be significantly higher.
Effectiveness	high Indicators for this tool are (1) Network Closeness, (2) Network Betweenness, (3) Average Number of Transfers and (4) Number of Lines per Transport Mode. These indicators can be calculated for different scenarios, however this mainly counts for indicator 3. For other indicators, a transport model is essential. The range of factors considered is fairly comprehensive, however the method for finding or calculating them might require further explanation.
Financial feasibility	medium Labour intensive and requiring staff with specialist knowledge.
Potential to transfer	medium It is a complex and high-maintenance tool. A simplification for the calculation of the relevant key indicators is essential.

Typology visual tool

Tool name	Typology visual tool
Tool number	3
Tool description	This is a visual tool aiming at understanding and comparison of various types of interchanges. It allows quick and efficient identification of the design and facility requirements. The tool can be used for monitoring changes: to compare a situation before and after any relevant interventions or to compare aims (objectives) and results (realisation).
Nature of the tool	Methodological
Usefulness	high The interchange typology tool is very useful and easy to implement in terms of resources. It provides a good summary of the present situation and allows prioritising future enhancements or upgrades. With some further explanation the tool can be used to deliver comprehensive information for decision makers for prioritising and comparing interchange configurations.
Effectiveness	high A simple and effective visualisation.
Financial feasibility	high
Potential to transfer	high Potentially this is a quick and useful visual check on how the proposed changes could improve the interchange connectivity. The instructions and

	templates can be updated to make the tool more feasible and clear for the user.
--	---

Urban environment indicators toolkit

Tool name	Urban environment indicators toolkit
Tool number	4
Tool description	The benchmark tool is a framework, in which diverse data can be integrated and compared, in order to understand diverse transport and land use phenomena together. The aim of the tool is to inform, support and guide the decision making process, both in the case of a new interchange and in the process of detection of present needs and prior areas for intervention, which require a complete diagnosis of the urban transport system.
Nature of the tool	Methodological
Usefulness	high The idea of this tool is considered very helpful as an open adaptable methodology at the stage of allocating and planning a new interchange. It follows a very orthological approach trying to quantify as many indicators as possible describing the urban complexity around an interchange. However, some difficulties were identified: availability of base data in GIS and calibration is required to improve reliability in different countries.
Effectiveness	high The tool delivers results at low cost and in a short time, with limited resources, especially compared with simulation.
Financial feasibility	high
Potential to transfer	high The proposed chart with indicators is a useful tool in order to start with planning basic lines and an evaluation guide between different alternatives.

Urban space interchange evaluation

Tool name	Urban space interchange evaluation
Tool number	5
Tool description	This tool is an indicator based design list. The tool aims through to guide and evaluate urban designers and transport planners proposals towards interchanges improvement in terms of performance and effectiveness.
Nature of the tool	Methodological
Usefulness	high The interchange evaluation check list is a very useful tool, easy to implement in terms of resources. It summarizes well the present situation and highlights deficiencies. Results depend on the availability of base data, i.e. maps of the interchange.
Effectiveness	high

	Straight forward tool with a smooth learning curve. However it is not suitable for comparison between schemes.
Financial feasibility	high
Potential to transfer	high The tool provides a simple list of key principles to assess and evaluate transfer points.

Urban integration (Space syntax: macro, meso, micro)

Tool name	Urban integration (Space syntax: macro, meso, micro)
Tool number	6
Tool description	Space Syntax is a theory and methodology developed by Hillier and Hanson in the 1980's. Network analysis is applied to understand spatial accessibility and the hierarchy of spaces within the urban network of streets and public spaces. This accessibility has proved its strong relationship with distribution of pedestrian flows, location of activities and certain land uses.
Nature of the tool	Technical (software)
Usefulness	high A very good tool, which provides real benefits for the planning and design of larger interchanges, however it does require the support of specialists.
Effectiveness	high The tool is very good and usable in its current form, however it might benefit from case study examples of its use at public transport interchanges.
Financial feasibility	high Relatively high cost as specialists and special software are required
Potential to transfer	high This tool is particularly interesting because it enables the evaluation of the most appropriate interchange location at all scales in a consistent way.

Mobility micro simulation

Tool name	Mobility micro simulation
Tool number	10
Tool description	Micro-simulation procedures are powerful tools that can provide qualitative and quantitative impact assessment and examine various policy scenarios both in demand and supply side. Especially taking into account that changes in transport supply as well as temporal changes in transport demand, may affect the provided level of service of transport networks nearby the interchange. There are many micro-simulation packages on the market: TransModeler, PTV VISSIM, TSIS-CORSIM, Cube Dynasim, LISA+, Quadstone Paramics, SiAS Paramics, Simtraffic and Aimsun.
Nature of the tool	Model
Usefulness	high

	The tested tool presents a very clear analysis visually, through the use of videos, which portray conflicts as animation. In this way the viewer can easily see where and how conflicts between vehicles occur. It enables any refinements made until the best design solution is found.
Effectiveness	high The tool saves time and costs by allowing a design to be tested before the interchange or station is built.
Financial feasibility	medium
Potential to transfer	medium Very effective, but costly. Software and consultancy required

Topic 2: Design

Assessment / survey and analysis

Tool name	Assessment / survey and analysis
Tool number	1
Tool description	Assessment/survey and analysis tool is a benchmarking tool to analyse current/existing status of the interchange related to design topics. This tool is intended to provide an assessment of the interchange being tested and a simple measure of the status of an interchange to enable interchange promoter / designer to understand the areas where it performs well and where it performs weak relative to design. The tool can also be used to monitor changes in the interchange due to design interventions. The tool is essential to discover design parameters and identify relevant design issues.
Nature of the tool	Technical / methodological
Usefulness	high In terms of the objectives the tool appears to be very useful and gives user a clear summary of strengths and weaknesses of the interchange. The basic information / data sheet is relatively easy to complete. The evaluation questionnaire is easy to understand and complete and doesn't require technical experts. The summary provided following completion are easy to understand, providing a really useful indication of performance, which will assist greatly in future dialogue with stakeholders. The references to other tools in the toolbox also provides a useful guide to access further resources to help with the on-going design challenge for the interchange with some quick wins being improvements to information and wayfinding.
Effectiveness	high An relatively simple tool to use which provides really valuable indications of performance of the interchange relative to design.
Financial feasibility	medium
Potential to transfer	high The survey tool offers a consolidated and easy system for benchmarking different interchanges.

Customer/ Stakeholder satisfaction evaluation

Tool name	Customer/ Stakeholder satisfaction evaluation
Tool number	2
Tool description	This instrument (Station Experience Monitor) is used by the Netherlands Railways to measure passenger station experience. Most interchanges have a functional design and focus on quality of material and production. Those stations are often not designed to cater for an increased experienced quality of the customer. The scientific basis of this instrument is explained in the "Pyramid of Public Transport Customer Needs".
Nature of the tool	Technical
Usefulness	high The Dutch railways were already convinced of the utility and high value of the Station Experience Monitor. The experiments within NODES proved that also in other settings -with a little adaptation of the monitor and questionnaire- this instrument also works in an international context. It proved that the monitoring is valuable and can easily be carried out in all types of interchanges (train, metro and bus oriented). The main issue is in the acceptance of the "change of focus" that the use of the instrument (Station Experience Monitor) implies: Most interchange operators are not used to place the customer central at the functioning of the interchange. A long process of convincing and "showing of prove" is therefore essential.
Effectiveness	high The tool is considered extremely relevant for the interchanges. The instrument (Station Experience Monitor) provides a management and monitoring tool that allows to steer the interchange improvements in a cost effectively manner with a true focus on the customer.
Financial feasibility	medium
Potential to transfer	high The Station Experience Monitor is a valuable instrument, which can easily be carried out in all types of interchanges (train, metro and bus oriented) and in different international contexts.

Trip generation assessment and analysis

Tool name	Trip generation assessment and analysis
Tool number	6
Tool description	Trip generation and analysis is a method of understanding the impacts on trip generation of particular land uses/ development activity/ commercial activity at, or in the proximity of interchanges.
Nature of the tool	Methodological / technical
Usefulness	high Useful in negotiations with developers around the interchange and in sharing out benefits/ mitigating effects to the community of new commercial developments in and around the interchange zone.

Effectiveness	high Both developers and local government accept it as a valuable tool, although its extensive set of variables makes it a potential source of conflict. The tools help the planning process proceed to an agreeable conclusion, which allows developments to take place and mitigation from their effects to be provided.
Financial feasibility	high
Potential to transfer	high The tool is relatively easy to use, doesn't require experts and delivers clear results.

Guidance for the planning /design of layout, accessibility, facilities and built form

Tool name	Guidance for the planning /design of layout, accessibility, facilities and built form
Tool number	8
Tool description	This set of tools assists design teams in the design of interchanges and in particular the key areas of planning/design of layout, accessibility and built form. The guidance consists of software tools, design guidelines and a toolbox. The background to the organisations producing the guidance is widely different.
Nature of the tool	Methodological
Usefulness	high Pursuing continuity in thinking on the typology of interchanges, the interchange master plan is an essential and extremely rewarding basis for the development of effective and attractive interchanges. The provision of guidance for planning and design of interchanges is provided in the form of widely varying documents. These address high-level social considerations such as why we should have well designed interchanges as well as the ground level 'how to build it'.
Effectiveness	high These guidelines collect all the updated principles and requirements, so they are vital amendments to the design standards.
Financial feasibility	medium
Potential to transfer	high This tool consists of a wide range of instruments, which could fit the local needs depending on the location and type of interchange.

Design standards and data

Tool name	Design standards and data
Tool number	9
Tool description	Design standards and data is a collection of different types of standards and regulations. There is no particular standard in the interchange design as a whole. The planning of an interchange must be based on several standards.

	These standards are issued by different organizations. Some of them focuses on the interchange while others have a more general scope.
Nature of the tool	Legislative/regulatory, technical
Usefulness	high Design standards and data help designers and promoters of transport interchange projects to plan and apply minimum standards into the design performance specification as design interventions evolve during the design process of public transport interchange.
Effectiveness	high These are useful tools to help increase awareness of problems and solutions to various aspects of interchange design and future operations. They provide good base information and illustrations allowing interchange designers to appreciate the options available for their own interchange developments.
Financial feasibility	medium
Potential to transfer	high This depend on the selected design standard and the local situation and type of interchange. The description of the tool is very clear, and therefore easy to apply.

Design and planning of the pedestrian environment and public realm

Tool name	Design and planning of the pedestrian environment and public realm
Tool number	11
Tool description	This tool provides a range of references around key areas that can influence the environment for pedestrians and public spaces that play a key role in the creation of successful interchanges. The tool description refers to a number of guidance documents that have been developed to assist transport planners and urban designers consider the facilities and accommodation of pedestrians in the urban environment.
Nature of the tool	Methodological
Usefulness	high A very useful tool for guidance in the areas of public realm and planning of the pedestrian environment. Not too complicated to use although there requires some adaptation of principles for the scenario of public transport interchanges.
Effectiveness	high Tool has readily available reference material covering a variety of areas relative to the pedestrian environment / public realm albeit would benefit from greater references to other European countries approaches beyond the UK.
Financial feasibility	medium The costs may be very variable, depending on the location and available information.

Potential to transfer	high The principles of the tools can be easily understood and applied, but the implications may require some understanding of the options as these may conflict with other requirements.
------------------------------	---

Design and planning of security

Tool name	Design and planning of security
Tool number	12
Tool description	The design and planning of security at interchanges is a key element for their successful operation and the experience of the users of them. The selected documents provide guidance for design teams to achieve high standards of security at interchanges. Used standards are 'Security in Design of Stations (SIDOS)' and 'Park Mark'.
Nature of the tool	Methodological / organisational
Usefulness	high Adopting the principles and standards in these guides will help to improve security at interchanges and will ultimately have a positive impact on users' perception of security, thus improving the customer experience.
Effectiveness	high A useful and effective guide to reducing crime - both actual and perceived. The tool works on four levels: reduce crime within the facility, provide guidance to owners and operators, raise awareness that measures have been taken, and provide a design framework.
Financial feasibility	low low for the assessment, potentially high for the implementation.
Potential to transfer	high Park Mark is especially relevant for interchanges with parking to effectively reduce perceived and actual crime. The method is easy to use and delivers a clear standard.

Design and planning for users emotional needs

Tool name	Design and planning for users emotional needs
Tool number	14
Tool description	The Pyramid of Customer Needs forms the basis of the embedding of the customers interests and emotional needs when planning, (re)designing and managing an interchange. A combination can be made with the Station Experience Monitor (2) to measure the results.
Nature of the tool	Methodological / technical
Usefulness	high The tool is fully applied into the services of the Dutch railways in general including in the redesign of the three stations Rotterdam, Utrecht and s'Hertogenbosch. It is observed that at the main train stations in Europe a similar approach is followed, yet also in mayor bus stations such as in

	Madrid. It also found that in still far too many EU interchanges the functional design is solely present, or at least dominating the design and service provision. As a result these stations are not very attractive for the customers to be used.
Effectiveness	high The method is considered extremely relevant for the interchange and their managers. It allows them to get a true idea of all important features of an interchange experience of the customer. It also helps them to understand the relationship between the different features and importance of each of them in relation to the stage of the interchange and its services provided
Financial feasibility	low
Potential to transfer	high The tool is easily understandable and fully applicable in many (international) cases.

Topic 3: Intermodality and ICT

Human individualised information/orientation service to users

Tool name	Human individualised information/orientation service to users
Tool number	4
Tool description	The development of transport networks and multimodal interchanges, together with the evolution of customers' expectations, make interchanges' managers adapt the way they support passengers. Providing an information and guidance service to travellers implies to coordinate a team of people over the multimodal interchange area to ensure the information given is well understood and users are given the information they need. This service includes the deployment of service agents and the creation of a passenger information control centre coordinating them.
Nature of the tool	Organisational / technical
Usefulness	high The multimode interchange customer reception and information service responds to a demand expressed by travellers. It backs up the various static and dynamic traveller information media, especially when there are disruptions and with respect to persons with reduced mobility and occasional travellers.
Effectiveness	high It is very effective, especially for the travellers assisted.
Financial feasibility	low There are several costs, i.e. salary costs, operating costs and investments costs. Yet investments in human presence at the interchanges is considered valuable.
Potential to transfer	high Easy to transfer

Multimodal journey planner

Tool name	
Tool number	5
Tool description	A multimodal journey planner enables people to view the overall journey from a starting point to their ultimate destination. A journey may use a sequence of several modes of transport, meaning that the system must know about different public transport services available (e.g. bus, tram, metro, train, car sharing, carpooling, bike sharing, etc.) and about transportation networks (roads, footpaths, cycle routes) for private transportation (automobile, walking, bicycle).
Nature of the tool	Organisational / technical
Usefulness	high Technical support IT-wise is inevitable. There are different providers of IT-solutions that can be contacted to get a good system running
Effectiveness	medium To get a good use of the journey planner, different involved parties have to participate. On the one hand, the will to bring the journey planner into a running mode has to be present. Then, the necessary data must be provided and kept up to date.
Financial feasibility	medium
Potential to transfer	medium Potential for transfer is high under the condition that all operators participate.

Static/dynamic multimodal map of an interchange / Real time multimodal map of an interchange

Tool name	
Tool number	6
Tool description	The goal of this tool is to develop of a static/dynamic interchange multimodal interactive map (2D/3D), enabling users to get transport networks' information (e.g. stop points, routes, next departures, disruptions, etc.) and to visualize the interchange outdoor environment.
Nature of the tool	Organisational / technical
Usefulness	medium The benefits for passengers are relative to: reduction of transit time between one transport mode and the other; shorter itineraries for passengers; better integration of facilities with their surroundings; possibility to choose the transport mode in relation to habits and needs and to plan the journey from source to destination in real time; increased safety; better access; increased passenger satisfaction; comfortable way of travelling.
Effectiveness	medium The benefits for Public Authorities are relative to: increased public transport modal share; better image for public transport operators; modal shift from

	private to public means of transportation; reduced air pollution in the area.
Financial feasibility	medium In general, the costs depend on the type of maps and information systems chosen for the area and on the complexity and requirements of the data to provide, with particular reference to the type of user receiving the information.
Potential to transfer	medium Depending on the available resources the basic ideas are good to transfer.

Mobile application for users guidance at interchanges

Tool name	Mobile application for users guidance at interchanges
Tool number	8
Tool description	Mobile application for the guidance of users at interchanges through indoor and outdoor coverage. That tool consists in: using all mobile capacities to help passengers (with mobile phone, iPad, etc.) to orient themselves around and inside the station; providing orientation based service during passenger journey (in a mobility context).
Nature of the tool	Organisational / technical
Usefulness	low Guidance function as well as search function requires a digital description of the station. That description have to cover all existing facilities and equipment that can be indoor or outdoor. If that description does not already exist, a back office becomes necessary to produce this description.
Effectiveness	medium If the basics are available, especially for “mobile” passengers this tool can be really effective
Financial feasibility	medium Mobile application development is quiet low. Main cost have to be expected for the integration with existing Journey Planner and producing and indoor and outdoor map and navigation path if not available.
Potential to transfer	medium At present these type of tools are getting easier to be transferred

Way-finding guidelines / passenger information master plan

Tool name	Way-finding guidelines / passenger information master plan
Tool number	10
Tool description	This tool provides references to information that will assist promoters and designers with a knowledge to help support the delivery of improved pedestrian information and way finding. Arriving at an interchange and ensuring the next part of the journey is hassle free can only be achieved if users are informed of their travel choices either to connect with other modes

	or to reach a final destination.
Nature of the tool	Methodological / organisational
Usefulness	high The focus of this tool is on two very innovative information and navigation systems, with both systems being based on the progressive disclosure of information: "Legible London" and 'Interconnect' which are considered both very useful tools.
Effectiveness	high Using the guidance referenced in this tool will enable designers to plan appropriate interventions for information and wayfinding at interchanges.
Financial feasibility	medium It may require the appropriate experts / professionals within a design team to interpret how they can influence their own schemes.
Potential to transfer	high The potential for transfer is considered very high.

Signage at interchanges adapted to communication impaired people

Tool name	Signage at interchanges adapted to communication impaired people
Tool number	12
Tool description	Development of symbols adapted to mental/cognitive-impaired people, non-native and illiterate individuals at the interchange with the objective to improve the autonomy of transport users. The main intent of this tool is to improve the autonomy of mental/cognitive-impaired people, non-native and illiterate individuals at the interchange, through the development of adapted signage.
Nature of the tool	Methodological / organisational
Usefulness	high The purpose of signage is to manage and organize information in the most effective way for the pursuit of its broadcasting and communication. To be effective, signage has to be readable and get across clear and unmistakable information.
Effectiveness	high When appropriated implemented it is considered very effective for the impaired travellers.
Financial feasibility	low Costs depend on complexity and data requirements. The provision of static information can be considered as a low cost measure.
Potential to transfer	high This tool is considered to have a very high potential for transfer.

Passenger information for hearing impaired - Visio conference

Tool name	Passenger information for hearing impaired - Visio conference
Tool number	14
Tool description	Development of a sign language reception service intended for impaired hearing PRM customers, using sign language, for a multimode interchange through a video-interpretation system working thanks to a call centre employing qualified sign language interpreters and qualified/trained reception staff. This is a service for organisations receiving deaf members of the public who express themselves in sign language. It allows the deaf person and the hearing agent receiving them to exchange freely, via a sign language video-interpretation system.
Nature of the tool	Organisational / technical (software)
Usefulness	medium This tool is globally easy to use both for the user and the service manager. However a preparatory phase lasting several months is to be considered to take into account questions of technical conformance.
Effectiveness	high For the users it is very effective.
Financial feasibility	medium The costs includes installation of the necessary application by the service provider, annual subscription to the video-interpretation service, including maintenance of the application and the annual fixed price for communication and initial training.
Potential to transfer	medium The potential for transfer is proven and requires setting up an in-house training process, setting up of procedures aimed at checking and maintaining good quality of service and exchanges with users.

Accessibility master plan / guidelines for making interchanges accessible

Tool name	Accessibility master plan / guidelines for making interchanges accessible
Tool number	15
Tool description	Country specific guidelines for making interchanges accessible for all passengers are a good tool to utilise for accessibility at interchanges in all different stages. These guidelines are based on the legislative standards that are set at European level (e.g. TSI-PRM) and national level, and sometimes partly on voluntary standards. These guidelines often provide a hands-on guide with a step-by-step approach for designing, operating and maintaining an accessible interchange with technical information, tips and tricks and reference documents.
Nature of the tool	Legislative/regulatory, methodological
Usefulness	high Guidelines for making interchanges accessible provide a guidance for interchange designers and managers concerning accessibility.

Effectiveness	high Chapter on transport interchanges is more often than not included.
Financial feasibility	medium Using and implementing guidelines can engender considerable larger costs depending on the initial stage of the interchange or plans.
Potential to transfer	medium Guidelines are often based upon national regulation or structures and cannot always be completely transposed to another Member state although the guiding principle is EU legislation on accessibility.

ICT applications / services / assessment through consultation with PRM (Consultation process of PRM for interchanges' accessibility assessment)

Tool name	ICT applications / services / assessment through consultation with PRM
Tool number	16
Tool description	As the experts on problems relating to the travel of disabled people are the disabled people themselves, one must discuss their needs with them, and look into the different types of disability and the possible technical solutions that can make travelling easier for all in a multimodal interchange. These solutions are to be implemented once they have been tested by the concerned passengers.
Nature of the tool	Organisational / methodological
Usefulness	high A successful consultation can have a disproportionately beneficial outcome compared with the resources spent for preparing and carrying it out.
Effectiveness	high Consulting associations of people with reduced mobility will contribute to making the interchange more efficient, improving intermodality, accessibility and liveability of the interchange.
Financial feasibility	low The costs are considered reasonably low.
Potential to transfer	high Easy to transfer.

Integrated ticket assessment form for interchange stakeholders

Tool name	Integrated ticket assessment form for interchange stakeholders
Tool number	20
Tool description	Assessment form based on the interchange showing degree to which integrated tickets are available and for what categories of journey / passengers. A fully flexible spreadsheet tool that can be adapted to any interchange and any number of public transport operators.

Nature of the tool	Methodological / technological
Usefulness	low The tool can be used to assess current availability of integrated tickets or to plan improvements / alterations for improved integration.
Effectiveness	medium Consideration of integrated ticketing can contribute to ease of interchange for passengers thus making choosing public transport multi modal journeys an easier choice.
Financial feasibility	low The costs are considered to be minimal.
Potential to transfer	high It has a high potential for transfer.

Assessment tool – secure stations scheme, design and management audit

Tool name	Assessment tool – secure stations scheme, design and management audit
Tool number	24
Tool description	Secure Interchanges Scheme is a design and management audit allowing operators to assess their interchange’s secure status. The audit document enables gaps in security or other issues relating to the safety and security of passengers and staff at the station to be identified at any point in time.
Nature of the tool	Methodological / technological
Usefulness	medium Improvements can then be selected and prioritised and carried out together or incrementally to suit budgets and needs.
Effectiveness	low It was considered well-structured and well developed as it covers all aspects of the interchanges' safety and security assessment.
Financial feasibility	low Costs are not very high.
Potential to transfer	high The potential is for transfer is considered to be very high. It is important to create the right mind set.

Topic 4: Management and business models

Public-Private Partnerships

Tool name	Public-Private Partnerships
Tool number	2
Tool description	A Public-Private Partnership (PPP) is a long-term contractual agreement between a public agency and a private sector party to secure funding, construction or refurbishment, operation and maintenance of an (infrastructure) project and delivery of a service that traditionally was provided by the public sector.
Nature of the tool	Economic / Financial
Usefulness	high It describes how through partnerships with the private sector, interchange projects can be made more affordable and realizable in times of shortage of public funds.
Effectiveness	high PPP's have proven successful in many infrastructure projects, such as Madrid's concession model.
Financial feasibility	medium
Potential to transfer	medium It depends largely on the national / local legislative context.

EU funds for Interchanges

Tool name	EU funds for Interchanges
Tool number	3
Tool description	Requests for funding can be submitted in several ways: directly by the national government, the national agencies for the European Commission or directly at the European Commission. Due to the fact that the funding is almost never 100% city or region has to partially contribute as well in funding for build and operation of interchanges.
Nature of the tool	Economic / Financial
Usefulness	high It is relevant for large projects of strategic importance that respond to the funding call.
Effectiveness	high EU member states can learn from each other when applying EU funds.
Financial feasibility	low
Potential to transfer	high This type of funding can apply to any interchange that responds to the call.

Public investment banks

Tool name	Public investment banks
Tool number	4
Tool description	Investment banks have different mechanisms that can be applied to fund infrastructure projects, typically of large scale and high structural importance. Banks, be it at national, European (EIB), or international (World Bank) level, can provide loans to different infrastructure projects, including interchange projects of strategic importance.
Nature of the tool	Economic/Financial
Usefulness	medium It is relevant for large projects of strategic importance that respond to the funding call.
Effectiveness	high It is an effective funding tool as it guarantees consistent funding flows throughout the project duration.
Financial feasibility	low
Potential to transfer	high This type of funding can apply to any interchange that responds to the funding call

Corporations and joint ventures

Tool name	Corporations and joint ventures
Tool number	7
Tool description	This tool describes the organisational integration of infrastructure and property development through co-financing of property developers as part of wider property development scheme. Property companies can be involved in co-financing large-scale development projects involving renewal of transport interchanges.
Nature of the tool	Technical / organisational
Usefulness	high It describes good practices related to laws and regulations in France and the UK. It can apply to interchanges of any size and typology.
Effectiveness	high Implementation of organisational integration with property development has proven effective in the good practices described in the tool.
Financial feasibility	medium
Potential to transfer	medium If national laws and regulations need to allow for the integration, the tool can be easily transferrable.

Location Value Capture

Tool name	Location Value Capture
Tool number	8
Tool description	Location value capture (also known as Land Value Capture or Value Capture Finance) is the appropriation of value, generated by public sector intervention and private sector investment in relation to an underused asset (land and/or structure), for local re-investment to produce public goods and services and potential private benefit.
Nature of the tool	Economic/financial, legislative/regulatory
Usefulness	high The tool is becoming increasingly popular.
Effectiveness	medium It can bring financial return to both the public and private sectors.
Financial feasibility	high
Potential to transfer	medium There are many different types of Land Value Capture.

Specialised structural subsidiary bodies of railway companies

Tool name	Specialised structural subsidiary bodies of railway companies
Tool number	10
Tool description	These bodies are in charge of specialised tasks with regard to management of interchanges, such as property, station developments and marketing. Typically, these are subsidiary entities of national railway companies.
Nature of the tool	Organisational, economic/financial
Usefulness	medium The creation of a subsidiary is considered very useful if the scale for exploitation of the interchange is of considerable size and value.
Effectiveness	high It enables the responsible body to organise a true focus on the service provision to the traveller / customer and full commercial exploitation of the interchange and interchange area.
Financial feasibility	medium
Potential to transfer	high Subsidiary bodies already exist in several countries: the tool can help transferability to other countries.

Cooperation between stakeholders

Tool name	Cooperation between stakeholders
Tools number	12
Tool description	The co-existence of different transport stakeholders at interchanges and the necessity to make each of those systems interoperable with the others requires a coordinated approach through the cooperation of interchange stakeholders which form can vary (institutional cooperation through conventions / informal cooperation). It takes place in different forms depending on the stage of interchange development (design, construction, operation, management).
Nature of the tool	Organisational
Usefulness	medium It is useful in bringing operators and authorities together in a partnership, addressing the user needs.
Effectiveness	medium It can help improve safety and security management, accessibility at the interchange or passenger information provision.
Financial feasibility	medium
Potential to transfer	medium The method is considered extremely relevant for the larger interchanges, but could be fine-tuned to allow the consideration at smaller interchange.

Business case for public transport operators

Tool name	Business case for public transport operators
Tool number	13
Tool description	The land owner evaluates the type of contractual agreements with the service provider and investigates the most appropriate business case to integrate the different transport modes and service providers at the interchange.
Nature of the tool	Organisational, economic / financial
Usefulness	high The tool guides public transport operators in achieving the right and robust business case according to the traveller's needs. It should be consulted in combination with other tools.
Effectiveness	medium It can be effective in fostering collaboration among different operating entities.
Financial feasibility	low
Potential to transfer	medium It depends largely on modes and number of operators in the urban transport system.

Business case for park & ride facilities

Tool name	Business case for park & ride facilities
Tool number	14
Tool description	The land owner investigates the most appropriate business case, to construct and operate (or only operate) P&R facilities near or at the interchange. The facilities can be managed in a number of different ways, for example including a private entity.
Nature of the tool	Economic / financial, organisational
Usefulness	high An appropriate operation of a park and ride facility can have a significant impact on attractiveness of an interchange.
Effectiveness	high It can be effective in improving intermodality, improving transfer to public transport from the private car.
Financial feasibility	low
Potential to transfer	high Different models are described by the tool, according to the location and requirement of the interchange.

Quality plan for taxi services

Tool name	Quality plan for taxi services
Tool number	16
Tool description	A quality plan is a signed procedural agreement between the taxi providers and the interchange manager. Its main objective is the optimum provision of taxi services in or around the interchange. The plan includes a number of issues, from the technical design specification of the sidewalks that can smoothly drive users to/from the taxi till regulation issues about the services provided. The land owner evaluates the provision of taxi stands for the contractual agreement with taxi companies serving the interchange.
Nature of the tool	Organisational, methodological
Usefulness	medium It depends largely on the size and location of the interchange and the availability of public transport modes. Most relevant for large and out-of-town interchanges.
Effectiveness	medium If well implemented, taxis should be considered as a complementary mode to the public transport offer.
Financial feasibility	low
Potential to transfer	medium It largely depends on the priority given to different modes.

Exploitation of commercial services

Tool name	Exploitation of commercial services
Tool number	19
Tool description	A large interchange offers economic possibilities. At these large interchanges, where train, tram, metro and/or buses have their stops lots of passengers will pass by on a daily basis. The interchange manager can organise concessions for the exploitation of commercial space.
Nature of the tool	Economic / financial, methodological
Usefulness	medium This tool has been applied to in several locations. Commercial services are becoming increasingly important.
Effectiveness	medium A number of non-transport related services can significantly upgrade the attractiveness of the interchange as a destination also for non-travellers. Nevertheless, it needs to be respected that the travel experience should remain the priority of interchange functionality.
Financial feasibility	medium
Potential to transfer	high It can be implemented around any main interchange attracting a significant number of visitors.

Franchising of advertising space

Tool name	Franchising of advertising space
Tool number	21
Tool description	The infrastructure owner and commercial company that advertises their product are brought together by a separate company that franchises the advertising space. This intermediate party is responsible for the maintenance of the equipment and arranges the advertisement.
Nature of the tool	Economic / financial
Usefulness	high It is a useful tool for the infrastructure owner (interchange operator, municipality or transport company) as the costs for maintaining the space at interchanges are high (maintenance, cleanliness of space).
Effectiveness	medium It can be effective if the Local authority (owner of interchange space) has some control over the design of the advertising infrastructure.
Financial feasibility	low
Potential to transfer	high It can apply to interchanges of all typologies.

Safety and control strategy

Tool name	Safety and control strategy
Tool number	22
Tool description	Safety measures at interchanges include safety procedures, training programmes for staff, safety plans (control of fire hazards, maintenance office protection systems, building evacuation procedures), security risk assessment, regular safety tests, control systems (CCTV, staffing, emergency alarms, fire protection etc.), identification of potential risks for the transport infrastructure.
Nature of the tool	Organisational, methodological
Usefulness	high The tool gives concrete examples of safety management at interchanges.
Effectiveness	medium Safety and control strategies are basic requirements for interchanges.
Financial feasibility	high
Potential to transfer	high Safety standards and requirements are fairly similar across Europe.

Stakeholder consultation

Tool name	Stakeholder consultation
Tool number	23
Tool description	The co-existence of different transport stakeholders at interchanges and the necessity to make each of those systems interoperable with the others requires a coordinated approach through the cooperation of interchange stakeholders which form can vary (institutional cooperation through conventions / informal cooperation). It takes place in different forms depending on the stage of interchange development (design, construction, operation, management).
Nature of the tool	Organisational
Usefulness	high The tool outlines the many benefits of stakeholder consultation and provides general guidelines as well as concrete examples.
Effectiveness	high The tool can be very effective in reaching end user-friendly interchanges.
Financial feasibility	medium
Potential to transfer	high Requirements are fairly similar across Europe.

Topic 5: Energy and Environment

Environmentally Sustainable building Design (ESD) guide

Tool name	Environmentally Sustainable building Design (ESD) guide
Tool number	1
Tool description	This guide gives a basic introduction to ecological sustainability issues and specifically how the built environment affects them. The bulk of this guide outlines initiatives that can be put in place to minimise the environmental and social impacts of buildings.
Nature of the tool	Methodological
Usefulness	high The tool ESD design guide approaches different opportunities which all have the aim to minimize environmental impacts. For all these opportunities there are explanations how the opportunities and the aims can be reached. For stations with buildings the tool is very useful. For stations without buildings there are fewer opportunities that are useful.
Effectiveness	medium The tool has been successfully tested in Osnabrueck.
Financial feasibility	low The ESD guide is provided by the commonwealth of Australia (The Department of the Environment and Water Resource) for free. Further costs could arise for possible implementations.
Potential to transfer	medium The ESD guide can be transferred to any interchange. For interchanges without buildings there are a few opportunities that can be tested successfully.

Environmental noise control

Tool name	Environmental noise control
Tool number	8
Tool description	Noise control activities include legislating noise emission limits (and vibration emission limits) on equipment used in our communities, influencing the location and the construction techniques of new highways and buildings, legislating noise emission limits at property boundaries and regulating aircraft flight procedures.
Nature of the tool	Methodological, technical
Usefulness	high Environmental noise control is essential for every interchange during operation and construction for security and health reasons. Both reasons affect workers as well as the environment nearby, including the

	neighbourhood.
Effectiveness	high This tool has been successfully tested in Osnabrueck (Germany) and Reading (UK). Reading Borough Council implemented several noise control measures during the reconstruction of the interchange.
Financial feasibility	medium The use of the tool does not cost much. When it comes to implementation of specific methods the costs can arise easily.
Potential to transfer	high The tool can be transferred to any interchange easily because noise and vibration emissions have to be kept to a minimum or at least within the respective laws.

Measuring air quality

Tool name	Measuring air quality
Tool number	9
Tool description	This tool gives an overview of the different methods to measure air quality. Moreover the methods are described briefly. There are many ways to measure air pollution, with both simple chemical and physical methods and with more sophisticated electronic techniques. There are four main methods: Passive sampling where the flow of air is controlled by a physical process, such as diffusion. Active sampling means using physical or chemical methods to collect polluted air to be analysed later in a laboratory. Automatic methods produce high resolution measurements of pollutants. Remote optical analysers use spectroscopic techniques.
Nature of the tool	Methodological, technical
Usefulness	high Measuring air quality is essential for every interchange for health reasons.
Effectiveness	high The tool has been successfully tested in Reading and the air quality in and around the station can be measured by analyses from air which is collected by installed tubes.
Financial feasibility	medium The costs for using the tool are relatively low, but costs can vary regarding which air measuring method is going to be implemented.
Potential to transfer	high The tool is not specified for any type of interchanges and can be transferred easily.

Cross Topic Tools

Interchange users' satisfaction assessment – Station Experience Monitor

Tool name	Station Experience Monitor
Tool number	3
Tool description	Station Experience Monitor (SEM) - This instrument is used in the Netherlands, UK and several NODES interchanges to measure passenger station experience. SEM is a valuable and helpful standard instrument which has proven it's added value in the NODES projects, for measuring, monitoring and comparing customer experiences on an European level.
Nature of the tool	Methodological, organisational, technical
Usefulness	high The present instrument allows a correct analysis and appreciation of the results. Depending on the main mode of the station "train" can be changed if necessary into "bus, tram, or metro" station.
Effectiveness	high SEM is considered to be very effective and has all potential to become the European standard were it comes to measure customer experiences.
Financial feasibility	low Costs are considered to be very low. Especially when taking into account the benefits this is a very valuable tool.
Potential to transfer	high The SEM has been applied at 12 various stations in 7 cities

Sustainable Urban Mobility Plan (SUMP)

Tool name	Sustainable Urban Mobility Plan (SUMP)
Tool number	5
Tool description	Sustainable Urban Mobility Plan (SUMP) is a Strategic plan designed to satisfy the mobility needs of people and businesses in cities.
Nature of the tool	Legislative / regulatory / methodological
Usefulness	high The policies and measures defined in a SUMP comprehensively address all modes and forms of transport in the entire urban agglomeration.
Effectiveness	medium The status and quality interchanges can be considered as an integral part of the SUMP. Outdated interchanges should be updated.
Financial feasibility	high The full-fledged development of a SUMP might involve some medium high cost, as it implies a long planning, consultation and design
Potential to transfer	high Becoming an European standard potential for transfer is considered high.

2. Main barriers and enablers for successful implementation of the tools (Toolbox)

Process evaluation aims at identifying facilitators and barriers encountered during the tools implementation in the different reference sites. Process evaluation aims to gain insight into drivers (enablers) and barriers (impeding factors) during the tools implementation and validation.

Process evaluation in the NODES reference sites aims at **identifying facilitators and barriers** encountered during the tools implementation which will contribute to define recommendations making project's results transferable to other urban transport interchanges in European cities and beyond.

The main focus lies on the factors of success and how barriers are overcome to enable successful application and transferability in other transport interchanges of the tools tested in the reference sites characterized by different transport patterns, governance models, interchange's lifecycle, etc.

Process-related investigation areas include:

- institutional communication, technical cooperation, different governance level (European, National, Local) integrations bearing impacts on the tools implementation,
- policy, regulatory, organisational, technical, financial and legal frameworks bearing impacts on the process of the tools implementation in relation to interchange lifecycle,
- financial, economic and physical internal factors able to influence interchange performance,
- relevant stakeholders participation, cooperation, knowledge sharing and awareness.

2.1 Process barriers in the reference sites

Process barriers are local constraints or overlapping conditions that hampers the process during test and validation of the selected tools which have been implemented in the respective reference site.

A broader number of barrier fields (**impending factors**) have been considered including political / strategic barriers, legal / regulatory barriers, financial barriers, technological barriers, etc.

The most important barriers encountered during the implementation and testing of the selected tools and methodologies have been finally identified by the respective reference site partner.

Generalising the results achieved by the different reference sites through the process evaluation template used for data collection, most common barriers are listed as follows:

- **involvement / cooperation:** lack of cooperation and interaction among different organisations (e.g. city administration, public transport operators, rail transport operators, transport planners, etc.), insufficient awareness of key stakeholders, insufficient cooperation among different governance level, difficulty in obtaining stakeholder approvals, need of strong management to assure cooperation among different departments, lack of willingness from the operators' side to share real time transport data, public transport operators unwilling to share real time information and data, acquisition of the necessary data for multimodal journey planning requires cooperation among various stakeholders, stakeholders consultation process and agreements is a time consuming due to the involvement of many stakeholders;
- **political / strategic:** opposition of key actors based on political and/or strategic motives, different stakeholders with different visions and lack of motivation causing poor assistance, bureaucracy issues causing inflexibility for a number of issues related with interchange operation and management, bureaucracy issues causing serious delays in conducting a

mature study in support of the application for funding request (e.g. investment banks), no inclusion of people with reduced mobility (PRM) associations in the planning process;

- **legal / regulatory:** hierarchical structure of organisations, no clear role and jurisdiction of involved stakeholders (including overlapping responsibilities), difficult decision making process for complex-structured organisations, regulations and processes for some organisations leading to inability to deliver equipment within the project's timescale, need of formal approvals of city administration for permissions to install specific equipment (e.g. info kiosks, totem, etc.) outside the interchange, no regulation for the consistent use of transport and mobility simulation models for the planning process even when models exist, no legal framework to obligate operators for data provision, lack of a universal set of signage symbols, existence of a number of legal documents which should be merged in a unique codex (e.g. public work and services, etc.);
- **financial:** costly (funding and personnel) to develop and maintain an updated (simulation) model, budget cuts of the city administration (owner of interchanges) causing not implementation of planned interchange improvements, not enough resources for full-scale tools implementation, limited dedicated public funds, poor synergies with other organisations;
- **organisational:** insufficient partnership arrangements, lack of leadership, activities required a strong involvement of operative departments among different organisations, poor training activities for the tools usage and test, lack of incentives for P&R operator to increase revenues because of existence of a fixed compensatory payment for operation of P&R facility;
- **technical:** specialists and skilled persons support required to test a number of tools, difficult to figure out which organisation is able to provide necessary data for tools testing and validation, outdated data of transport and mobility simulation models, for interchange planning process it is possible that not all necessary data and relevant studies are available, internet connection issues that hindered the smooth operations of transport information systems;
- **cultural / social:** public sector in some Countries have in general not endorsed open data policies, customer satisfaction survey at interchange is not a common practice in some Countries, certain groups of end users have difficulties in using modern technologies, not consultation activities with people with reduced mobility (PRM) associations during the planning phase of ICT applications and dedicated facilities, legal departments of stakeholders are unwilling to share the legal documents (contracts), any specific life style patterns.

2.2 Process drivers (enablers) in the reference sites

Process drivers are local constraints or overlapping conditions that stimulates the process during test and validation of the selected tools which have been implemented in the respective reference site.

A broader number of driver field (**enablers**) have been considered including political / strategic drivers, legal / regulatory drivers, organisational drivers, financial drivers, technological drivers, etc.

The most important drivers encountered during the implementation and testing of the selected tools and methodologies have been finally identified by the respective reference site partner.

Generalising the results achieved by the different reference sites through the process evaluation template used for data collection, most common drivers are listed as follows:

- **involvement / cooperation:** constructive and open consultation, effective involvement of competent organizations and authorities, strong cooperation among different departments and/or governance level, raising awareness of key stakeholders, assisting decision making process and the prioritisation of targets, importance of assessing customer satisfaction;
- **political / strategic:** commitment of key actors based on political and/or strategic motives, presence of sustainable development vision and planning, contribution of many tools leading to a production of medium-long term delivery plan with wider stakeholder support, having a clear political steer which provides commitment as clear signal to partners/potential investors,
- **legal / regulatory:** less hierarchical structure of organisations, clear role and jurisdiction of involved stakeholders, fluid decision making process for simpler-structured organisations, smart formal approvals of city administration for permissions to install specific equipment (e.g. info kiosks, totem, etc.) outside the interchange, some specific regulation and habit for the use of transport and mobility simulation models for the planning process, etc.;
- **financial:** a number of low cost but very effective tools are accessible by the NODES Toolbox, significant investment from private partners as key factor in enabling the fullest support the project implementation, economically viable interchanges triggered testing of alternative business models and funding schemes, rational management of the P&R facility;
- **organisational:** effective partnership arrangement, the setting up of appropriate governance arrangements with stakeholders to take initiative forwards, individual motivation of all responsible people to a high degree existence of trained focus group moderator within organisation, know-how of key involved stakeholders;
- **technical:** high technical capacity and competences of in house personnel, interchange managers' awareness of the usefulness of real time information for transport users, existence of the software licence and transport and mobility simulation model as well as trained professionals, existence of strategic documents such interchange master plan, SUMP, etc.;
- **cultural / social:** citizens and users of transport service fully aware of the importance of real time information especially in interchanges, travellers confidence and familiarity in using google maps and apps (see multimodal journey planner), real-time multimodal passenger information is widely recognised as essential element of any modern interchange, real-time data facilitates public transport use and thereby attracting more users.

3. Lessons learned and recommendations

3.1 Key lessons learned from the reference sites

Urban interchanges play a key role for public transport success. An urban transport interchange is complex and interactive, where planning and internal / external cooperation among different organisations and stakeholder's categories are a key issue. Planning, organisational and methodological tools for local authorities and public transport operators are essential for the quality of service for end user. Interchange users' involvement and assessment is a key issue as well.

Key conditions to successfully exploit results elsewhere are, firstly, to find the leader of the overall project with the right abilities, competences and complex approach, who can set up and manage the team responsible for the implementation and developments of an interchange. The appointed leader

should have a strong vision regarding the aims and goals. Another key factor is to find the right person to cooperate with, within each organization. It is important to find the common aspects in different vision of different partners, because it could provide motivation for other stakeholders.

The contribution from all organisations that are responsible for transport infrastructure (e.g. stakeholders, city administration, public transport companies, rail operators, etc.) has to be in place. Competent organisation should have precise ideas in which field the interchange is supposed to be optimized (e.g. either energy and environment, intermodality, safety and security, etc.). Financial security from public and/or private parties should be guaranteed to realise needed improvements.

3.1.1 Lessons learned from the tool implementation

With regards to the NODES toolbox, the **tools tested in the different reference sites covered a wide range of activities, including planning, design and operation considerations**. Many tools were used to a greater or lesser degree in the different selected interchanges that tested the tools.

The main challenges encountered during the tools testing and overcome during the validation process have been as follows: to deal with the diversity of the interchanges in terms of perimeter of influence, ownerships, type of users, feeder modes of transport, transport patterns, local/national regulations, etc.; to find the right / competent person in charge in other organisations for cooperation and data sharing, providing the necessary information during the tools testing and implementation; to understand and accept the different scope and aims of the other stakeholders involved in the tools implementation as well as recognize the common aspects in these different visions; to value and optimize the interchanges (costs-quality of service ratio); to consider user perception of interchanges and integrating users' feedbacks in the interchange further improvements in terms of both interchange's infrastructures and services; the need to use specialists to support some technical (software) tools testing (e.g. Space Syntax); financial cuts of city administration (local authority) during the project lifetime, despite of specific plans were developed and planned to be implemented within the project's timescale; some tools were dimensioned mostly for (large) interchanges with buildings such as rail stations, thus some test results were less meaningful for smaller interchanges; delays in the construction of the interchange originally to be constructed within the project's timescale, causing some specific tools locally testing in other similar/comparable interchange.

The Station Experience Monitor (SEM), for instance, is a tool which assesses the customer experience of the interchange. Based on customer insights, policy is made, leading to targeted measures. The effects of measures are assessed using the SEM, determining the degree of improvement and to adjust policies.

Environmental stimuli such as sound, temperature, colour and smell are experienced unconscious, although they influence passengers' emotions and therefore their behaviour. A dirty, chaotic or noisy environment leads to unpleasant emotions, whereas a clean, tidy and quiet environment leads to positive emotions. The SEM therefore represents a valuable, effective and transferable instrument for monitoring customer experience, enabling to assess interchanges' strengths and weaknesses in terms of the customers experiences considering areas where interventions have the greatest impact.

Space Syntax (Macro, meso, micro) is another a very effective tool, which provides real benefits for the planning and design of larger interchanges but it requires the support of specialists for using the tool. Space Syntax is a tool which offers insight in accessibility and connectivity of a street in a network. Based on this theoretical pedestrian movement in and outside the interchange is estimated.

Reference site partners have learnt a lot from experiences coming from other public transport stakeholders throughout Europe. Experiences led on different reference sites give more inspiration

for future digital solutions that will contribute to improved performance of interchanges elsewhere in Europe and beyond. Other lesson learned are, among others, perceiving transport stations more as interchanges where to provide mobility services adapted to users and according to an integration approach, increasing coordination, cooperation, exchange of best practices and experiences, as well as definition of possible solutions to improve interchanges performances through the Toolbox.

The Toolbox contains a wide variety of tools: tools for strategic decision-makers (e.g. SUMP), tools for a complete diagnosis and identification of priority areas or mobility macro simulation tools, etc. Governmental organizations, Local Authorities, public transport operators, private stakeholders and other actors can choose the tools which cover their needs and well-fit their plans.

3.1.2 Lessons learned for the usage of the Toolbox

Building a new interchange implies a strong and effective coordination among the involved stakeholders than interchange refurbishing. In on-going process of developing interchanges in the upcoming years, the NODES Toolbox will provide new approaches as well as added value solutions.

Main lessons learned during the implementation of the NODES Toolbox in the sixteen (16) reference site's interchanges from the impact evaluation viewpoint have been to assess to what extent the application of the selected tools enabled to improve the interchanges performance in the evaluation areas of land use, transport, society, economy, energy and environment.

Eight (8) **strategic evaluation objectives** were defined during the evaluation planning phase (D5.1 Evaluation plan) properly reflecting the aforementioned evaluation areas as follows:

- enhance accessibility and integration (evaluation area: *Land use*)
- enhance intermodality (evaluation area: *Transport*)
- enhance liveability (evaluation area: *Society*)
- increase safety and security conditions (evaluation area: *Society*)
- increase economic viability and costs efficiency (evaluation area: *Economy*)
- stimulate local economy (evaluation area: *Economy*)
- increase environmental efficiency (evaluation area: *Energy and Environment*)
- increase energy efficiency (evaluation area: *Energy and Environment*)

On the basis of the impact evaluation results (in-depth described in the deliverable D5.2 Data set for each Reference Site) the strategic evaluation objectives have been achieved with different level of success based on the degree of the tools implementation as well as relevant physical (e.g. construction works, equipment installation, etc.) and organisational interventions (e.g. setting up public-private partnerships, contractual agreements with stakeholders, etc.) undertaken in the project timeframe.

As previously highlighted, the reference sites' interchanges on which the tools and methodologies, included in the Toolbox, were tested cover a wide spectrum of **interchange types** as follows:

- intermodal areas in large cities and tertiary (IA) – Rome, Thessaloniki, Osnabrück;

- second level interchanges in very large city/wider catchment area (SL) – Toulouse, Budapest, Thessaloniki;
- central interchanges in large city/wider catchment area (LS) – Reading, Netherlands, Rouen;
- central interchanges in very large city/wider catchment area (LD) – Toulouse, Netherlands, Birmingham.

In the meantime the reference sites cover a wide spectrum of **interchange improvement** as follows:

- newly build interchange (Thessaloniki),
- large restructuring of the interchange infrastructure (Reading, Netherlands),
- interchange refurbishment (Toulouse, Budapest, Birmingham),
- new organisational structures/management and services changes (Toulouse, Rome, Osnabrück),
- no changes foreseen (Toulouse, Rouen, Thessaloniki).

The aforementioned **coverage of wide spectrum of both interchange types and improvement enables to reach a potential high level of results transferability in other interchange in Europe and beyond** on the basis of different urban settlements, regulatory frameworks, transport patterns, modal split, management and business models as well as lifecycle of the site's interchanges.

The most effective tools and methods tested in the reference sites' interchanges which have been successful in terms of reaching the first strategic evaluation objective, are listed as follows:

Land use (enhance accessibility and integration):

- Tool for a complete diagnosis and identification of priority areas (Budapest)
- Tool to evaluate strategic scenarios for a new interchange (Thessaloniki, Birmingham)
- Typology visual tool (Reading, Budapest, Thessaloniki)
- Urban environment indicators toolkit (Budapest, Thessaloniki)
- Urban space interchange evaluation (Reading, Budapest, Thessaloniki, Birmingham)
- Urban integration (Space syntax: macro, meso, micro) – (Birmingham)
- Mobility micro simulation (Reading, Budapest)
- Trip generation assessment and analysis (Reading)
- Design and planning of the pedestrian environment and public real (Reading, Birmingham)

Lessons learned related to enhance accessibility and integration of an urban transport interchange using the combination of the relevant tools and methods of the NODES Toolbox can be summarized on the basis of the experience achieved in Toulouse, Reading, Budapest, Thessaloniki as well as Birmingham.

The Interchange Master Plan currently being developed in Toulouse is based on a diagnostic that exists and questions all the functions and aspects of the interchange: for each interchange development project, a ramification exists, so that all aspects impacting the project have been taken into account. The Reading station enhanced accessibility and integration through opening up the interchange to the north and south of the station and by improving the connecting pedestrian ways better such as to the platforms and car links as well as link them to the wider network.

The Ujpest City Gate in Budapest will become a significant role in improving the connection between the interchange and the city, increasing public transport use. Results of quantitative and qualitative assessment of different scenarios (network closeness / network straightness) in the MIKRA station in Thessaloniki by using a traffic simulation tool provided information about impacts of traveller movements to the interchange surrounding and wider city area. Thessaloniki's SUMP has already highly prioritised the need of interchanges in a transportation system that is currently changing in order to improve by others the quality of peoples' life and better connection with the other means of transport. Results of qualitative assessment using specialist consultants Space Syntax/JMP illustrated in the Snow Hill Interchange Plan (SHIP) in Birmingham provided different scenarios beyond the NODES project where Birmingham Snow Hill interchange will enable to reach seamless pedestrian movements in and around the station as well as to enhance its functional integration.

The most effective tools and methods tested in the reference sites' interchanges which have been successful in terms of reaching the second strategic evaluation objective, are listed as follows:

Transport (enhance intermodality):

- Assessment / survey and analysis (Toulouse)
- Human individualised information/orientation service to users (Toulouse)
- Multimodal journey planner (Toulouse, Reading, Budapest, Rouen, Rome, Thessaloniki, Osnabrück, Birmingham)
- Static/dynamic multimodal map of interchange / Real time multimodal map of an interchange (Toulouse, Reading, Budapest, Rouen, Rome, Thessaloniki, Birmingham)
- Mobile application for users guidance at interchanges (Toulouse, Rouen)
- Way-finding guidelines / passenger information master plan (Budapest)
- Integrated ticket assessment form for interchange stakeholders (Toulouse, Reading, Budapest)

Lessons learned related to enhance intermodality of an urban transport interchange using the combination of the relevant tools and methods of the NODES Toolbox can be summarized on the basis of the experience achieved in Toulouse, Reading, Budapest, Rouen, Rome, Thessaloniki, Osnabruck as well as Birmingham.

The info-mobility aspects have reached a prominent position in the public transport sector encouraged by the growing need for sustainable mobility, by the massive spread and pervasiveness of technology now released its economic and physical constraints, as well as by the need for better management and optimization of existing transport infrastructure assets.

In Toulouse, interactive maps of stations/interchanges and a mobile application (providing real-time information on board of bus, metro, light rail) were successfully improved. This application provides

information about the fastest travel route (door-to-door), next to departure times of all transport modes at the nearest stops, informs on upcoming news and changes within the network. The three public transport authorities in Toulouse (Tisséo, Arc-en-Ciel and SNCF) are thinking seriously - also on the basis of the experience achieved in the NODES tools testing – about the implementation of integrated fares to have a single tariff for using the public transport services within the urban, departmental and regional network, thus enhancing intermodality by integrated ticketing.

Reading station enhanced the number of train platforms and bus stops as well as the availability of bike storage and rental facilities. Based on the experiences and knowledge achieved through the relevant NODES tools testing, possible future improvements would be to upgrade the information board “PlusBus” in front of the station to a central bus information by showing more detailed information about bus services such as real-time special services and operational disruptions.

Ujpest City Gate Interchange in Budapest enhanced the linkage and transfer conditions between offered transport modes (train, metro, urban and suburban bus, P+R). Furthermore the introduction the FUTÁR passenger information system improved significantly the availability of real-time information about regular services and operational disruptions.

In Rouen, “Théâtre des Arts” interchange enhanced intermodality by the provision of real-time passenger information at all light rail and high level of service bus system stops as well as at passenger information kiosks. Based on the experiences achieved during the NODES tools implementation, future possible improvements to ease the intermodal transfer for all kind of public transport users (regular and occasional passengers, PRMs) will be the way finding inside the interchanges by mobile applications. Flaminio station in Rome enhanced intermodality by the provision of real-time passenger information (website and App) and different types of transport on-site information equipment (e.g. displays, totems, navigation signs, timetables, static maps, etc.).

In Thessaloniki, intermodality will be enhanced by the provision of improved static and real-time passenger information connecting public transport modes as well as physically improved walking connections. Birmingham Snow Hill interchange enhanced intermodality by the provision of different types of transport information equipment including, totems, navigation signs, timetables, etc.

The most effective tools and methods tested in the reference sites which have been successful in terms of reaching the third and fourth strategic evaluation objective, are listed as follows:

Society (enhance liveability, increase safety and security conditions):

- Customer / Stakeholder satisfaction evaluation (Toulouse, Reading, Budapest, Netherlands, Rome, Thessaloniki, Birmingham)
- Guidance for the planning /design of layout, accessibility, facilities and built form (Toulouse, Reading, Budapest)
- Design and planning for users emotional needs (Netherlands)
- Signage at interchanges adapted to communication impaired people (Toulouse)
- Passenger information for hearing impaired - Visio conference (Toulouse)
- ICT applications/services/assessment through PRM consultation (Toulouse, Thessaloniki)
- Design standards and data (Reading, Budapest)

- Design and planning of security (Toulouse, Reading)
- Assessment tool – secure stations scheme, design and management audit (Reading, Thessaloniki)
- Safety and control strategy (Toulouse)

Lessons learned related to enhance liveability as well as to increase safety and security conditions of an urban transport interchange using the combination of the relevant tools and methods of the NODES Toolbox can be summarized on the basis of the experience achieved in Toulouse, Reading, Budapest, Netherlands, Rome, Thessaloniki as well as Birmingham.

Improvements of the Toulouse interchanges were undertaken, notably improved escalators, updated signage (including the consideration of PRM needs), enhanced human presence and user guidance at the interchange as well as provision of passenger information for hearing impaired users through a system of visio-interpretation. At the Reading station a balance was found between extra spaces for pedestrians and the need for reasonable bus access and other vehicles to the town centre. Upon completion of the Reading interchange, its South West area has faced a great improvement compared to the previous messy interface outside the station and has become a more attractive and provides opportunities for people to come together as well as is supportive of local businesses.

The SEM was applied on the Netherlands reference sites to assess the impact of interchange improvements in terms of passenger station experience. The results have been used to adapt and steer the customer oriented organisation and design of the station. Liveability at the Flaminio station in Rome needs to be enhanced by creating a high quality passenger information system based on a proper design of facilities (static/interactive maps, dynamic light rail stop totem, signage system).

In Thessaloniki, through the shift of the IKEA interchange to the MIKRA interchange location (once it becomes operational), waiting conditions (weather protection) and offered services for connecting transport modes (P+R, taxi, car sharing) will be enhanced. In addition the transfer conditions will considerably be changed to achieve a more liveable and user-friendly interchange. In Birmingham Snow Hill interchange, perception of safety was measured as part of the SEM testing, enabling to provide a summary of the passengers' experience including feeling of safety.

The most effective tools and methods tested in the reference sites which have been successful in terms of reaching the fifth and sixth strategic evaluation objective, are listed as follows:

Economy (increase economic viability and costs efficiency, stimulate local economy):

- Public-Private Partnerships (Toulouse, Thessaloniki)
- EU funds for Interchanges (Thessaloniki)
- Public investment banks (Thessaloniki)
- Corporations and joint ventures (Toulouse)
- Location Value Capture (Toulouse)
- Specialised structural subsidiary bodies of railway companies (Netherlands)
- Cooperation between stakeholders (Netherlands, Thessaloniki)

- Business case for public transport operators (Thessaloniki)
- Stakeholder consultation (Toulouse, Thessaloniki)
- Business case for park & ride facilities (Thessaloniki)
- Quality plan for taxi services (Netherlands, Thessaloniki)
- Exploitation of commercial services (Toulouse)
- Franchising of advertising space (Toulouse)

Lessons learned related to increase economic viability and costs efficiency as well as stimulate local economy of an urban transport interchange using the combination of the relevant tools and methods of the NODES Toolbox can be summarized on the basis of the experience achieved in Toulouse and Thessaloniki.

In Toulouse, the main lesson learned is to consider a global economic model for the interchange by analysing the possible activities at interchanges such advertising spaces, commercial leases and other market and non-market services, etc. The tool “Contractual/ management and operational agreements between stakeholders” provided added value proposals as well as possible solutions to be implemented to increase costs efficiency and stimulate local economy.

In Thessaloniki, a study to test different management and operational models for the interchange's expansion - including retail and entertainment facilities with the Memorandum of Cooperation between ATTIKO METRO and ThePTA - is planned to better assess potential impacts of business collaborations. The local economy benefits considerably by providing more direct jobs due to the supply of more non-transport related services.

The most effective tools and methods tested in the reference sites' interchanges which have been successful in terms of reaching the seventh and eighth strategic objective, are listed as follows:

Energy and Environment (increase energy and environmental efficiency):

- Environmentally Sustainable building Design (ESD) guide (Osnabrück)
- Environmental noise control (Osnabrück, Reading)
- Measuring air quality (Osnabrück, Reading)

Lessons learned related to increase energy and environmental efficiency of an urban transport interchange using the combination of the relevant tools and methods of the NODES Toolbox can be summarized on the basis of the experience achieved in Reading, Netherlands and Osnabrück.

During the Reading Station construction locally sourced materials were used to reduce CO2 emissions as well as promoting local industry. The rebuilding of Reading Station and interchanges used a highly effective waste management plan during the construction process. 25,597 tonnes of materials were recycled and reused.

In Osnabrück, the national law / regulatory framework strongly influenced executing construction works in the Neumarkt interchange in terms of waste avoidance and reduction as well as recycling and secure waste disposals. In the meantime, the Noise Action Plan for the city of Osnabrück

provides current and future measures (e.g. 30 km/h zones close to interchange zone, use of low-noise material for the reconstruction of traffic lands, etc.) to be applied for reducing the noise level.

Rotterdam Centraal station in Netherlands enhanced the energy efficiency of the interchange by using energy from solar panels (renewable energy production) used for the escalators, lifts and lighting at the interchange. The solar cells achieve a 8% reduction of the station's overall CO₂ emissions.

3.2 Transferable roadmap for efficient and sustainable urban interchanges

The proposed transferable roadmap covers the three main stages of any urban transport interchange's lifecycle as follows:

- planning,
- design,
- operation.

Which are main issues to pay attention for planning, design and management of urban interchange?

The overall aim is to provide an effective and smart pathway (roadmap) for supporting competent Local Authorities and interchange managers / promoters to plan, 2) design and 3) manage of urban transport interchanges based on the NODES experience and the final results of the tools testing.

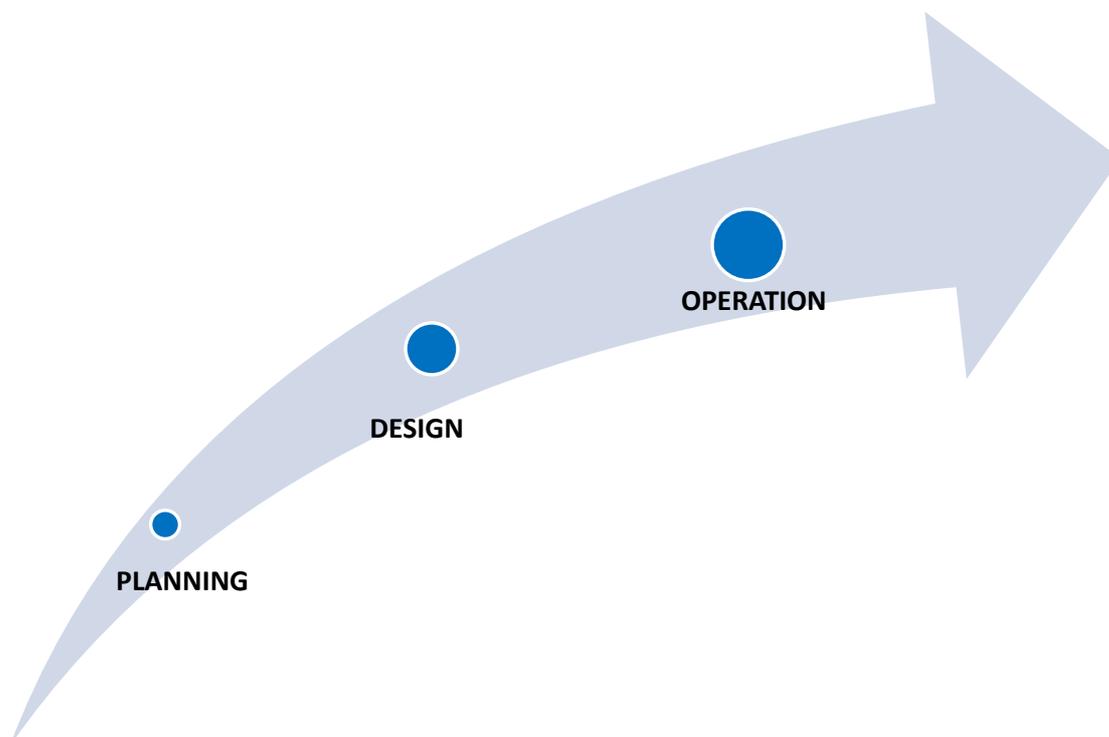


Figure 1 - Transport interchange's lifecycle

Planning

Many businesses see great value in high intermodal and international accessibility. They are likely to settle in direct proximity of large public transport interchanges. The attractiveness of an interchange for urban development around it also depends on its proximity to highways and airports.

Achieving balance in functional diversity and different user groups of interchanges contributes to reduce mono-functionality and social exclusion. To provide a full spectrum of urban street life inside and around an interchange, public and semi-public functions such as libraries, theatres, sports facilities, schools, day care centres and medical services contribute to attracting users. The potential for denser, innovative development and the resulting social and commercial opportunities can be better used through stacked programme. Development of high or medium rise building typologies has advantages, such as possibilities for joint development and mixed use of apartments, retail and various services. Intensive way of building and concentrating different functions encourages use of public transport, and takes pressure off large-scale development in suburban areas.

Interchanges would benefit from cross-sectoral mechanisms for delivering higher density development around public transport interchanges, founded on an understanding of the interrelationships between accessibility, location, design and intensity of land use. Such an approach could unite land use planning and the development industry with transport planning.

In order to achieve this the following issues have to be dealt with:

- **Increased coordination:** at interchanges different sectors and different policy and territorial levels come together. It is about transport traffic and mobility, yet also about living, working and commerce. The local, regional and (inter-) national level are involved. More cooperation should take place between interchange managers, operators, local and regional policy makers and area developers. The NODES planning tools can provide the technical basis on which this coordination and the different planning discussions can be implemented.
- **Creation of a wider acceptance:** inclusion of the citizens and business, such as local in the case of small interchanges and regional in case of larger interchanges, should help to create a wider acceptance and better integration of the interchange in its urban and social local environment. This should be a two-way communication. It allows the local government to explain the need of an improved urban transport interchange, also allowing the local government to learn from the very local experiences of the involved citizens and businesses.
- **Public-private cooperation:** intelligent forms of public private cooperation allow to get better planned and quality urban transport interchanges. Avoiding that all risks are with the authorities, the local authorities should provide the first stimulation (e.g. in the form of subsidies; simplifying local regulation, or investments in the public space). Private parties can also be asked to invest a percentage of the investments costs in additional improvements.
- **Development of business cases:** during the planning phase the different actors should regard with more attention the potential business case of the transport interchange that make the new or improved infrastructure financially, socially and environmentally more profitable. Business cases should take also into account an increased integration of the local environment with the interchange as well as multimodal functions of the interchange itself.

Design

Designing is proposing interventions: changes in a current situation (temporal aspect) for a current condition taking into account a future, projected state of the context and expected performance of a design. Either designing a new interchange, or improving an existing interchange, the design interventions will affect the object and its context.

The design of interchanges differs in nature based on construction and configuration, programme, facilities and services offered, modes of transportation integrated and scale of these modes, and finally contextual aspects such as location and position in the (urban) environment and transport network. Based on these principle interchanges can be classified in typologies. Every type of transport interchange has its own requirements, requiring a specific set of valid tools and effective strategies and therefore specifically applicable criteria and valuable indicators.

On a strategic level, the key in designing new interchanges or preparing designs for current interchanges is looking from the perspective of the user. While interchanging, every user is a pedestrian. User oriented design is essential to deliver the suitable design framework, to set the right design goals and to apply the appropriate means to fulfil the design requirements.

Main action points are listed as follows:

- **User-oriented design approach** versus (main) mode of transportation: during the design phase, all actors should take into account the perspective of the (end) user. Performance of various design scenarios should be measured using (key) performance indicators. The importance of slow-modes and local access should not be underestimated.
- **Transfer quality** (intermodality) versus **staying quality** (liveability): the more an interchange is optimised by offering adequate facilities reducing transfer distance, time and effort, the less services are required and beneficial. On the other hand, services are required to reduce the impact of waiting time, e.g. by offering comfort and conditions for a pleasant stay. Besides, the 'destination' functions can become the main attractor of the interchange, conflicting with the main purpose of the interchange: being a transfer node in a transport network.
- **Accessibility and integration** (configuration): a key issue in design is the integration in its surroundings for different modes of transportation, offering easy access for all types of users. Important is not only the connections made, but also specifically the way the interchange is organised: the configuration of the components of the nodes determines the internal and external accessibility and potential integration.
- **Spatial and architectural quality of design** (type of interchange): an interchange should be an attractive 'building', fitting into its spatial context, offering a sustainable and durable solution. Internally, the architecture should provide a clear understanding of the structure. Especially, in multilevel and underground interchanges, the recognition of the structure is essential.
- **Spatial-temporal situation**: in design the temporal aspect of use, either the daily rhythm, or the weekly, monthly and yearly characteristics of use and flows of travellers should be taken into account. During the day, flows shift in intensity and between modes. The design should not only be robust to comply with rush hours conditions: peaks in transfer movements and a high amount of vehicle moves, but also consider the conditions during off-peak hours. Besides, in time the configuration or flows within the node might shift, revealing other patterns of use and thus influencing spatial-temporal conditions.

Operation

Efficient day-to-day management and operation of an urban transport interchange depends largely on established partnerships, good cooperation and communication between the different stakeholders. It is essential to identify the potential stakeholders to be considered in the management and operation of the interchange. These are:

- Interchange manager(s)
- Transport authority(s) or other local authorities
- Transport operator(s)
- Property owner(s): land owner(s) / building owner(s) or specific subsidiary dealing with management of the commercial space; local shop owners
- Emergency and security services
- Retailers

Evidence from surveys shows that a large number of key players and bodies generally make the planning and building process of interchanges more complex, protracted and costly. Having different persons and bodies responsible for different areas and/or modes can lead to poor management and organisation of public transport and interchanges, with negative consequences (e.g. transport services are not synchronised, through-ticketing is not available, staff are not able to answer enquiries about onward travel, etc.). Deregulation and privatization, without careful public control and co-ordination, have generally exacerbated integration problems.

A nominated responsible party for operations of the interchange, or 'station manager' should be in charge of the daily operations. Specific tasks such as the management of commercial spaces can be separated from the daily management by the establishment of a subsidiary company. Specific aspects of interchange management can be taken up by specific groups of stakeholders (e.g. 'bus interchange group' bringing together bus operators, etc.).

The interchange site manager:

- ensures compliance with agreements and conventions,
- ensures the monitoring of customer satisfaction,
- coordinated follow-up meetings,
- monitors the quality indicators (quality methodology),
- tracks the corrective actions.

If an interchange facility is owned, managed or served by more than one organisation, the parties involved should agree cooperative procedures.

Ideally, these procedures will be set out in an interchange facility management agreement to:

- **Identify interfaces** between all the parties involved in managing and serving the transport interchange facility including external bodies, particularly the fire brigade, ambulance service, police and local authorities.
- **Establish clear responsibilities** for managing these interfaces and provide **unambiguous accountabilities** for the tasks that are required to ensure that the interchange facility operates successfully.
- Establish a **Memorandum of Understanding** between the involved partners.

Procedures should cover day-to-day operation of the transport interchange facility and stipulate what should happen in case of an emergency or service disruption. Interchange facility management agreements should not be made in isolation from existing agreements, such as for staffing, but should be built into them if commercially or legally feasible, and supplement them where it is not.

A unique stakeholder for transversal tasks and on every multimodal interchange would be relevant, with redistribution of charges and allocation by quotas.

Cooperation needs to take place at different levels:

- cooperation with energy suppliers, water and waste management,
- cooperation with architects and urban planners,
- cooperation with retail shops and food outlets,
- cooperation with fire & police departments in the definition of safety plans,

According with user needs and requirements, urban transport interchanges should offer an increasing variety of services and functions. This puts more strain on operations and management which becomes more complex. Establishing relationships between the different stakeholders to define clear responsibilities in management/operational task for a user-friendly interchanges.

3.3 Final recommendations

The NODES Toolbox enables to support decision making, allowing an integrated and balanced realisation process from the initial planning phase of an interchange, up to its operation and management. The different tools and innovative strategies implemented in the NODES reference sites' interchanges provided valuable contributions in reaching the strategic evaluation objectives defined during evaluation planning phase, properly reflecting the respective evaluation areas.

1) *Enhancing accessibility and integration of urban transport interchanges*

Enhancing accessibility of an interchange (including interchange zone) should cover a range of different aspects of planning and design activities such as land use planning and interchange design.

Effective access to interchange's transport services and facilities, allowing easy and fast movements within the interchange as well as the surrounding area (interchange zone), should be properly addressed through careful planning and design of the local built environment recognising the user needs. **Enhancing urban and mobility integration of interchanges (including interchange zone) is recommended to be properly addressed during planning, design, (re-)design as well as construction of an urban transport interchange.** Transport interchange is recommended to be located in a strategic urban environment and conveniently integrated for the functional and aesthetic viewpoint. It is very important to understand the whole system of land use and mobility dynamics.

The recommended NODES tools and strategies:

- Tool for a complete diagnosis and identification of priority areas
- Tool to evaluate strategic scenarios for a new interchange
- Urban environment indicators toolkit
- Typology visual tool
- Urban space interchange evaluation
- Space Syntax
- Mobility micro simulation
- Design and planning of the pedestrian environment and public realm

The **tool for a complete diagnosis and identification of priority areas** of the NODES toolbox is recommended to support decision makers and planners enabling to create an accurate analysis and indicating areas of potential interventions.

Strategic decisions for a new interchange development by evaluating different possible alternatives (scenarios) are recommended to be taken through the possible support of innovative tools such as the **tool to evaluate strategic scenarios for a new interchange**. It is important to completely understand the public transport network, its integration, its needs and priority areas for intervention and/or investment; whereas a simple tool enables to guide strategic projects of a new transport interchange. At a city or regional level, there are many factors that usually lead to the final decision for the interchange location such as already existing intermodal connections points that require improvements, extensions or a completely new facilities, already existing transport stations to be expanded or re-designed to host new transport modes or lines, availability of public land of a certain required size in the city, investment opportunities in strategic locations of the city, etc.

Key indicators to be considered for the selection of most effective location of an urban transport interchange are “closeness centrality” and “straightness centrality”.

“Closeness centrality” enables to measure how near an interchange is to all the other nodes along the shortest paths using travel time. It describes the ease of movement along the public transport network, in terms of speed and service frequency. Closeness centrality of the interchange can be calculated as the average travel time to all other transport nodes of the network. This is an indicator of objective accessibility and strategic position and helps to identify and measure potentialities as an origin or destination. The impact of the interchange on closeness centrality of the other transport nodes is also recommended to be analysed and assessed.

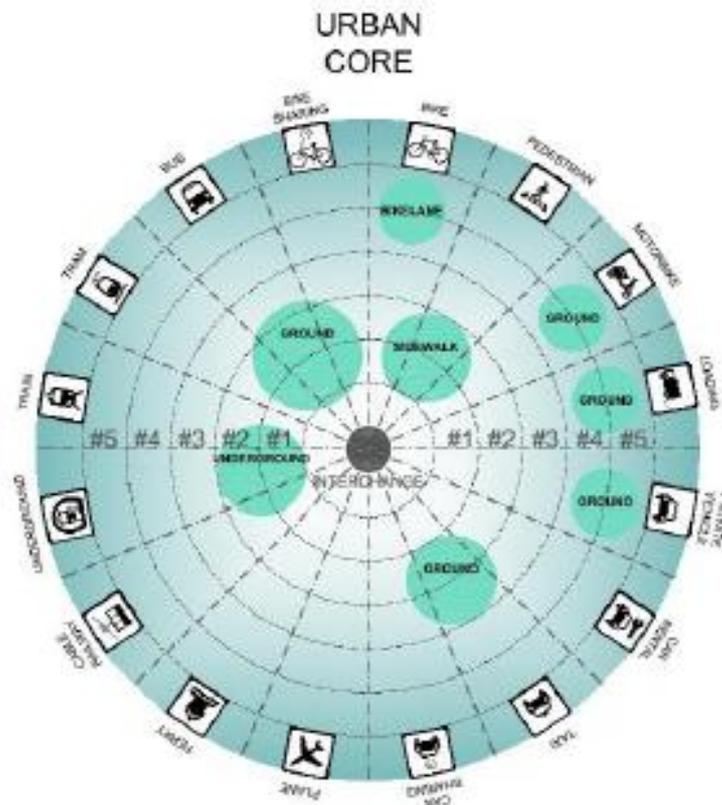
“Straightness centrality” enables to describe directness of journeys along the public transport network, focusing on the number of transfers. It is a topological network indicator, measuring average minimum number of transfers between the interchange and any other node. The impact of the interchange on straightness centrality of the other transport nodes is recommended to be assessed.

A new interchange must have a positive impact on the whole transport network efficiency and mobility integration. By providing new connections between nodes, lines and transport modes, an interchange should have a direct impact on straightness centrality of the other transport nodes, causing a general reduction of necessary transfers. The average of variations in straightness centrality values of the entire network is therefore another important indicator to be considered during the process of planning and design of a new urban transport interchange.

For enhancing accessibility and integration during interchange planning process, it is recommended to use an orthological approach enabling to quantify relevant key indicators describing the urban complexity around the interchange. It is important to choose indicators able to be a synthesis of the key issues within the planning process that affect transport demand (access and dispersal) and transport performance in general. The **urban environment indicators toolkit** of the NODES toolbox can support in analysing the urban environment. It enables to evaluate alternatives setting recommended location of an interchange. The tool indicates quantitative targets to be reached concerning: a) built density, b) morpho-typology, c) land use and d) economical activities.

Understanding and comparison of the various types of transport interchanges beyond any adjective or classification is another important aspect when planning or design an interchange. **Typology visual tool** included in the NODES toolbox enables to understand from the beginning facility requirements and design stakes of each interchange, comparing various types of interchanges. The circle-shaped interchange typology diagram is able to support understanding of urban implications, space and design requirements, according to different transport modes, urban position, land availability, etc. It gives a simple solution to show and summarize the spaces required by different modes. Planners can easily compare the space required by bus station, parking lot, P+R, etc.

The position of the circle (distance to the diagram centre) enables to identify the level of integration within the interchange area, which indicates the hierarchy of access as follows: (1st) closest to the diagram centre being excellent access; (2st) quite satisfactory access; (3st) average access; (4st) quite unsatisfactory access; (5st) very unsatisfactory access. It is important to assess the position of facilities with regard to their level of integration within the interchange area and the size of the circle (small, medium, large) for each transport mode identifying the size or level of facility for each mode.



For enhancing accessibility and integration of an interchange, it is recommended to identify any physical barriers on main routes of passengers within the interchange and in the surrounding areas.

Design of the urban public spaces around the interchange is crucial for its final success and performance. Different urban designers' proposals as well as transport planners' proposals should be evaluated. It is important to provide useful benchmarks for metrics which can help to site an interchange in an optimum location. Clear targets for the development of entry / exit routes between the interchange and the immediate urban public spaces is a key aspects to take in considerations in the decision making process. **Urban space interchange evaluation** of the NODES toolbox allows improving the interchange urban integration, guiding pedestrian in-out flows and access in a coherent and proper way according to the city area and the interchange design.

The aforementioned tool recommends key principles as follows:

- bus/tram stops and underground/railway station entrances must be in direct visual connection to one another;
- the most direct path between each stops / entrances must be analysed; when it is not possible to walk following the straightest line (the visual connection), it must be checked that the shortest itinerary: not deviating from a straight line of more than 10 meters, not implying more than 3 turns, not including any discouraging elements being disincentive to transfer;
- the shortest itinerary must satisfy the requirements of proximity, safety, comfort, but also attractiveness, assuring a high quality design and locating liveable elements in the path;

- waiting time is one of the most discouraging factors, according to most travellers; thus it is important to locate waiting areas in positions where users may keep themselves entertained at least by watching other people (e.g. people staying in urban spaces, shopping, etc.).

Transport interchanges must be located in strategic positions within the city. Space Syntax studies have developed several modelling tools for urban planning and design in order to “create the right places” to host specific land uses, therefore considered ahead during the planning stage.

The **Space Syntax** axial model is recommended to measure to what extent transport interchanges are located in a “strategic positions” within the transport network and integrated in the urban environment. Therefore, the NODES project recommends to use Space Syntax (macro, meso, micro) to assess urban integration of transport interchanges. The tool consists of a software platform in which cartographies of current or alternative project scenarios are analysed. An expert is required during the process and for the interpretation of results. Space Syntax theory and methodology provides effective tools to understand and predict passengers’ behaviour in relation to the design of the interchange. It analyses passenger flows and way-finding based on visibility criteria. Therefore, Space Syntax may help to find optimal places to locate/allocate information according to each objective. Space Syntax sets a common evidence-based framework in order to detect visually more integrated places, as well as key locations, in order to satisfy traveller information needs both at the moment of accessing/leaving the interchange and during transfers. Syntax can be used by interchanges stakeholders for: visual integration (eye-level), visual integration (foot-level) or isovist analysis from emergency exits. Space Syntax followed a statistically significant sample of the population using the station, recording the paths chosen for interchange as well as from the main entrances to the surrounding area. This showed the volume of people using the station as an interchange and also as a transport destination for the city centre. The analysis provided a clear picture of the preferred routes within the station towards the surrounding areas.

Mobility micro simulation models are also effective in the assessment of the “hinterland” of the interchange. Micro simulation models simulate the characteristics and interactions of individual vehicles. Micro-simulation procedures are powerful tools that can provide qualitative and quantitative impact assessment and examine various policy scenarios in micro scale base, both in demand and supply side. Micro-simulation models simulate the characteristics and interactions of individual vehicles or pedestrians. The level of analysis is usually an intersection, section of road or a complex space. This approach has procedures and rules for vehicle acceleration, lane-changing and passing manoeuvres, as well as for pedestrian movements. The micro-simulation models are effective in evaluating changes to lane and intersection geometry, as well as spatial configuration and design. However, due to the very detailed scale and data precision, this tool is not appropriate for the analysis of large areas. A team of experts is required during the process and for the interpretation of results. There is a wide range of scenarios for which micro-simulation models is recommended to be used: one of these scenarios is the modelling of an urban transport interchange.

Pedestrian simulation is also important to the assessment process: infrastructure operators and interchange managers are turning to pedestrian simulation, whether to analyse designs in the project phase, before making irreversible planning decisions and implementing specific designs or to optimise existing infrastructure. Pedestrians are often very adaptable and pedestrian movements in congested areas can flow almost as a liquid would flow around obstructions and through available gaps. Where large pedestrian flows exist and poor facilities or insufficient space is provided these flows can cause physical discomfort and even safety issues. **Design and planning of the pedestrian environment and public realm** can properly guide planners in well facing these issues.

2) Enhancing intermodality of urban transport interchanges

Transport interchanges should guarantee an effective intermodality to minimise distance and time taken between the different transport modes (both public transport and feeder modes) through integration of transport modes, information, signalling as well as ticketing integration.

Interchanges planning requires an overall conception articulating different modes (e.g. metro, tram, urban and interurban bus, bike sharing, car sharing, carpooling, taxi, pedestrian, personal vehicles, coach, high-speed line, etc.) and Information and Communication Technologies (ICT) solutions play an increasing role and actively contribute to the general performance of transport interchanges in cities. ICT enables to facilitate intermodality at interchanges, by contributing to provide quality passenger information services, reducing connection times from one transport mode to another through smart and integrated ticketing systems as well as ensuring safety and security at the interchange through monitoring systems. Information is crucial for interchange's users and travellers.

Passenger information should take various forms and be distributed through different media of dissemination, in particular static (signage and wayfinding), dynamic (including real-time), spoken and tactile (in particular for visually impaired people). Static information should always be provided through both symbols and written information to be easily understood by interchanges' users.

Mapping is essential for travellers to orientate themselves in space, find the path to follow, find the location of the right platform. Transport passenger dynamic information, given its capacity to be provided in real time and to be modified, is able to respond to users' increasing expectations.

Dynamic information can be updated static information or differed information (update of theoretical information related to a given period of time) or real-time information (theoretical time removed from the display after each departure through an update, indication of waiting time before next mode arrival time, information on disruptions and incidents). It can be disseminated through various visual and audio media: different types of displays, Visual Management Systems, kiosks, information points, mobile devices, etc. Interactive kiosks and physical information points deliver a customized information to respond to users specific inquiries. Information is used by a variety of people at an interchange, including citizens or public transport users, subscribers (frequent) or occasional users, native or non-native speaker users and able-bodied people or Persons with Reduced Mobility (PRM).

Cooperation of the different transport stakeholders involved at the interchange is crucial. Indeed, both static and dynamic information depends on the commitment and the coordination of all actors involved being able to provide adapted information solutions to users. Legislation / regulation and standards, in particular at EU level, are favouring the provision of common and thus legible information to users through encouraged exchange of data between stakeholders.

The recommended NODES tools and strategies:

- Multimodal journey planner
- Static/dynamic multimodal interactive map of interchange
- Real-time multimodal map of an interchange
- Mobile application for users guidance at interchanges
- Integrated ticketing solutions

Multimodal journey planner is a service based on a system enabling to provide travellers with an itinerary for an intermodal passenger transport journey. The multi-modal journey planner is an effective, IT-based tool to optimize a journey with different modes. It should be reachable via internet, tablets and mobile phones as well. A trip with multiple transport modes, requires a coordination of these. The system can provide timetable, routing and other travel information. A multimodal journey planner is a great addition to the interchange enabling to plan trips in advance. Data provisioning is a key issue for the quality of journey planner services. Data provisioning consists in merging data coming from different stakeholders (transport data owners). To integrate real time information into the journey planner it is recommended to invest time and resources to improve info-mobility services.

For enhancing intermodality of urban transport interchanges, it is recommended to develop a **static/dynamic multimodal interactive map of interchange** (2D/3D), enabling users to get transport networks' information (e.g. stop points, routes, next departures, disruptions, etc.) and to visualize the interchange outdoor environment with the visualisation/cartography of the different levels of services existing at the interchange. Moreover, it is recommended to develop a **real-time multimodal map of an interchange** (including static and disruptions information) through dynamic panels (totems), station displays, mobile application, NFC solutions as well as other innovative tools.

It is recommended to implement a web-based innovative, multimodal, geo-referenced and personalized system to ensure efficient interoperability between different modes of transport in the transport interchange, with benefits for the individual and for the community. It is a way to harmonize and integrate the information systems related to unimodal transport in a single information platform by collecting, merging and processing of databases of different public transport operators.

Paper-version of multimodal map is the cheaper solution, with minimal maintenance. Digital version of multimodal map can display an amount of information and combined with real-time information of transport lines and (for example) detailed information of nearby shops and stores, it can be the ultimate tool of providing information. In this case, it requires much more effort to keep it up-to date.

Dynamic or static multimodal maps can be designed to effectively enable travellers to negotiate the interchange from arrival using one mode to departure using another. Interchange maps should be designed to be centred on the station and guide travellers from platforms to bus stop and vice versa.

Interchange maps can be complex or can be very simple. Two key requirements are remarked as follows: 1) maps must be as up to date as possible and be able to be changed when locations or services change; 2) maps need to actually be displayed at or in the interchange(s).

Real-time multimodal information display is an effective way to provide up-to-date information, mostly on dedicated screens. Providing real-time information makes the journey predictable and convenient. Malfunctions, breakdowns and replacements can be easily communicated. The multimodal displaying of real-time information can be realized as screens of different modes, operators, etc. collected to one (or more) point of the interchange. This is the much simpler solution, because all the operators can provide their own equipment's, data's, employee of maintenance, etc. - but the different structures of information (e.g. different font types and colours, pictograms) can be very confusing, so some basic agreements are recommended. Accurate and real time travel information at interchanges make public transport an attractive and high-quality alternative to traveling by car. Availability of real time transport information at interchanges is now mostly assumed to be the case for the provision of any modern, inclusive and effective urban transport interchange.

Development of a **mobile application for users guidance at interchanges** enables to provide a guidance service to users within the interchange area and through public transport networks, available indoor and outdoor using 2D representations. Way finding depends on user profile and

station typology. For occasional passenger, the application aims at finding the shortest path to go through the connection. For very large interchange, the application suggests a path having a maximum of signage. For stations that are usually crowded at peak hours, the application enables to suggest a path according to circulation route. The application can finally support PRM to go in and out of an interchange on their own, guiding them to the appropriate equipment and facilities.

Smart and **integrated ticketing solutions** can facilitate multimodal transfers at interchanges, as they enable to optimize the transport network management and to address users' difficulties to transfer easily from one transport mode to another, making public transport more attractive. The implementation of smart and integrated ticketing system at interchanges provides benefits to all mobility stakeholders, enabling to save time and money. However, the solution provided by smart ticketing can only be achieved through intensive cooperation between local authorities, transport operators and industry. Finally, systems interoperability, fare integration as well as simple and clear tariff information are essential to increase multimodality. The implementation of an integrated smart ticketing solution requires major changes in particular throughout transport systems and processes.

3) *Enhancing liveability of the urban transport interchanges*

Interchange liveability is another key aspect when designing and managing transport interchanges in order to properly reach a pleasant and comfortable (perceived) place from the user's perspective.

Providing high quality interchange environments will improve all aspects of a user experience. From a user's point of view, the success of a transport interchange is based on its perception as a singular space that clearly presents its functionality and possesses environmental characteristics that make users' time in the interchange pleasant. Comfortable, clean and well maintained interchanges provide an attractive and liveable environment. Legible environment makes navigation and movement easy and seamless helping improve peoples' understanding, enjoyment and experience.

Persons with reduced mobility (PRM) has a high demand for information as they need reassurance that they will be able to utilise the transport system even with their disability. Special information and communication needs to be implemented for the PRM's with communication disabilities.

The recommended NODES tools and strategies:

- Station Experience Monitor (SEM)
- Guidance for the planning /design of layout, accessibility, facilities and built form
- Signage at interchanges adapted to communication impaired people
- Consultation of PRM associations to assess ICT applications / services

For enhancing liveability of urban transport interchange, it is strongly recommended to firstly assess strengths and weakness of the interchange from the users' prospective. **Station Experience Monitor** (SEM) of the NODES toolbox, enables to effectively support the assessment of an interchange liveability, which provides a simple summary of interchanges strengths and weaknesses in terms of the customers experiences and areas where interventions have the greatest impact.

In order to deliver a more pleasant and liveable transport interchange the SEM was developed. The original Dutch Station Experience Monitor has been tested and worked out to potentially become a standard tool applicable across Europe. The users' experiences at the larger interchanges should be measured every three months while at the smaller interchanges, once a year. At every station,

passengers should be selected randomly when waiting at the stations platforms. In order to have a good overview of the experiences during peak and off-peak hours it is recommended to have about 300 questionnaires filled in total per interchange. Besides larger refurbishment and redesign of the interchanges, it was found that often very simple low cost intervention can already have a large impact on the waiting and travel experiences of the interchange users.

It is recommended to “change the prospective” focusing on the customs’ experience in order to deliver a more pleasant and liveable urban transport interchange well-fitting users’ needs.

The NODES toolbox provides **guidance for the planning /design of layout, accessibility, facilities and built form** in the form of widely varying key documents and relevant guides. The publishers of the linked documents have approached the subject of design for performing interchanges from different prospective reflecting their major interests.

To effectively face this specific needs, it is important to develop **signage at interchanges adapted to communication impaired people** through the implementation of symbols adapted to mental/cognitive-impaired people, non-native and illiterate individuals to improve their autonomy

The combination of symbols and written information to represent and inform users about a specific location at the interchange, for instance transport networks’ stations, answers such users’ orientation needs by providing reduced anxiety, comfort and ease of movement through the interchange itself. A coordinated approach between interchange stakeholders as well as the cooperation with disabled people associations, etc. is essential to reach effective symbols understood by all users.

The particular needs of disabled people can be answered through adapted visual, spoken and tactile information, including innovative systems. Visual signals should always be supplemented with acoustic signals. The abilities of the disabled or PRMs vary significantly but ICT applications/services allow modification and personalisation in order to provide solutions which are bespoke to each subjects’ needs Hearing impaired people’s journeys can be made difficult, and even affect their own security, in case of faulty visual signage or when network disruption are mainly indicated through spoken information. Purchasing tickets also remains problematic for hearing impaired people due to difficult communication with transport operators’ sales agents especially in case of absence of information display. It is important to develop a translation service in sign language aimed at hearing impaired interchange users by a system of visio conference with a call center and trained staff.

Consultation of PRM associations to assess ICT applications / services and to consider coherent measures based on ICT at interchanges towards the different types of disability through accessibility comities, focus groups, etc. is strongly recommended for enhancing liveability for these categories. Key actions to be implemented through consultation with PRM are as follows:

- when considering changes to interchange infrastructure engagement should be made with organisations representing or persons with reduced mobility themselves;
- these organisations should be involved in any design processes to verify that facilities proposed are ‘fit for purpose’ or to identify which facilities might be mostly needed for PRM;
- solutions which provide for the accessibility of all users need to be incorporated in design;
- newly installed or built facilities need to be reality checked to ensure what was intended to help someone actually does;
- it should be particularly checked that facilities are not only available but can be used by PRM.

4) Increasing safety and security conditions of urban transport interchanges

Interchange design must consider public security against a range of different threats, both man-made and natural. All stations face a certain level of risk associated with various threats be they the result of natural events, such as flooding and accidents, or through malicious practices.

Transport interchanges should create not only effective solutions to minimise the risk against safety and security issues, but also provide scenarios where users' perception is considered of key importance. Safety and security aspects need to be properly addressed during a new interchange design, an interchange refurbishment as well as during interchange operation to identify, evaluate and control the risk factors in and around the interchange as well as to plan and activate a proper response to incidents and emergencies (including fire, accident and crime prevention).

Common definition of safety and security - on the basis of the Public Transport Union - is as follows:

- Safety: "accident"/ no malevolence (e.g. fire, etc.)
- Security: "incident" / notion of malevolence (e.g. act of terrorism, etc.)

Safety and security conditions of interchanges should cover at least three key issues as follows:

- Safety and Accident Prevention,
- Personal Security,
- Fire Prevention.

Safety and Accident Prevention: all those using an interchange zone, passengers, staff and nonusers, should be able to expect to do so in safety and without fear of injury or accident. All interchange facilities should be designed and operated to be fully compliant with all fire, safety and security regulations. Emergency procedures and an emergency management plan should be agreed between all interchange zone stakeholders and with the emergency services.

Personal Security: when considering opportunities for crime and disorder in interchange it is crucial to involve crime prevention specialists as early as possible in the scheme's design. This will ensure factors such as lighting and CCTV are included in the context of existing crime factors in the vicinity.

Fire Prevention: the entire fire prevention system in the transport interchange is designed to ensure the protection of users from the risk of fire. Current state regulations on Fire Prevention Conditions must be taken into account and in case Fire Prevention Regulation does not cover transport interchange stations they must be the subject of a specific study that must be presented for approval to Local Authority to provide a favourable permission. The fundamental design of the fire protection conditions is the definition of the set of measures that contribute to confining a fire to a specific sector, stopping it from spreading and providing escape routes to clear the building safely.

The recommended NODES tools and strategies:

- Design and planning of security
- Secure stations scheme design and management audit
- Safety and control strategy

The **design and planning of security** at transport interchanges is a key element for their successful operation and users' experience. Examples of guidance that is available in the UK to help assist design teams in achieving high standards of security at stations and P+R. Protection of passengers and staff who use transport networks and stations is a priority for government and rail operators.

Incorporating physical security measures into stations is one method of mitigating the risk of a terrorist attack and other crime. Incorporating such measures at an early stage in the design of a new and/or major redevelopment of an interchange has benefits both in terms of their effectiveness and of minimising costs. The safety of users and their perception of safe can be ensured through its Security Management and Safety Management via internal procedures and obligations relating to standards.

Secure stations scheme design and management audit enables interchange managers and operators to assess their stations secure status. The audit document enables gaps in security or other issues relating to the safety and security of passengers and staff at the station to be identified.

The UK Department for Transport Secure Stations Scheme design and management audit is designed to allow operators of stations to assess their stations secure status. This 66 question document looks at both inside and outside the interchange. The audit looks at physical and operational aspects and considers any specific incidents that have occurred and need to be prevented in future. The objective is to encourage station operators to improve the status and apply for a 'Secure Station' certificate which is valid for 2 years. The audit document will enable gaps in security or other issues relating to the safety and security of passengers and staff at the station to be identified. It will result in a thorough assessment of the status of the interchange from a safety and security point of view. The principle is transferable to different organisations involved in interchanges outside the UK. The cost of doing the audit is not going to be expensive but the resulting conclusions may indicate changes required to the physical aspects or the operation which could have a more significant cost implication (www.gov.uk/secure-stations-scheme-accreditation-for-rail-operators).

An effective **safety and control strategy** should be planned and implemented by different measures including safety procedures, training programmes for staff and safety plan (control of fire hazards, maintenance office protection systems, building evacuation procedures), security risk assessment, regular safety tests, control systems (CCTV, staffing, emergency alarms, fire protection, etc.).

5) Increasing economic viability and costs efficiency of urban transport interchanges

Increasing economic viability and costs efficiency of transport interchange management is a key aspect. Approach adopted is mostly to reduce the operating costs of the different public transport modes operating at the interchange as well as of the interchange's relevant services/systems.

In order to enhance economic viability of transport interchange management, interchange manager / promoter should identify and set-up new and additional business opportunities, also offering complementary services (e.g. information points, commercial / shopping areas, business areas, leisure areas, non-transport related services, etc.).

The NODES tools and strategies recommended:

- Public-Private Partnership (PPP)
- EU funds for interchanges
- Public investment banks
- Corporations and joint ventures
- Land Value Capture / Value Capture Financing
- Specialised subsidiary bodies of railway companies
- Contractual relationships between stakeholders

Public-Private Partnership (PPP) represents an effective and proven business model: PPP is a long-term contractual agreement between a public agency and a private sector party to secure funding, construction or refurbishment, operation and maintenance of an (infrastructure) project and delivery of a service that was traditionally provided by the public sector. It involves the sharing of risks and rewards, multisector skills, expertise and finance to deliver desired policy outcomes.

The concept of PPP may cover different types of arrangements. One of them is the mixed economy company by two parties: a public entity, representing the local community, and a private one. They intend to reach specific goals with a clear division of roles, rights and obligations. Another application of PPP is project financing. It combines the responsibility of a public authority to establish public transport infrastructure, integrated into urban development, with the innovation, efficiency and funding capacity of the private sector. There is a significant diversity in the way those models are applied and the results they finally have. Most relevant examples of PPP are concession agreements (the granting of a right to the dealer by the administration of finance, build, management and maintenance of an infrastructure in exchange of a fee, either directly from the Public Administration or from the end-user of infrastructure) and Private Finance Initiative (PFI).

European PPP Expertise Centre (EPEC) is an initiative involving the EIB, the European Commission and European Union Member States and Candidate Countries trying to help strengthen the capacity of their public sector members to enter into Public Private Partnership (PPP) transactions.

European Commission's funding opportunities are strongly suggested to be explore and exploit for the development of efficient and integrated urban transport interchanges.

Requests for **EU funds for interchanges** can be submitted in several ways; directly by the national government, the national agencies for the European Commission or directly at the European Commission. Every year new working programmes are released with special focus points. Some of the well-known financing Instruments of the EU are: Horizon 2020, Intelligent Energy Europe with the subdivided actions entitled STEER and ELENA, the CiViTAS Initiative, European Regional Development Fund, Cohesion Fund, JESSICA (Joint European Support for Sustainable Investment in City Areas). JESSICA, in particular, is an initiative of the European Commission developed in co-operation with the European Investment Bank (EIB) and the Council of the European Development Bank (CEB) supporting sustainable development and regeneration through financial engineering mechanisms. It is very important to know advantages and disadvantages of the different funding schemes as well as the procedures that have to be followed by the local governments in order to secure a successful outcome. It is recommended to deeply assess strengths and the weaknesses of each funding instrument, procedures to follow for funding requests as well as other key aspects.

Public investment banks (national, European, global) such as European Investment Bank (EIB) can give loans to (transport) infrastructure projects with strategic importance in EU Member Countries. Investment banks specialize in large and complex financial transactions such as underwriting, acting as an intermediary between a securities issuer and the investing public, facilitating mergers and other corporate reorganizations, and acting as a broker and/or financial adviser for institutional clients. Investment banks have different mechanisms that can be applied to fund infrastructure projects, typically of large scale and high structural importance. Banks (at national, European (EIB) or international level), can provide loans to different infrastructure projects, including big transport interchange projects of strategic importance for the cities and regions across Europe.

Corporations and joint ventures are also recommended for a cost-effective implementation and management of urban transport interchanges. Co-financing of property developers can be a part of wider property development scheme. Property companies can be involved in co-financing large-scale development projects involving renewal of transport interchanges. The central government or local authority grants to the corporation development rights for land located above or adjacent to public transport interchanges to help finance the construction of new infrastructure projects, instead of injecting cash or providing direct subsidies. National laws and regulations can facilitate such corporations. In France, examples of such regulations are the Urban Partnership Projects, Partnership Contracts and Local Development Contracts. Setting up a route contract approach locally may take between one and three years considering the prior policy agreements needed for the organisation of co-operation between the various stakeholders (e.g. operators, local authorities, urban planners, etc.). Urban Partnership Projects are agreements associated with a license for urban development which lists the public development improvements to be made on the land unit concerned. It sets out the cost of public facilities, the amount of the participation of the developer, timely payment and performance of work. Local development contracts and partnership contracts enable to connect economic or residential development and mobility.

Land Value Capture (LVC) / Value Capture Financing is the leveraging of public land through the return on investments for interchange operators (financing from commercial activities and rents of commercial spaces). Tax Incremental Financing (TIF) is a form of LVC. It is a public financing method that is used as a subsidy for redevelopment / infrastructure projects using future gains in taxes to subsidise current improvements. LVC is the appropriation of value, generated by public sector intervention and private sector investment in relation to an underused asset (land and/or structure), for local re-investment to produce public good and potential private benefit.

The LVC mechanism applied in transport recoups the investment in public transport and returns the increase in profits to the source of the investment, such as the taxpayers. Although all land value capture schemes differ to a greater or lesser extent, three main mechanisms can be recommended:

- Betterment Tax as value capture financial mechanism on property that has benefited from transport infrastructure gains;
- Tax Increment Finance as economic development incentive package;
- Joint Development as cooperation agreement between public sector and private developers.

Specialised subsidiary bodies of railway companies in charge of specialised tasks with regard to interchange management such as property, station developments, etc. is another effective approach for increasing economic viability of urban transport interchange.

In France, SNCF Gares & Connexions has two subsidiaries AREP (architecture, town planning, civil engineering, design) and its own subsidiary PARVIS (project management on behalf of owners –

property and station development programmes) and A2C (marketing of station space). In Germany, DB Station & Service is responsible for the operation and provision of services at stations while DB Mobility Networks Logistics is responsible, in conjunction with DB Real Estate, for the development projects of stations and optimization of properties of the Deutsche Bahn.

In the Netherlands, NS is the owner of station buildings (including commercial facilities) while ProRail is the owner of the infrastructure (transfer space of passengers including maintenance of building). NS stations is the subsidiary of the Netherlands railways (NS). NS station is exploiting, develops and manage all train stations (about 402) in the Netherlands. NS station is responsible for the following tasks: (1) Infrastructure and development during the reconstruction of the station and station area; (2) retail and services, responsible for the commercial retail and additional transport services (NS taxi, bicycle, car sharing); (3) Station operation management; responsible for the operation management and maintenance of the stations and related property. Of special interest is the organisation of the retail services at the station. This can be considered as an innovation. The commercial exploitation of the interchanges is the responsibility of the NS, which they placed into their subsidiarity NS Stations. Prorail is responsible for all functional elements. The creation of a subsidiary NS Station for the commercial exploitation and service provision at the stations seems to be a successful manner to make optimal use of the interchange potential. The proposed approach seems specifically of interest for larger interchanges and/or interchange areas in which there is a potential for commercial exploitation. This approach is considered extremely relevant for the larger transport interchanges.

Key element in the procedure of transport interchange development is the involvement of the most relevant stakeholders (city council, local authority, transport operator and urban developers). For this reason **contractual relationships between stakeholders** is strongly recommended.

Different kinds of contractual relationships are commonly used between stakeholders in order to establish official relationships between the involved parties. The private entities can have their origin in one of the Member States of the European Union. These are the possible types of contractual agreements that can be formed between the stakeholders involved in the interchanges construction or operation. Clearer and more scientific sound procedure should be followed in order to estimate the returning value of the investment to the contractual parties.

For example, Memorandum of Cooperation (MOC) Agreements between NS and ProRail in the Netherlands. The commercial exploitation of the interchange is the responsibility of the NS, which the placed into their subsidiarity NS Stations. NS stations is the subsidiary of the Netherlands railways.

The co-existence of different transport stakeholders at interchanges and the necessity to make each of those systems interoperable with the others requires a coordinated approach through the cooperation of interchange stakeholders which form can vary (institutional cooperation through conventions / informal cooperation). It takes place in different forms depending on the stage of interchange development (design, construction, operation, management).

Consultation with end users is important to make the interchange user-friendly and to attract new users. It can also come in the form of contractual agreements for better coordination, provision of data, and achievement of integrated approach in a project between stakeholders. This refers to the spatial management of the interchange zone and can include safety and security management, accessibility at the interchange, or passenger information.

This approach seems specifically of interest for larger interchanges and/ or interchange areas in which there are different actors own and manage the infrastructure, are responsible for the transport services, and exploitation of the other transport and commercial retail services.

6) Stimulating local economy of urban transport interchanges

The interchange manager/promoter should also address the question of how its interchange might stimulate the local economy such as using local products and/or local service providers, proposing new business opportunities in the interchange as well as in the surrounding area increasing.

Shops located in interchanges can not only be a source of revenue to the station manager/operational organisation, they can also enhance the attractiveness of the space and make a connection to the urban tissue and its services. An effective exploitation of commercial opportunities in and around a transport interchange has generally a direct impact on the level of economic activity in the area that it serves, stimulating investment as well as creating employment. In addition, some of the value created can be captured and used to defray investment costs. Realising the commercial potential of a station can result in a 'win-win' alignment of social, economic and commercial objectives, helping to ensure the deliverability and success of a station investment scheme.

Advertising is another form of commercial exploitation of public space at interchanges.

The recommended NODES tools and strategies:

- Concession for commercial space
- Franchising of advertising space
- Quality plan for taxi services

At large interchanges **concession for commercial space** can be assigned by public tenders to companies which will become responsible for a variety of retail and horeca formulas. Several different shops and food points are set up at stations to satisfy user needs.

Franchising of advertising space at interchange can also be managed by the advertising company itself. At public transport locations where a lot of passengers pass by or have to wait for their transportation the space around the waiting area can be used for advertising.

Public transport domains nowadays have been franchised to companies that maintain the area and arrange the advertising in that area. Transport interchange is full of areas where people can sit down and wait for their mode of transportation. When they look around they can spot advertisement around them. Passengers are of great value for the commercial parties. All of this equipment needs to be maintained, repaired and kept clean for the passengers to use it in a comfortable way. This costs a lot of money for the interchange operator/municipality or transport companies by franchising of advertising space. The two parties bring together in a separate company that franchise the advertising space. The company will be responsible for the maintenance of the equipment and arranges the advertisement. Therefore the commercial parties will pay enough for the advertising so that the intermediary party can maintain and repair the area and make some profit.

Quality plan for taxi services is finally recommended being a signed procedural agreement between the taxi providers and the interchange manager, enabling optimum provision of taxi services in or around the interchange. The plan includes a number of issues, from the technical design specification of the sidewalks that can smoothly drive users to/from the taxi till regulation issues about the services provided. The land owner evaluates the provision of taxi stands for the contractual agreement with taxi companies serving the interchange. This approach is recommend specifically for larger interchanges or areas in which there is a potential for commercial exploitation of taxi services.

7) Increasing energy and environmental efficiency of urban transport interchanges

Increase environmental and energy efficiency during the interchange lifecycle (design, construction and day-to-day operation) is a key objective of each transport interchange manager/promoter.

The construction phase is crucial for the successful completion of an interchange infrastructure aiming to reduce its impacts on the environment. Given that many urban transport interchanges are situated below ground level and can be used by modes of transport that emit harmful gases and increase the ambient temperature, specific attention should be paid to the monitoring of environmental conditions in the interchange zone. One approach for achieving greenhouse targets is to ensure that buildings use minimal amounts of “fossil based” energy. The energy consumption of a building is largely determined at the design stage. It is here that energy efficient features affecting air conditioning and lighting (the main contributors to energy consumption) can be incorporated.

The best way to reduce all of the environmental impacts of an interchange infrastructure is to consider an integrated design process in any project where a new building or reconstruction (or redesign or refurbishment) is envisaged. Consequently the implementation of technologies that seek to reduce the environmental impact of buildings in both construction and operation are envisaged.

The main techniques for the minimisation of energy consumption during the design phase are:

- passive design – use of thermal mass, natural light, natural cooling and heating potential;
- appropriate sizing of lighting, heating and cooling systems;
- effective zoning, sensors and controls (heating, cooling and lighting are provided only when and where needed);
- appropriate building management (e.g. measuring energy performance) including equipment purchasing;
- use of renewable energy (green power (electricity which comes from wind, water, solar sources, geothermal/ ground coupling), photovoltaic systems, etc.);
- minimizing embodied energy in materials.

The choice of materials in a new or refurbished building has also an impact on the environment. This impact is not as large as that of the operation of the building, but it is still considerable. Materials impact the environment in the following ways: consuming energy in manufacture and transport (embodied energy), potentially having an impact on toxicity in manufacture and in use, using water in manufacture (called embodied water) as well as consuming other materials that have their own impacts (e.g. mining, land clearing, etc.). Materials should be chosen aiming to have a minimal impact and ensure their usage for the maximum amount of time. The aim is to minimise the impacts of building materials and any material or process used in construction and development.

The recommended NODES tools and strategies:

- Environmentally Sustainable building Design guide
- Environmental noise control

Environmentally Sustainable building Design (ESD) guide can strongly support energy and environmental efficiency of urban transport interchanges.

Useful overall guide to environmentally sustainable building design, also covering a range of issues including minimising transport impact is suggested to be used by developers. (<http://www.environment.gov.au/resource/esd-design-guide-office-and-public-buildings>)

The ESD gives a basic introduction to ecological sustainability issues and specifically how the built environment affects them, including minimizing transport impacts. Other issues are integrated design and process management, indoor environment quality, energy management, choosing materials, waste minimisation and water use reduction. The ESD design guide approaches different opportunities which all have the aim to minimize environmental impacts. These opportunities are the following: integrated design, social sustainability and occupant satisfaction, optimising indoor environment quality, minimising energy use, minimising transport impact, minimising ozone layer depletion, choosing materials, minimising waste, water conservation and land use. For all these opportunities there are explanations how the opportunities and the aims can be reached.

Environmental noise control activities include legislation on noise emission limits for equipment, influencing the location and the construction techniques of new highways and buildings, legislation on noise emission limits for property boundaries and regulating aircraft flight procedures.

To reduce noise pollution at transport interchanges it is important to control noise emissions and also implement measures able to reduce these emissions. Noise control activities include legislating noise emission limits on equipment used in our communities, influencing the location and the construction techniques of new highways and buildings, legislating noise emission limits at property boundaries and regulating aircraft flight procedures. The most common measurement in environmental noise is the dB(A) level. It can be measured with a simple sound level meter having an a-weighting filter to simulate the subjective response of the human ear. By using noise absorbing materials, the effects of an interchange can be reduced widely. In terms of interchanges noise should not only be measured from the traffic, it also should be measured within the interchanges to have a good noise climate.

High environmental noise during the construction can be generated by pneumatic drills, pile drivers or jack hammers. The impact of this noise needs to be considered on both passengers and staff within the interchange and on people and building users outside. Operational interchange noise comes from vehicles e.g. trains and buses or the squeal of tram wheels and also from on-site announcements. The Reading Station and depot projects have shown the need to recognise in advance where a nuisance is likely to occur but also to be prepared to modify plans to counter complaints if they occur. A plan to do the noisiest works during the business day has clear advantages and it is better to plan than to have to react. A survey of the nearby environment should show what kind of surround the station or interchange and plans can be developed accordingly.

The guide can be found as follows: http://www.enviropedia.org.uk/Air_Quality/Measuring.php

4. Conclusions

The tools testing and impact evaluation activities implemented in the NODES project enable to identify successful tools and innovative strategies for planning and implementing efficient and sustainable transport interchanges in Europe and beyond. The overall results achieved in the nine different reference sites enable to provide criteria for their transferability and key lessons learned.

The tools tested in the different reference sites cover a wide range of activities, including transport interchange planning, design and operation. Effective planning, design and operation of urban transport interchanges need interdisciplinary and integrated approaches, covering land use planning, transport planning, transport facilities design, real-time information and ICT, public-private partnerships and business cases, safety and security as well as energy and environment aspects.

The NODES Toolbox was successfully tested in different sites characterized by different local constraints, transport patterns, regulatory framework, different interchanges' lifecycle, etc.

The reference sites' interchanges on which the tools and methodologies, included in the NODES Toolbox, were tested cover a wide spectrum of interchange types (e.g. intermodal areas in large cities, central interchanges in large city/wider catchment area, central interchanges in very large city/wider catchment area, etc.) as well as cover a wide spectrum of interchange improvements (e.g. newly build interchange, interchange refurbishment, new organisational management and services changes). This enables to reach potential high level of results transferability in other interchanges.

The NODES Toolbox contains a wide variety of tools: tools for strategic decision-makers enabling a complete diagnosis and identification of priority areas for performance-oriented interchanges (e.g. Tool to evaluate strategic scenarios for a new interchange, Typology visual tool, Urban environment indicators toolkit, etc.), mobility simulation tools (e.g. Urban integration - Space syntax, Mobility micro simulation, etc.), tools addressed to info-mobility aspects enabling to enhance intermodality and liveability at urban transport interchanges (e.g. Multimodal journey planner, Static/dynamic multimodal map, Way-finding guidelines, Passenger information for hearing impaired, Signage at interchanges adapted to communication impaired people etc.), tools for increasing safety and security conditions (e.g. Secure stations scheme, design and management audit, etc.), tools for increasing economic viability and costs efficiency of interchanges (e.g. PPP, Location Value Capture, Corporations and joint ventures, Exploitation of commercial services, etc.) as well as tools for energy and environmental efficiency (e.g. Environmentally Sustainable building Design guide, etc.).

Most common barriers can be solved by the NODES Toolbox which can support cooperation and interaction among different organisations, constructive stakeholders consultation and agreements, effective involvement of competent organizations and authorities, sustainable development vision and planning based on relevant diagnosis and simulations, reducing costs and dedicated public funds to develop and maintain urban transport interchanges, exploring innovative partnerships, potential investors as well as market-oriented business models, reinforcing customer satisfaction's prospective during the design and operation of urban transport interchanges including the consultation of PRM associations as well as other relevant organisations, better providing real-time and multimodal passenger information as essential element of seamless transport interchanges.

Planning, organisational and methodological tools for local authorities and public transport operators are essential for the quality of service provided in urban transport interchanges. Competent organisation should have precise ideas in which field the interchange is supposed to be improved.

Key aspect is to secure efficient and effective allocation of resources and validate a realistic and integrated plan able to ensure effective coordination among different financing schemes. Financial

security from public and/or private parties should be guaranteed to realise needed improvements. In the (public) traditional funding model, design, construction and management of transport infrastructures is drawn from the public administrations' accounts. The resources initially come from public administrations' budget. Public finance models are primarily used for awarding large grants

Technical expertise and capability of Local Authorities in planning and implementing sustainable interchanges based upon innovative business cases, profitable and financing models is requested.

For the planning perspective, interchanges should benefit from cross-sectoral mechanisms for delivering higher density development around public transport interchanges, founded on an understanding of the interrelationships between accessibility, location, design and intensity of land use. In order to achieve this, key drivers are: increased coordination among different sectors, different policy and territorial level, creation of a wider acceptance by the inclusion of the citizens and business, public-private cooperation for better planned and quality interchanges, sustainable business cases making transport interchange financially, socially and environmentally profitable.

An effective planning for a transport interchange can be achieved through a collaborative process involving the different stakeholders. Connecting infrastructure's facilities with the wider zone surroundings requires an understanding of local patterns of movement and principle local origins and destinations by all modes of transport by an analysis of land use and urban activities distribution.

From the design perspective, the key aspect in designing new transport interchanges or preparing designs for current interchanges is looking from the end user's perspective. User-oriented design approach is essential to deliver the suitable design framework, to set the right design goals as well as to apply the appropriate means to fulfil the design requirements. Performance of different design scenarios should be measured using key performance indicators. Both transfer quality / easiness and liveability at transport interchangers should be optimised by offering adequate facilities reducing transfer distance, time and effort as well as offering comfort and conditions for a pleasant stay. Spatial and architectural quality of design contributes to guarantee an attractive interchange, fitting into its spatial context, offering a sustainable and durable solutions and properly facing spatial-temporal conditions.

A smarter urban interchange should be able to reach short and easy transfers among the different transport modes allowing to reach higher comfort and speed of passenger flows as well as higher integration of the all the modes of transport. In the design of an urban transport infrastructure, it is important to evaluate any predicted growth as well as any current usage to ensure appropriate capacity in a flexible infrastructure which should be able to cope with increasing/changing transport demand.

From the operation perspective, the efficient day-to-day management and operation of an urban transport interchange depends largely on established partnerships, strong cooperation and communication between the different stakeholders. It is essential to identify the potential stakeholders to be considered in the management and operation, namely interchange managers, transport authorities or other local authorities, transport operators, property owners, retailers, etc.

Taking into account user needs and requirements, urban transport interchanges should offer an increasing variety of services and functions. This puts more strain on operations and management which becomes more complex. Establishing relationships between the different stakeholders to define clear responsibilities in management/operational tasks represents a key issue to be managed.

The results achieved in the NODES project in the different reference sites can be considered as the showcase proving the effectiveness and benefits of using the Toolbox in order to put in place sustainable urban transport interchanges.