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Infrastructures Impacts Assessment, deliverable 4

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Infrastructures impacts assessment

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Infrastructures impacts assessment

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1 INTRODUCTION

1.1 Background

The *TranSEcon* project addresses “task 2.1.2/4 cluster on socio-economic impacts of transport investments and policies and network effects” -frame of studies in the key action of “sustainable mobility and intermodality” and in particular “subtask 3: urban transport and local socio-economic development” (accompanying measures project).

Urban transport policies and investments are implemented on the basis of urban transport planning and management and therefore their evaluation usually is linked to performance in terms of transport operations (e.g. travel-speed, travel-safety). However, urban transport policies and investments may have wider socio-economic impacts and effects not only along the corridor or within the areas that are designed to serve, but throughout the city-region and through time. Therefore it is necessary to carry out research in evaluating these socio-economic impacts and effects stemming from urban transport policies and investments.

The main expected technical achievement of this research is to provide documentary evidence regarding the social and economic long-term impacts and effects of urban transport investments and policies (so called “indirect effects and impacts”), in order to inform city authorities in their transport and related policy development and infrastructure planning, as well as to support relevant EU policies.

1.2 Project Objective

The *TranSEcon* research project aims to provide a qualitative and quantitative evidence regarding the existence of the direct and indirect effects and impacts of transport infrastructure investments in 13 European cities.

The long term effects of implemented large scale infrastructure investments of all types of mode are to be analysed using existing data-bases together with stakeholder interviews in the 13 European case studies. The selected case studies cover a good range of city and intervention types (in terms of geographical distribution, city size, transport policies and investments). The research partnership involves 16 organisations (6 universities, 2 research centres, 7 consultancies) in 9 EU member states, an EEA country and an Accession country.

The methodology is driven from a multi-disciplinary perspective requiring expertise in related fields such as: urban and regional land use planning and sustainable development planning, urban re-generation and renewal design, implementation and management, sociology, macro-economics, development economics, labour economics, political science, decision making process, organisation science and institutional development. Thus the project approach is not to concentrate on the normal transport-related socio-economic impacts (e.g. modal split changes, accessibility improvements, time savings, vehicle operating cost changes, environmental and safety benefits, revenues and financial concerns).

The project work-plan involves 12 inter-related work packages, which address operational requirements (such as database development, dissemination, project co-ordination) as well as thematic impact assessment topics (such as policy, infrastructure, employment, urban re-generation, etc) see Figure 1-1.

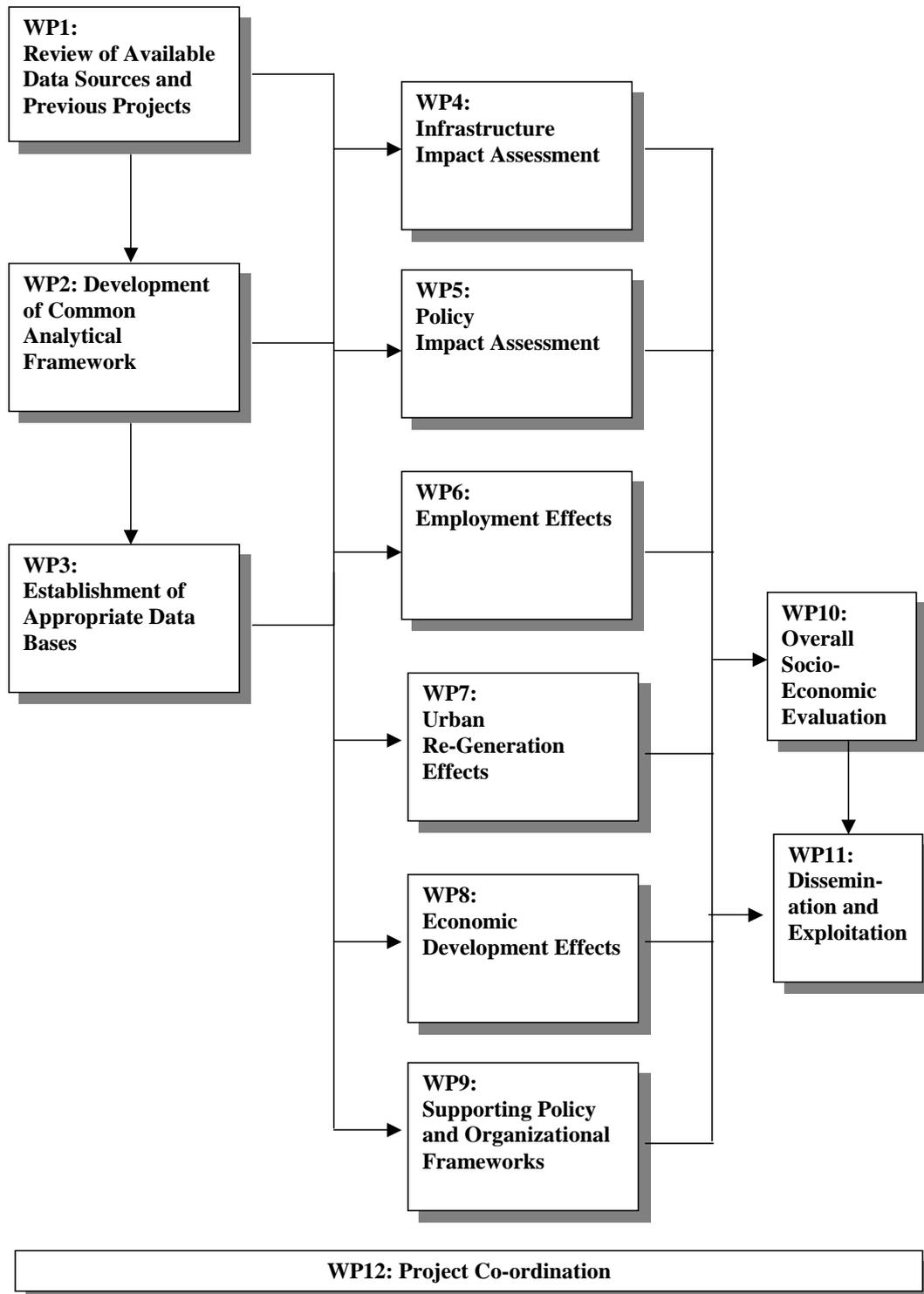


Figure 1-1: Work Package flow chart of *TranSEcon*

Work package 4 works complements policy and other socio-economic impacts addressed in the other work packages 5 to 9 (Figure 1-1).

Work package 4 work analyses each case study individually following the general methodology defined in work package 2 (the relevant sections of Deliverable 2 for WP4 are presented in chapter 2). Individual case study analyses are presented in appendix 2 to 14. The core of this report is a comparative analysis of all the elements of the transport system.

The objective of the work package is to produce qualitative analysis of the evolution of the transport system after important infrastructure investment project, and also to produce quantitative indicators. These indicators will be developed for use in work package 10 "Overall socio-economic evaluation".

1.3 Content of the report

Report is organised as follows:

- chapter 2: presentation of the general methodology for impact assessment within **TranSEcon** project. The basis of this has been described in Deliverable 2 and the relevant sections for work package 4 from that deliverable are exactly reproduced here;
- chapter 3: presentation of the general framework of work package 4. In this chapter the application of the general methodology developed for work package 4 is described. The grid of indicators is first described and then data production and collection is commented;
- chapter 4: presentation of the case studies;
- chapter 5: description and impact on public transport and private transport supply system. Here some indicators are described to quantify both public and private transport supply. The impact on investment, operating costs and transport related revenues is then analysed;
- chapter 6: analysis of the impact on demand of the case studies project in terms of mobility, passenger*kilometre and time savings;
- chapter 7: is dedicated to results concerning transport environment and safety impact analysis.

2 GENERAL METHODOLOGY FOR IMPACT ASSESSMENT WITHIN TRANSECON PROJECT

The general methodology for impact assessment within *TranSEcon* project has been defined in work package 2 and described in deliverable 2 “Common analytical framework”. This chapter reproduces this general framework exactly. Chapter 3 describes the application of this framework.

2.1 Analytical framework¹

The overall analytical framework of the *TranSEcon* project is represented Figure 2-1. This takes into account the key issues discussed in the previous section.

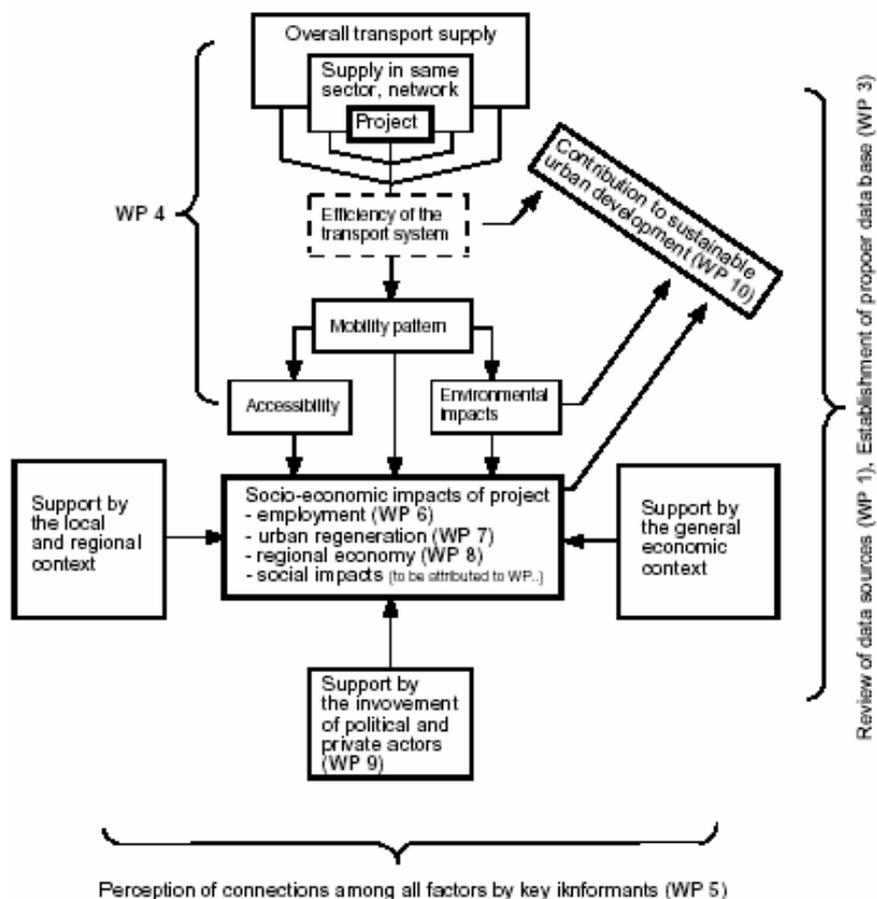


Figure 2-1: Analytical framework for the *TranSEcon* project

The analysis starts with the identification of the projects (large scale infrastructure investment), as part of a network of the same type and in the context of the overall transport system in the urban region. The analysis ends with the assessment of the

¹ Section 2.3 of Deliverable 2

project's contribution to sustainable urban development (top right part of the diagram).

Within the chain of effects that leads from the start to the end there will be some effects that are relevant for the final assessment, such as:

- the efficiency-increase of the transport system, induced by the infrastructure investment;
- the changes in environmental quality, as a result of the effects of the infrastructure investment on the mobility pattern;
- the socio-economic impacts of the project (as the core part of the assessment and the **TranSEcon** project), that are induced by changes in the accessibility of the region and its territorial subdivisions, by changes in the environmental quality, and in addition by the above mentioned exogenous and endogenous contextual inputs.

All this together allows for the triple evaluation under economic, environmental and social criteria that is characteristic of the sustainability principle. For each element of the analysis suitable indicators need to be developed and, for their interaction, significant lines of argument must be developed.

2.2 Categorisation of effects with regard to time²

The life-cycle of a transport infrastructure investment can be classified in the following phases (see also Figure 2-2):

- the planning, evaluation and design-phase; during that phases the political decision is made;
- the construction phase;
- the operation phase.

The planning and evaluation phase of a potential infrastructure investment normally provides an estimation of its forecasted quantitative and qualitative effects. This helps the decision makers to start or to reject the project. The estimation consists normally of cost benefit calculations and descriptions of other societal benefits. In order to make a positive decision to invest (the decision to start the transport infrastructure investment) more positive than negative effects and expectations need to exist. The investment must be seen to be beneficial for the city and it must be seen to support the transport and mobility policy of society.

The direct effects and impacts of the construction phase can be negative for the use of (public) transport system, if the construction work hinders the use of public transport (lack of service, poor replacement services, poor temporary connections etc.). The effects can be seen, e.g. in passenger statistics and in general opinions collected (e. g. complaints) concerning the construction phase. The construction phase can change the modal split at least temporarily if the former users of public transport shift to private car use (more private car users in the area where the

² section 2.4 of deliverable 2

construction work is done). From a marketing and public acceptability point of view, there is a need for minimising the negative impacts of any new transport system during the construction phase.

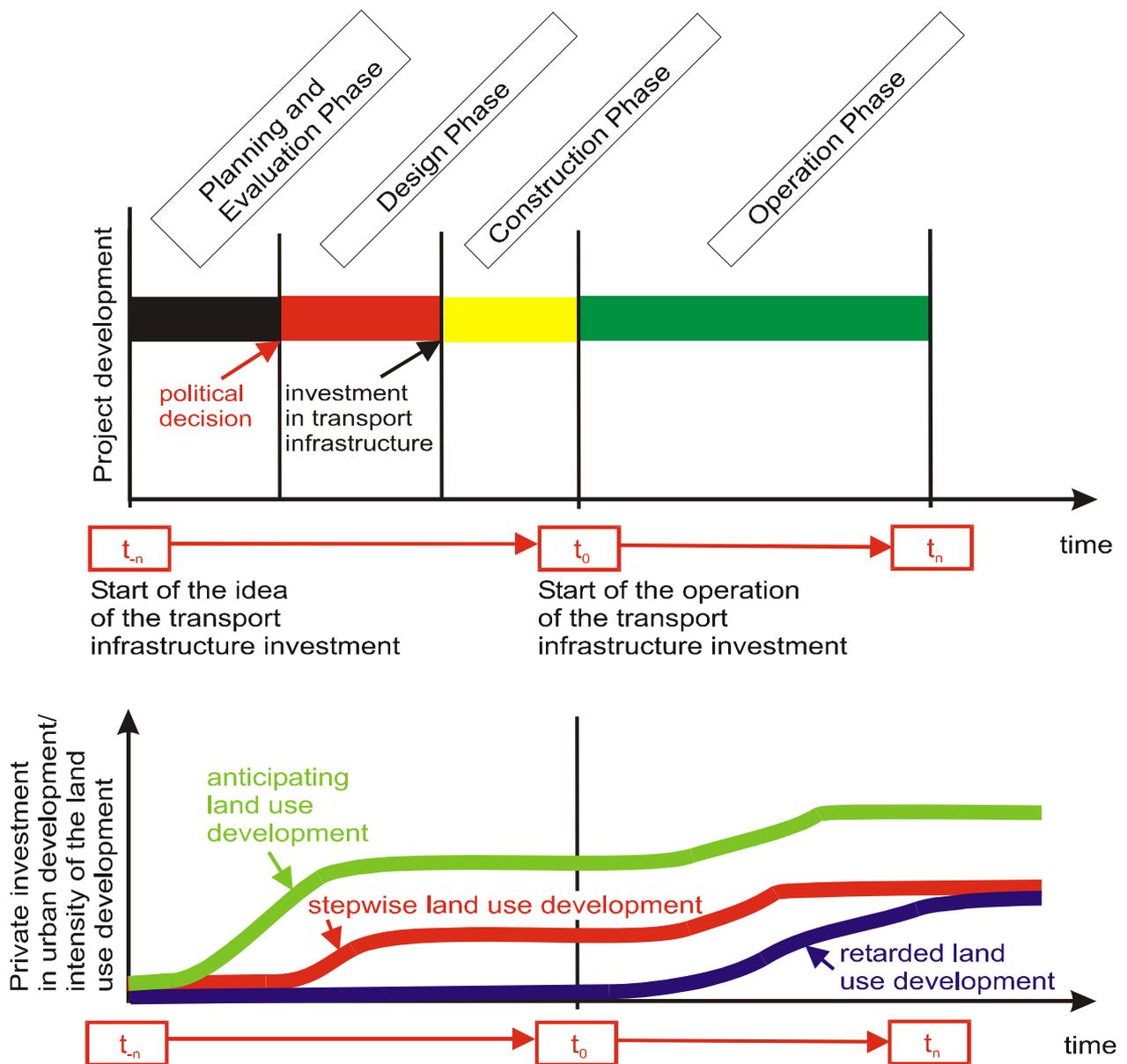


Figure 2-2: Infrastructure investment development and land use development

Because *TranSEcon* is focused on the investigation of socio-economic effects and impacts, the influence of the different phases on these effects have to be particularly considered. Transport policy measures, especially infrastructure investments, can have an effect on real estate development at different phases of the infrastructure investment life cycle (see

Figure 2-2). Decisions for private investments can occur long before a political decision is taken on the infrastructure investment, during construction or after start of operation. Compared with the phase the infrastructure is ready for operation, the socio-economic impacts could occur earlier and/or later. By probably excluding some

important impacts, this time shifts can have a great influence on the result of the evaluation.

The reasons for such anticipating, stepwise or retarded private reaction on infrastructure investment may be that not all real estate developers assess investment risks in the same way, and that local or general economic contexts of private investment show certain cycles as well. It is common knowledge that infrastructure investment cycles and private investment cycles often do not have the same rhythm. Monitoring of socio-economic effects of transport infrastructure and policy measurers must take account of such interference.

As a conclusion for the *TranSEcon* project it is necessary to distinguish two classes of impacts and effects:

- impacts and effects, which occur during the planning, evaluation, design and construction phase;
- impacts and effects which occur during the operation phase of the infrastructure investment;

2.3 Definition and relevance of effects and impacts³

The *TranSEcon* project is being carried out simultaneously with two other projects: TIPMAC and IASON. These projects are clustered with *TranSEcon*. Therefore definitions in all three projects should be harmonized, although it must be stated, that each project has different demands on definitions caused by different objectives. At least it must be ensured, that definitions used are not inconsistent.

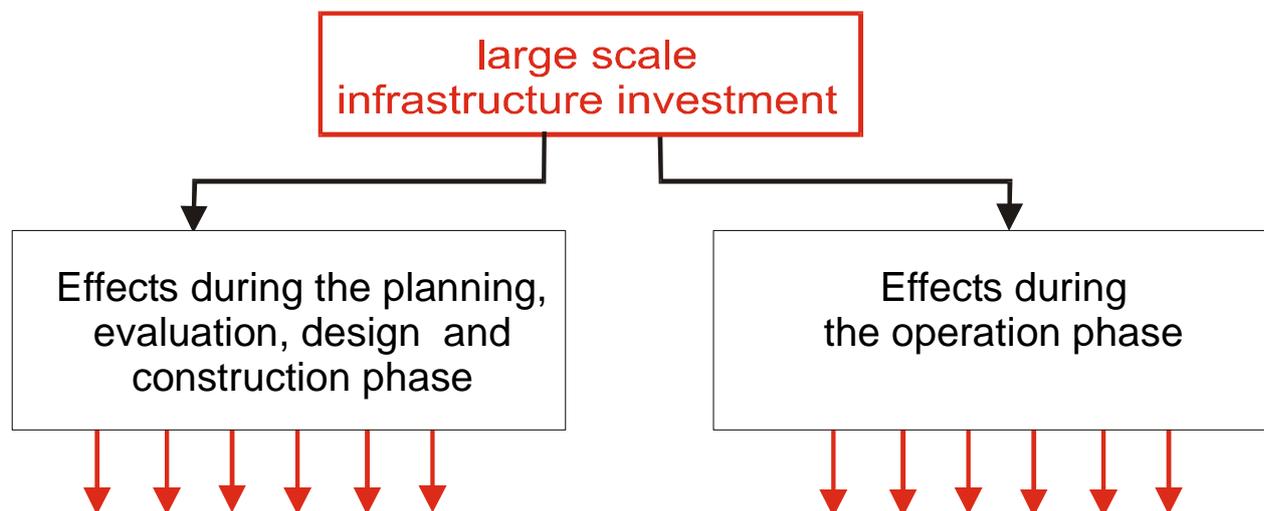


Figure 2-3: Classification of effects

³ section 2.5 of Deliverable 2

An additional distinction of relevant effects of each measure has to be defined and investigated (see Figure 2-3):

- effects during the planning, evaluation, design and construction phase;
- effects during operation phase of the invested infrastructure investment.

2.3.1 Planning, evaluation, design and construction phase

In Figure 2-4 the different types of effects are presented, which occur during the infrastructure development phases:

Direct effects

These direct effects are related to transport users, operators, neighbours who are directly affected by the planning, evaluation, design and construction work of the transport investment. These effects can be measured in changes of route choice, destination choice, travel-costs, travel-time etc. of the effected transport users or changes in revenue/costs for pt-operators, noise and gas emissions caused by the construction work or changes in the transport supply for users. These effects have a relative short time impact and mainly occur during the construction phase. They are not very relevant.

Direct network effects

The direct network effects occur within the transport system and are caused by changes in transport behaviour of the direct effected users, operators, neighbours or by transport caused by construction work transferred by network flows to other users of the network, who are not themselves directly affected by the construction work of the infrastructure investment. These effects can cause changes in route choice, destination choice, travel costs, noise and gas emissions etc. of these not directly affected users. These effects have a relative short time impact and mainly occur during the construction phase, therefore they are not very relevant.

Indirect effects (third-party effects, socio-economic effects)

These effects are distinguished from the direct effects because they are transmitted throughout the transport market outside of the transport system. These effects are caused by the planning, evaluation, design and construction work but they occur in an other market system as labour-market (e. g. the consultants who are involved in the design phase), product market (e. g. production of public transport vehicles) etc. These effects are very relevant for the **TranSEcon** project, but they have a relative short time impact and mainly occur during the design and construction phase.

Indirect network effects

These effects are caused by the changes in the indirect or third party effects and occur in the transport system. Changes in the employment and product market causes changes in the transport demand. This transport demand produces changes in the traffic flows, which are generated through other markets. These indirect network effects have a relative short time impact and are not very intensive. Therefore they are not very relevant.

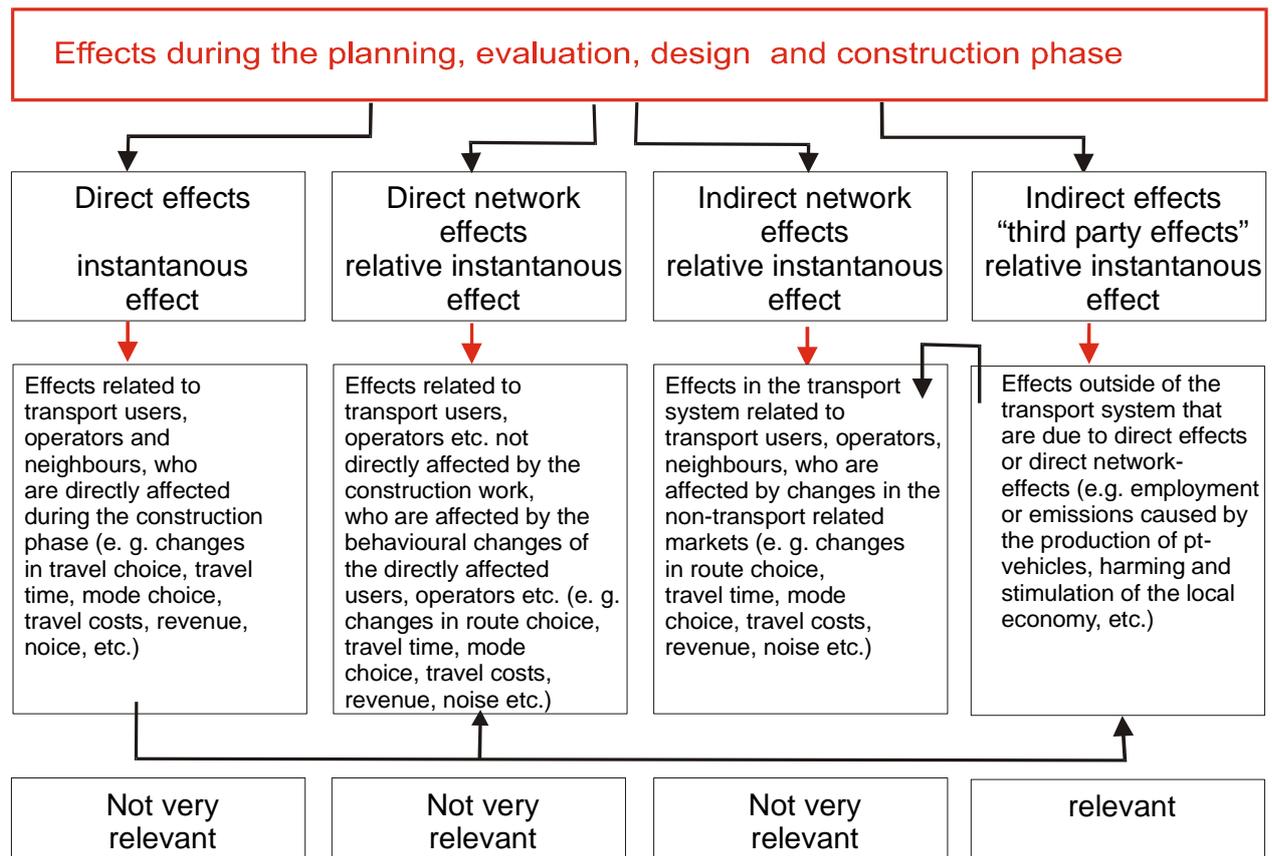


Figure 2-4: Classification of effects in the planning, evaluation, design and construction phase

2.3.2 Operation phase

The effects during the operation phase are classified in the following way (see also Figure 2-5):

Direct effects

The effects are related to transport users, operators, neighbours, who are directly affected by the transport investment and policies. These effects can occur as changes in the transport behaviour (route-choice, travel-time, destination-choice, travel costs, etc.) but also as changes for the operator or neighbours of the infrastructure investment (changes in operation costs, investment costs, gas emissions, noise, etc.).

Direct network effects

The direct network effects occur within the transport system. They are related to not directly affected transport users, operators or other concerned people. These persons are affected by the behavioural changes of directly effected transport users, operators or neighbours, what causes network effects e. g. in transport flow. This could lead to changes in route choice, destination choice, travel costs, noise and gas emissions etc. of these not directly affected users as well.

Indirect effects (third-party effects, socio-economic effects)

These effects are long term effects which occur in other markets than the transport system. They are caused by the changes in accessibility and other effects transmitted throughout the transport network and are leading to changes in the labour market, product market, health and environmental situation, etc.

Indirect network effects

These effects are caused by the changes in the indirect or third party effects and occur in the transport system. Changes in the labour market, product market and attractiveness of the city are influencing the transport demand. This transport demand produces changes in the traffic flows, which are generated through these other markets.

To conclude, effects during the operation phase show how the new infrastructure investment is adapted by the society; what kind of effect it has on land use, modal split, other services and development in the area, and how well it completes the transport system as a whole etc. **TranSEcon** will mainly focus on indirect effects (third party effects). But direct effects, direct network effects and indirect network effects will also be considered (work package 4).

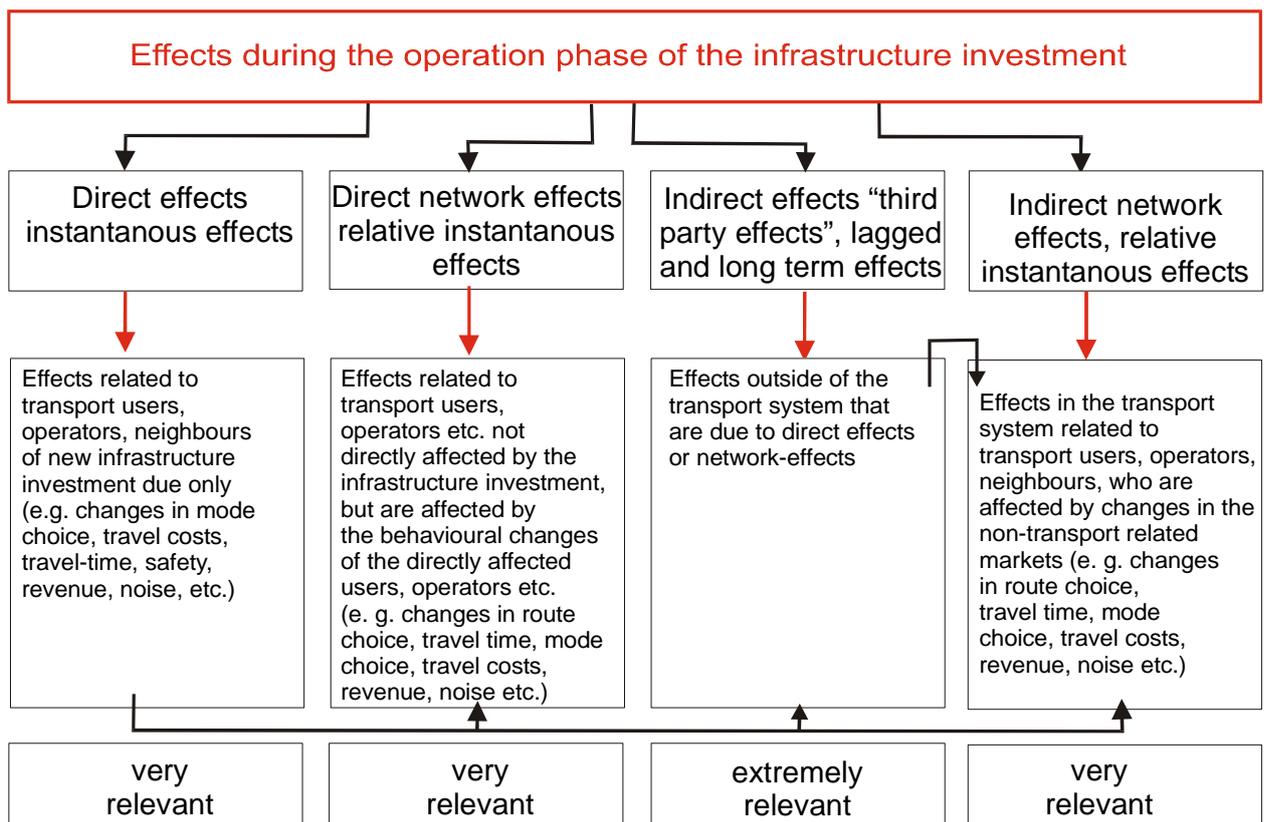


Figure 2-5: Classification of effects in the operation phase”

2.3.3 Indirect effects

The indirect effects are the main focus of the *TranSEcon* project. Figure 2-6 gives an overview, which type of the indirect effect will be investigated and which work package is responsible for.

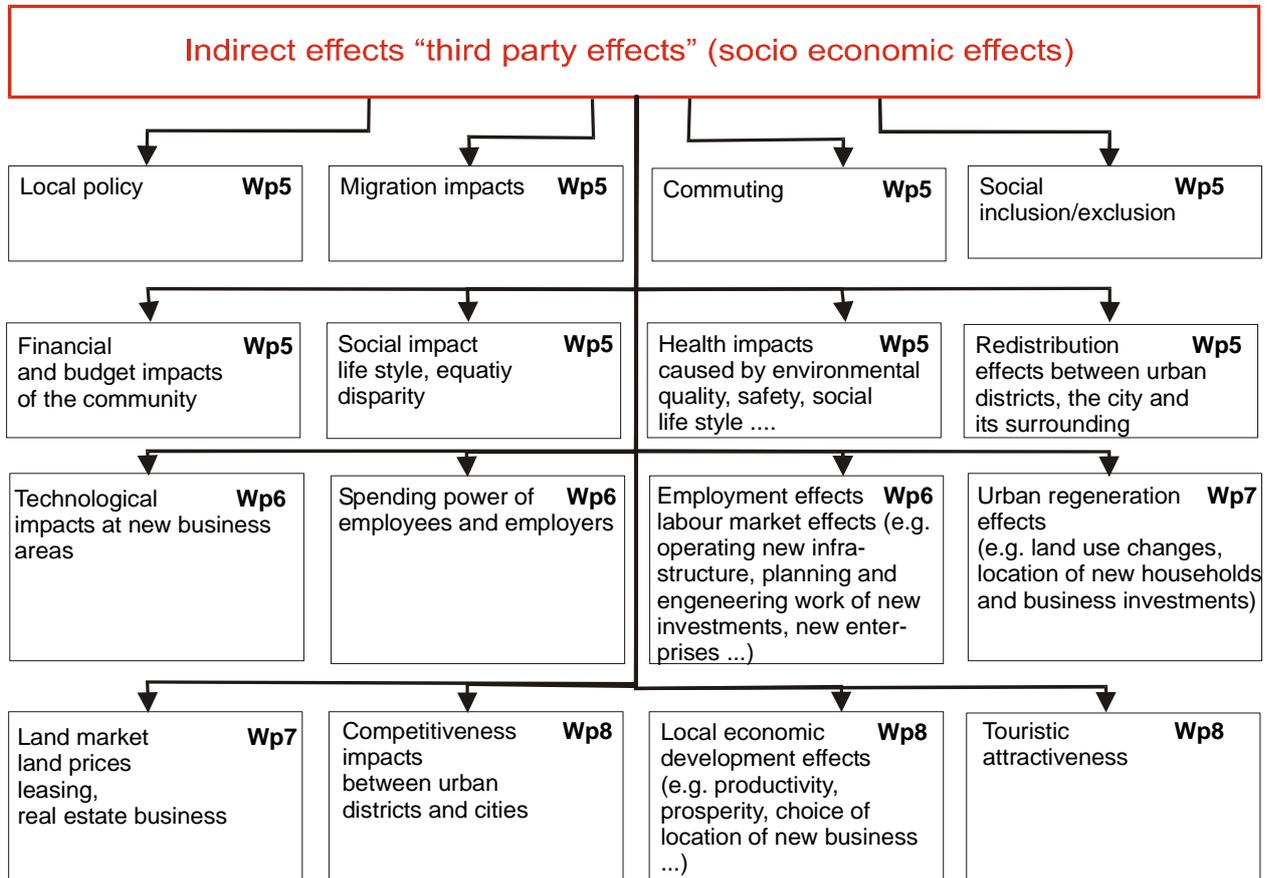


Figure 2-6: Overview of the indirect effects and the relevant work package

2.4 Spatial distribution of impacts and effects⁴

Changes in the transport infrastructure in a specific area can have a positive or negative impact in other parts of an urban region. It is possible that positive impacts in one urban area is causing negative impacts in another urban area, which does not benefit of an improvement in transport infrastructure (so called **local impacts**). Possible types of these effects could be direct and indirect network effects or indirect effects (see also section 2.3). In addition transport infrastructure may have a positive or negative impact on the city region as whole. It is important to find out how the competitiveness of the city is increased/decreased compared to those of others (so called **inter-regional impacts**) This type of effect is considered as an indirect or socio-economic effect.

⁴ section 2.6 of Deliverable 2

Investigating direct effects the study area is ideally a corridor along the infrastructure investment including some districts, suburbs or subdivisions of the city. Direct and indirect network effects can occur in the whole transport system itself. In some extreme cases, intercity relations are affected as well. Usually for urban infrastructure investments it is sufficient to consider the transport network (all modes) of the conurbation area or the corridor of the case study to determine the direct and indirect network effects.

A further point is that not only the transport related network indirect effects should be considered, but also the other markets in the area (e. g. labour- or product market)

Thus, it is very important for **TranSEcon** to take into account the spatial distribution of the effects and impacts, in dependency and the type of effect. This will be done in work package 4 to work package 9. It is one of the main objectives of **TranSEcon** to get results about the mechanism of the spatial distribution of the indirect effects.

2.5 Definition of scenarios⁵

Types of measures:

On the basis of the survey undertaken in work package 1 of **TranSEcon** to establish the type of measures and data availability for each of the case studies, two types of broad measures can be classified:

- infrastructure investments, typically improving the public transport systems such as metro and light rail, bus priorities, suburban rail, intermodality, including park & ride facilities, establishing a bicycle network and pedestrian zones, but sometimes also an extension of the urban road network and road traffic capacity improvements;
- policy measures by traffic regulation and/or management (such as access control, parking control, staggered working hours, car pooling, traffic calming, etc.), or pricing (such as public transport fare subsidies and integrated ticketing including multiple or season passes, parking pricing, special charges, etc.), or promotion of intermodality between transport modes including park & ride, bike & ride facilities. These measures can be seen as accompanying measures to the infrastructure investment.

Types of scenarios:

For assessment purposes, at least three different scenarios have to be defined in **TranSEcon**.

⁵ section 2.7 of Deliverable 2

- scenario of existing situation before the implementation of the infrastructure investment. This scenario describes a real life situation (scenario 0 at t_n);
- scenario with the implementation of the infrastructure investment. This scenario describes a real life situation (scenario 1 at t_n);
- scenario without implementation of the infrastructure investment (in literature “do-nothing scenario” or “do minimum scenario”). This scenario is fictitious, no real life data are existing (reference scenario at t_n).

The impact analysis is based on comparing scenarios with or without the infrastructure investment. Unlike the situation “before implementation” the “reference scenario” will include possible developments in the case study area over the time period investigated. In the reference scenario a reference district in the case study city without investments in extending the transport infrastructure can be used to determine possible developments (especially for the determination of the indirect effects). A second possibility determining these effects and impacts of the reference scenario is a modelling procedure (especially to determine the direct and indirect network effects). The reference scenario can include alternative transport infrastructure investments in other areas in the same community, transport infrastructure investments in other modes in the same community, investments in other sectors in the same community (e.g. housing), transport infrastructure investments in other communities (same or other mode), no investment at all and tax reduction or reducing of the public household deficit or simply “do nothing” scenario. That means, that the reference scenario can consist of a big variety of different measures with a high variety of the spatial and social distribution of effects and impacts. For the **TranSEcon** case studies it is not possible to get the information: In which way the financial resources would have been invested if the transport infrastructure measure would not have been realised? Therefore the reference scenario could be assumed as no alternative investments affects the development of the case study area.

To conclude, in each case studies following scenarios are to be defined:

- the scenario existing situation before construction;
- the reference scenario without implementation of the infrastructure investment; an alternative investment would not have affected the case study area;
- the scenario with implementation of infrastructure investment.

The difference in time between year t_0 and t_1 is important. **TranSEcon** will be studying infrastructure projects as a rule that have been in existence for at least 10 years time of operation between t_0 and t_1 .”

In the following these three scenarios are called:

- before scenario (some times the abbreviation Before is used);
- reference scenario (some times we use the abbreviation RS is used);
- scenario with (some times we use the abbreviation with is used).

Next chapter 3 described how this general framework is applied for work package 4.

3 GENERAL FRAMEWORK OF WP4

3.1 Application of the general framework to work package 4

In this paragraph, the application of the main elements of the general framework for *TranSEcon* work to work package 4 is defined.

Effects during the planning, evaluation, design and construction phase are excluded from work package 4. This kind of effect on transport systems are mainly short time effects which are not fully considered in *TranSEcon*.

The analysis concentrates on effects which occur during operation phase. It can be seen from the classification of effects (Figure 2-5), that the main concern are the direct effects, direct network effects and indirect effects which impact on transport systems. Indirect network effects mainly concern urban system other than transport systems. These indirect network effects are not considered as they are the core of work packages 5 to 9.

Understand the effects considered in work package 4 requires discussion of time horizon (section 3.1.1), zoning (section 3.1.2) and reference scenario (section 3.1.3).

3.1.1 Time scale

TranSEcon is mainly concerned with long term effects. Traditionally this time horizon is thought more relevant for the quantification of effects on different urban sectors other than transport (like housing market, labour market, economic effect...), in contrast to effects inside transport system where main effects are observed at short term. After short term transport effects are generally decreasing. For work package 4, three time horizons are defined:

- Short time (2-4 years after the investment);
- Medium time (4-6 years after the investment);
- Long time (about 10 years after the investment).

Of course when available, data for the situation before the investment is added. Time horizon for each case studies is given in sections 11.1.3 to 11.13.3.

3.1.2 Zoning of case study

The analysis of the impacts for all case studies should allow us to assess the impacts on the project area (direct effects). We therefore define for all case study the area of the project. We call this zone "Zproject". We define this zone as the catchment area of the investment to be assessed. This catchment area is defined as a circular zone around each station of the public transport investment, with a diameter comprised between 500 metres and 2 kilometres which depend on the nature of the public transport investment.

Next zone is directly affected by the investment. In general it is in this zone that the greater effects (except in Zproject) can be seen at the level of the conurbation. It's the zone of the direct effect network. In this report we call this zone "Z1 zone".

The last zone corresponds to a sector of the conurbation where the effects are generally less important, but still non negligible. It's the zone where main indirect network effects will be found. This zone is defined as "Z2 zone". In some case studies, this zone will be divided into two zones Z2a and Z2b. This distinction allows to hierarchy Z2 zone information in relation with the importance of the effect (more important in Z2a than in Z2b).

For two case studies a "Z3 zone" has been defined. It's a control zone where the investment to be assessed has no impact at all, and where there was no important investment in transport sector. This zone is used for the two case studies to calculate the effect of the investment from a comparison of indicators evolution in Zproject, Z1 and Z2 zones on one hand and Z3 zone on the other hand.

In order to harmonise the definition of Z1 and Z2 between case studies, there are two different cases depending on the nature of the public transport investment. The first case corresponds to an investment mainly dedicated to improve public transport system in the centre of the conurbation (Figure 3-1). The second one corresponds to an investment which improve public transport relation between suburb and centre of the conurbation or between suburbs (Figure 3-2).

Case 1. The project concerns the inner city

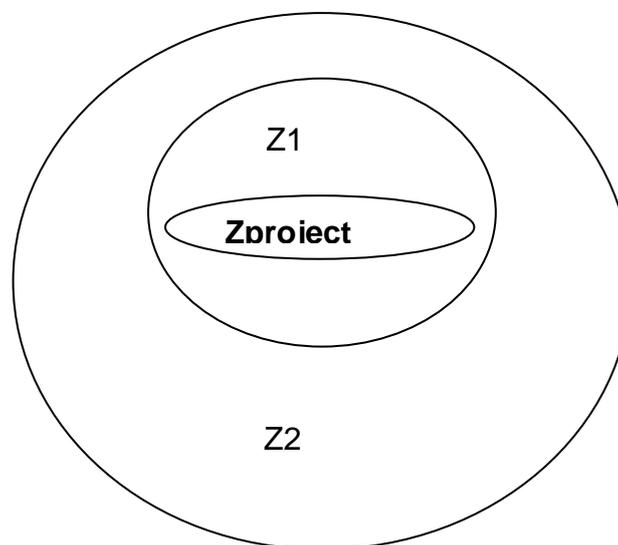


Figure 3-1: Zoning for case study with public transport investment in the centre of the conurbation

Case 2. The project concerns the suburbs

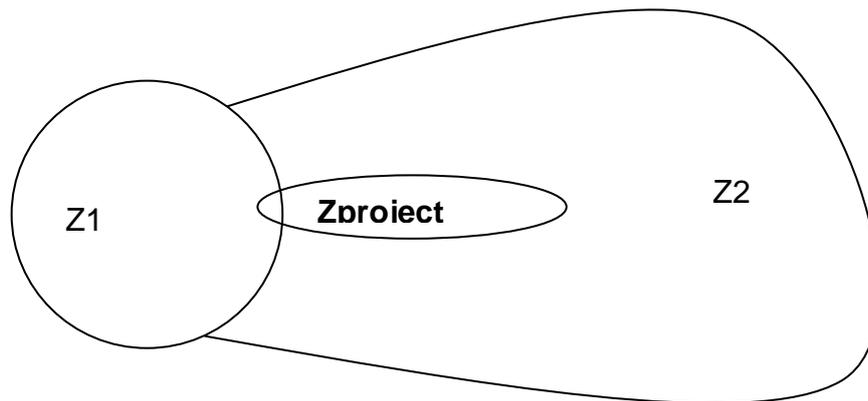


Figure 3-2: Zoning for case study with public transport investment in the suburbs of the conurbation

For the comparative analysis a distinction is made between these two different zoning systems.

For each case study a definition of the three different zones (Zproject, Z1 and Z2) is provided with a map presenting the zoning system. Data on population, employment and density is also given so as to take into account the context of each conurbation (sections 11.1.4 to 11.13.4).

3.1.3 Definition of the reference scenario

The absence of a common definition for all case studies of a reference scenario in deliverable 2 for work packages 4 to 9 is a crucial problem for work package 4. Each case study has to define its own definition guided by the definitions which have been proposed in deliverable 2 (section 2.5). But if the situation is relatively clear regarding the investment which is assessed (each case study considers a situation where the investment is not realised except Bratislava and Zurich case studies who use a control area (Z3 zone)), it is not so clear which other components of transport policy such as other investments in public transport than the investment considered in the case study and road infrastructure and parking investment or management should be considered.

Furthermore, the absence of transport models in several conurbations does not permit the computation of the effect of a reference scenario where it is assumed the investment is not realised. Even for conurbation where a model is available, the structure of the model does not always permit to produce data for all modes of transport and for parking nor financial data for transport system.

Therefore, the definition of the reference scenario which has been chosen by each case study partner is given in sections 11.1.5 to 11.13.5 and data collection process in sections 11.1.6 to 11.13.6.

3.2 Presentation of the indicators grid

The assessment of the impacts of urban transport infrastructures leads to quantifying the role of new transport supply on the urban transport system. New indicators which contribute to characterise the urban transport need to be defined.

These quantitative indicators should characterise the transport system and be suitable in use in work package 10 for the overall socio-economic evaluation. Both public transport and private transport are considered as well as both the supply and the demand sides. Lastly the effects of transport production and use on non users will need to be taken into account.

In order to respond to the list of tasks which have been defined in work package 4 description inside the *TranSEcon* project, indicators are organised in four groups.

3.2.1 Structure of the list of indicators

The first group of indicators assess the extent to which the project modifies the urban transport supply. The comparison of the public transport supply between the two scenarios measures the public transport performances gap due to the project. It would provide an assessment of the part of the investment on supply variation. Therefore, this group of indicators would provide the principal arguments to conclude the actual effect of the new project on the public transport supply.

The second group of indicators aims to quantify the effect of the project on transport demand. These indicators should quantify the evolution of transport demand and trip behaviour. It therefore allows a quantification of the role of the new project on modal split.

The third group of indicators deals with the impact of the new project on time savings. The aim here is to assess the extent to which the investment modifies the time spent on transport.

The fourth group deals with the impact of the new project on the transport environment, mainly emissions and safety. The objective is to isolate the part played by the new supply in the variation of the level of environmental externalities.

Therefore, the indicators are organised in 4 groups:

- urban transport system and supply;
- mobility and trip behaviour;
- time savings;
- transport environment.

3.2.2 Tables of Indicators

3.2.2.1 Urban transport system: supply

Both public transport and private transport systems are considered.

The public transport system: network and operator

The public transport system assessment needs to ascertain the gap in the supply performance characteristics between the two scenarios. The supply level is first defined, the effect of the investment on financial characteristic of the public transport network (cost operation, operation revenue, investment, contribution of the public transport authority).

| | Indicators | Zone | Time horizon | Hypotheses with respect to Reference Scenario | Needed for WP10 |
|--------------------------------|--|----------|--------------|--|-----------------|
| Characteristics of the network | Capacity in number of standing and seating places.km | Z1+Z2 | Short term | Appraisal of the variation in the public transport system quantitative supply. In what measure has the project an impact on the overall public transport supply? | no |
| | | | Medium term | | |
| | | | Long term | | |
| | | Zproject | Short term | | |
| | | | Medium term | | |
| | | | Long term | | |
| Financial characteristics | Annual fare revenue | Z1+Z2 | Short term | This indicator allows an assessment of the impact of the new investment on the overall public transport revenue. | yes |
| | | | Medium term | | |
| | | | Long term | | |
| | | Zproject | Short term | | |
| | | | Medium term | | |
| | | | Long term | | |

| | Indicators | Zone | Time horizon | Hypotheses with respect to Reference Scenario | Needed for WP10 |
|---|---|-------------|---|--|------------------------|
| Financial characteristics | Annual operation costs | Z1+Z2 | Short term | This indicator allows the assessment of the impact of the new investment on the overall public transport operation costs. | yes |
| | | | Medium term | | |
| | | | Long term | | |
| | | Zproject | Short term | | |
| | | | Medium term | | |
| | | | Long term | | |
| | Total investment expenditures for the project | Zproject | Short term | This indicator characterises the financial input of the project | yes |
| | | | Medium term | | |
| | | | Long term | | |
| | Annual investment (other than for the project) | Z1+Z2 | Short term | This indicator allows a comparison of the financial weight of the new project investment in overall public transport investment. | yes |
| | | | Medium term | | |
| | | | Long term | | |
| Annual contribution of the transport authority to public transport | Z1+Z2 | Short term | This indicator allows the assessment of the weight of the new investment in terms of its dependence to the financial public contribution. | yes | |
| | | Medium term | | | |
| | | Long term | | | |

Private transport supply

The indicators characterises private transport supply: car ownership, road supply and parking facilities in the two scenarios.

| | Indicators | Zone | Time horizon | Hypotheses with respect to Reference Scenario | Needed for WP10 |
|----------------------|--|-------------|---------------------|---|------------------------|
| Car ownership | Number of passenger cars per 1000 inhabitants | Z1 | Short term | This indicator allow the assessment of the impact of the new project on the car ownership | No |
| | | | Medium term | | |
| | | | Long term | | |
| | | Z2 | Short term | | |
| | | | Medium term | | |
| | | | Long term | | |
| Road network | Average speed of trips by car | Z1-Z1 | Short term | This indicator allows the assessment of whether the new project has an impact on the performance level of road supply | Yes |
| | | | Medium term | | |
| | | | Long term | | |
| | | Z1-Z2 | Short term | | |
| | | | Medium term | | |
| | | | Long term | | |
| | | Z2-Z2 | Short term | | |
| | | | Medium term | | |
| | | | Long term | | |

| | Indicators | Zone | Time horizon | Hypotheses with respect to Reference Scenario | Needed for WP10 |
|-------------------------------|--|-------------|---|---|------------------------|
| Road network | Length of the expressways (unrestricted roads) | Z1+Z2 | Short term | These context indicators are to assess if road supply has increased compared to the increase in public transport supply. They give an idea of road transport policy in the case study in comparison with the public transport policy (including the project). | No |
| | | | Medium term | | |
| | | | Long term | | |
| | Complete circular road with expressway | Z1+Z2 | Short term | | No |
| | | | Medium term | | |
| | | | Long term | | |
| | Road with traffic calming measures | Z1 | Short term | | No |
| | | | Medium term | | |
| | | | Long term | | |
| | | Z2 | Short term | | |
| | | | Medium term | | |
| | | | Long term | | |
| | Investment expenditures for increasing urban road network | Z1+Z2 | Short term | | Yes |
| | | | Medium term | | |
| | | | Long term | | |
| Average car fuel price | Z1+Z2 | Short term | Context indicator to assess the level of road transport cost. | No | |
| | | Medium term | | | |
| | | Long term | | | |

| | Indicators | Zone | Time horizon | Hypotheses with respect to Reference Scenario | Needed for WP10 | | |
|--------------------------------------|--|--------------------|--------------|---|--|---|----|
| Parking facilities | Capacity of public (off-street) car parks | Z1 | Short term | Parking supply indicators to indicate scope of accompanying measures to the project and to evaluate the impact of the project on the parking policy (restructuration, etc.) | No | | |
| | | | Medium term | | | | |
| | | | Long term | | | | |
| | On-street public parking slots | Z1 | Short term | | The project may have an impact on the parking behaviour. These indicators provide an assessment of the impact of the project on the parking use. | No | |
| | | | Medium term | | | | |
| | | | Long term | | | | |
| | Private supply | Z1 | Short term | | | Context indicators of the parking policy. | No |
| | | | Medium term | | | | |
| | | | Long term | | | | |
| | Average on-street parking occupation rate | Z1 | Short term | Context indicators of the parking policy. | | | No |
| | | | Medium term | | | | |
| | | | Long term | | | | |
| | On-street parking turnover rate | Z1 | Short term | | Context indicators of the parking policy. | | No |
| | | | Medium term | | | | |
| | | | Long term | | | | |
| | Number of parking slots of park and ride facilities | Zproject / Z1 / Z2 | Short term | | | Context indicators of the parking policy. | No |
| | | | Medium term | | | | |
| | | | Long term | | | | |
| Off-street fee revenue | Z1 | Short term | | Yes if available | | | |
| | | Medium term | | | | | |
| | | Long term | | | | | |
| On-street parking fee revenue | Z1 | Short term | | | Yes if available | | |
| | | Medium term | | | | | |
| | | Long term | | | | | |

3.2.2.2 Mobility and trip behaviour

The aim is to assess the impact of the public transport infrastructure in term of urban mobility. The indicators show to what extent the new public transport supply modifies the trip behaviour (in terms of public transport and car use and modal shift to public transport). This impact is quantified both in terms of number of trips and passenger kilometre so as to calculate total time savings or emissions.

| Indicators | Zone | Time horizon | Hypotheses with respect to Reference Scenario | Needed for WP10 | | | | | |
|---|--|--------------|--|--|--|--|--|--|-----|
| Number of public transport trips (including the project area) | Z1-Z1; Z1-Z2; Z2-Z2; Zproject | Short term | A new transport project has an impact on trip behaviour. The modal splits changes. Indicators can assess the modal share for each competitive related-investment mode and the level of change for the mode which benefits from the investment in the case study. | Yes | | | | | |
| | | Medium term | | | | | | | |
| | | Long term | | | | | | | |
| Number of public transport trips on the project only | Zproject | Short term | | A new transport project has an impact on trip behaviour. The modal splits changes. Indicators can assess the modal share for each competitive related-investment mode and the level of change for the mode which benefits from the investment in the case study. | Yes | | | | |
| | | Medium term | | | | | | | |
| | | Long term | | | | | | | |
| Passenger-km (including the project area) | Z1-Z1; Z1-Z2; Z2-Z2; Zproject | Short term | | | A new transport project has an impact on trip behaviour. The modal splits changes. Indicators can assess the modal share for each competitive related-investment mode and the level of change for the mode which benefits from the investment in the case study. | Yes | | | |
| | | Medium term | | | | | | | |
| | | Long term | | | | | | | |
| Passenger-km on the project area | Zproject | Short term | | | | A new transport project has an impact on trip behaviour. The modal splits changes. Indicators can assess the modal share for each competitive related-investment mode and the level of change for the mode which benefits from the investment in the case study. | Yes | | |
| | | Medium term | | | | | | | |
| | | Long term | | | | | | | |
| Number of car trips | Z1-Z1; Z1-Z2; Z2-Z2 | Short term | | | | | A new transport project has an impact on trip behaviour. The modal splits changes. Indicators can assess the modal share for each competitive related-investment mode and the level of change for the mode which benefits from the investment in the case study. | Yes | |
| | | Medium term | | | | | | | |
| | | Long term | | | | | | | |
| Car-km | Z1-Z1; Z1-Z2; Z2-Z2 | Short term | | | | | | A new transport project has an impact on trip behaviour. The modal splits changes. Indicators can assess the modal share for each competitive related-investment mode and the level of change for the mode which benefits from the investment in the case study. | Yes |
| | | Medium term | | | | | | | |
| | | Long term | | | | | | | |
| Modal shift to public transport | Z1-Z1; Z1-Z2; Z2-Z2; Zproject | Short term | A new transport project has an impact on trip behaviour. The modal splits changes. Indicators can assess the modal share for each competitive related-investment mode and the level of change for the mode which benefits from the investment in the case study. | | | | | | No |
| | | Medium term | | | | | | | |
| | | Long term | | | | | | | |

3.2.2.3 Time savings

Time savings are an important issue in the assessment of the effect of the transport investment.

| Indicators | Zone | Time horizon | Hypotheses with respect to Reference Scenario | Needed for WP10 | | |
|---|--|--------------|---|-----------------|-----|-----|
| Average trip travel time on the public transport (bicycles for Delft) network | Z1-Z1; Z1-Z2; Z2-Z2; Zproject | Short term | | Yes | | |
| | | Medium term | | | | |
| | | Long term | | | | |
| Average trip travel time on road network by car | Z1-Z1; Z1-Z2; Z2-Z2 | Short term | | | Yes | |
| | | Medium term | | | | |
| | | Long term | | | | |
| Average trip travel time on the new project | Zproject | Short term | | | | Yes |
| | | Medium term | | | | |
| | | Long term | | | | |

3.2.2.4 Transport environment

The assessment of the environmental impacts of the infrastructure include air pollution and safety data.

| | Indicators | Zone | Time horizon | Hypotheses with respect to Reference Scenario | Needed for WP10 |
|---|---------------------------------|-------------------|--------------|--|-----------------|
| Air pollution on main chemical effluents emissions | CO | Whole conurbation | Short term | The new project implementation may have an impact on emissions. The change should be assessed. | Yes |
| | | | Medium term | | |
| | | | Long term | | |
| | CO2 | | Short term | | Yes |
| | | | Medium term | | |
| | | | Long term | | |
| | SOx | | Short term | | Yes |
| | | | Medium term | | |
| | | | Long term | | |
| | NOx | | Short term | | Yes |
| | | | Medium term | | |
| | | | Long term | | |
| | Lead | | Short term | | Yes |
| | | | Medium term | | |
| | | | Long term | | |
| VOC | Short term | Yes | | | |
| | Medium term | | | | |
| | Long term | | | | |
| PM10 | Short term | Yes | | | |
| | Medium term | | | | |
| | Long term | | | | |
| Safety | Number of fatalities | Whole conurbation | Short term | The new project may have an impact on the level of safety. It should be assessed. | Yes |
| | | | Medium term | | |
| | | | Long term | | |
| | Number of injured people | Whole conurbation | Short term | | Yes |
| | | | Medium term | | |
| | | | Long term | | |
| | Total casualties | Whole conurbation | Short term | | Yes |
| | | | Medium term | | |
| | | | Long term | | |

3.3 Description of the data collection methodology

Data collection has been the responsibility of each case study partner using the methodology defined in work package 4. Each case study partner has used the previous tables which have been sent in an Excel sheet with information about unit for each indicator and a commentary when necessary.

Each partner was asked to send the corresponding sheet with comments on the method of collection and additional comments when necessary. This has been synthesised for each case study in sections 11.1.6 to 11.13.6.

In general data for the before scenario and the scenario with have mainly been collected from existing mobility surveys, census, report from transport operators or transport authorities. Some data was not available and as time dedicated to **TranSEcon** was not sufficient to organise specific survey production. Therefore in these cases, the corresponding data have not been produced by the case study partner.

For reference scenario the situation is most variable. Where model was available data have been computed (in this case for some case studies, some data have been computed for both reference scenario and scenario with in order to ensure the coherence of data). In other cases data have calculated from analysis of existing data.

3.4 General comments on data quality

Data collection has been much more time consuming than expected for all case study partners because some data was not easily available in existing surveys or reports. In this case some additional works has been necessary to calculate the data or to collect data from different actors of urban transport system.

In some other cases, data are still not produced by case study partners because the information is not accessible. For example in Great Britain, the deregulation of the bus sector has meant that data has become too strategic to divulge.

Another difficulty was the absence of a definition of a common reference scenario in work package 2. The same definition in all case studies has not been possible even if all partners have chosen a "do-minimum scenario". Furthermore, the construction of the reference scenario is also quite complex because it does not correspond to an existing situation. For some partners, the availability of a model has overcome this difficulty. But for other partners data have been estimated from complex analysis of existing data.

The combination of multiple sources or methods to produce the data has resulted some-times in a lack of coherence. For example it could the case between the evolution of the number of trips and the evolution of the number of passenger*kilometres which can be produced from different sources. Where possible all coherence checks have been made, but some problems still remain.

Therefore some caution is still necessary when analysing the data and the trends are perhaps more relevant than the exact figures given in the different tables.

In the appendix figures are given with a certain precision. But the limits encountered in data collection, especially for reference scenario, should be remembered in its interpretation as the precision may be illusory. In most cases observed variation are too small to be really significant but indicate the direction of the change of the effect on transport.

3.5 Impact calculation method

The calculation of the impact of the public transport investment involved in the case study is defined by the methodology adopted in deliverable 2. For one indicator, the impact of the project corresponds to the difference between the value of this indicator for scenario with project and the value of the same indicator for reference scenario. With this calculation we define the absolute variation:

Absolute variation = (*Data " with "* – *Data " RS "*),

With:

Data " with " : data for the scenario with project;

Data " RS " : data for the reference scenario.

From this absolute variation, it is possible to calculate the relative variation of the indicator with the following formula:

Relative variation = ((*Data " with "* – *Data " RS "*) / *Data " RS "*).

For eleven project the definition of the reference scenario corresponds to the definition of a do minimum scenario with the production of the data for this scenario (see Table 4-4). In this case, it is possible to apply this method directly. But for two case studies (Bratislava and Zurich) the reference scenario correspond to a reference area where it is supposed that the project have no or minimum impact. In this case, it is not possible to apply directly the above formula. To keep the same principle of calculation we propose to define the impact as the difference between the growth of one indicator in the impacted area with the growth of the same indicator in the reference area. Therefore it is no more possible to calculate the absolute variation, but only the relative variation with the following formula (for example for one indicator in zone Z1 and for short term):

Relative variation =

(*Data " with "(ST, Z1)* – *Data " with "(Before, Z1)*) / *Data " with "(Before, Z1)* –

(*Data (ST, ref _area)* – *Data (Before, ref _area)*) / *Data (Before, ref _area)* With:

Data " with "(ST, Z1): data for the scenario with project for zone Z1 for short term horizon;

Data " with "(Before, Z1): data for the scenario with project for zone Z1 in the before situation;

Data (ST, ref _area): data for the reference scenario for the reference area for short term horizon;

Data (Before, ref _area): data for the reference scenario for the reference area in the before situation.

This impact is calculated for each indicator, each zone and each time horizon.

3.6 How to perform the comparative analysis

For the comparative analysis, it is necessary to deal with the fact that time horizons are not always the same between case studies. This problem can be illustrated with the figure below (Figure 3-3) (assuming for simplicity of representation a linear development in effects).

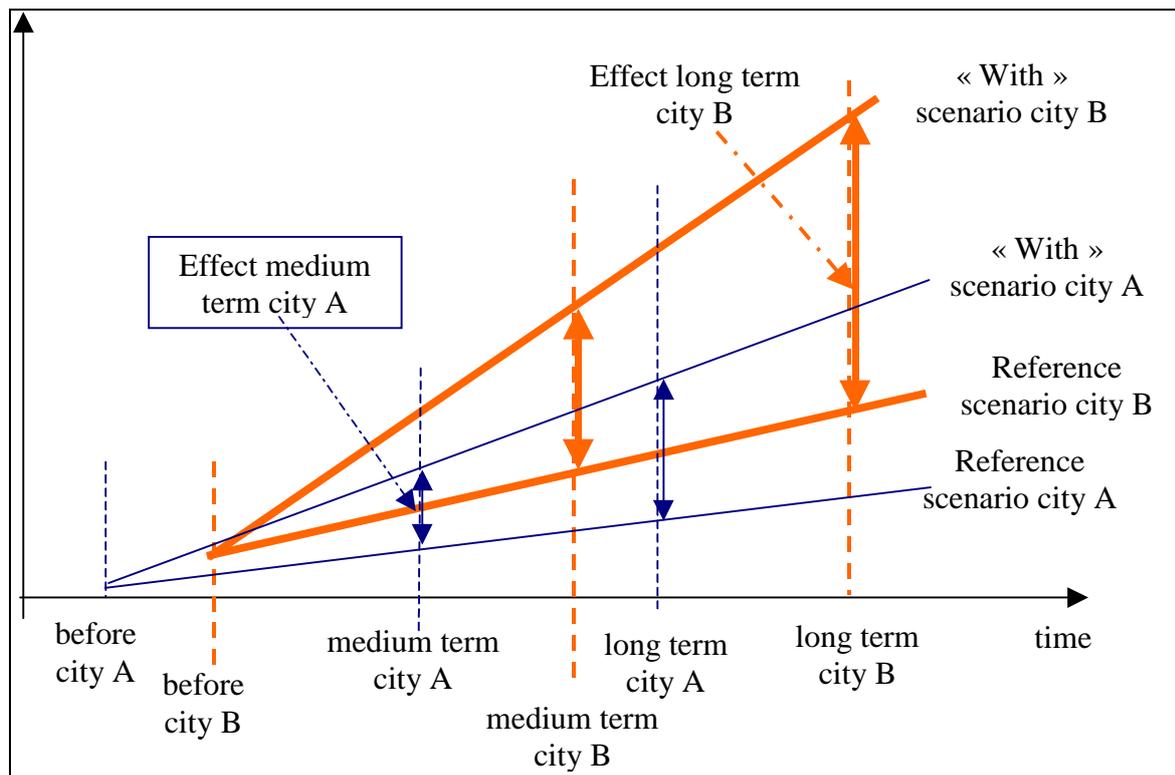


Figure 3-3: Illustration of the comparison problem with different time horizon

The direct comparison of absolute effect for short term and medium or long term could therefore conduct to misinterpretation. In order to face this problem, for the comparative analysis, results should be presented in terms of annualised variation.

Furthermore the indicators increase generally at a faster pace in short term than in medium and long term as shown in Figure 3-4. The development curve is non linear and may obviously differ between case studies for the same indicator.

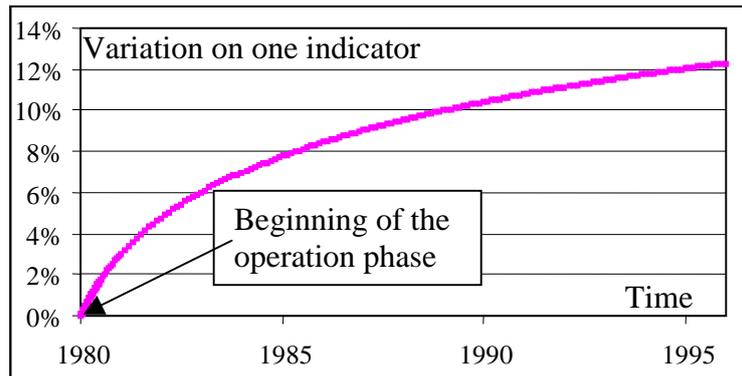


Figure 3-4: General evolution of variation of most indicators over time

Since it is impossible to calibrate different development curves for each case study, the best compromise found is to assume a *constant* annual growth ratio for each time horizon. Then annual growth ratio can be compared across case studies for the same time horizon, since time intervals (time horizon - time before) are broadly the same across case studies⁶.

The “annualised effects” are calculated from the relative variation of the indicator (i.e. $(Data\ "with"\ -\ Data\ "RS") / Data\ "RS"$), then as a constant growth ratio per year on the time interval $Year\ Horizon - Year\ Before$, the year horizon being for short, medium and long term. For all calculation the number of years between the time horizon and the year chosen for “before data” is considered. This year is preferred in lieu of the operation date because it allows to smooth the effects of the construction years which often introduce perturbation in transport system especially for public transport system. The formula is:

$$\left(1 + \left(\frac{Data\ "with"\ -\ Data\ "RS"}{Data\ "RS"} \right)^{\frac{1}{Year\ Horizon - Year\ Before}} \right) - 1$$

For the two case studies for which the reference scenario is defined by the reference area, we apply the same calculation but with the relative variation defined in the previous section (section 3.5).

This indicator allows to illustrate the decreasing effect which can be observed on most of the indicators for which both short, medium and long term data are available for one case study. But it should be noticed that it is not possible with this indicator to compare short term data of one case study with long term data of another case study. This calculation is represented in Figure 3-5. In this Figure 3-5 we have the following results:

⁶ i.e. short term 2-4 years after the investment, medium term 4-6 years after the investment, long term about 10 years after the investment.

- short term effect (1985), relative variation = 7.78%; annualised effects = 1.51%;
- long term effect (1995), relative variation = 12.04%; annualised effects = 0.76%.

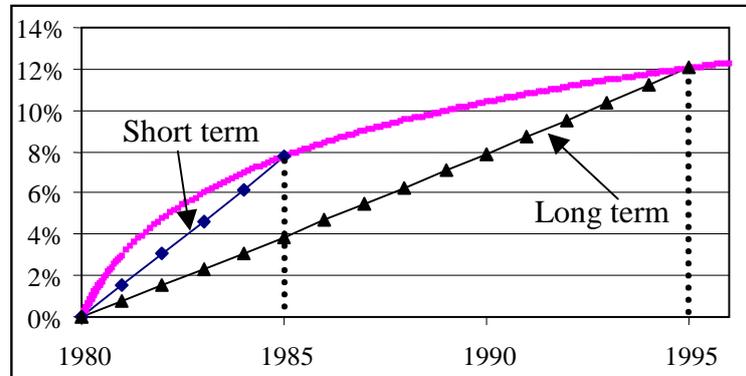


Figure 3-5: Illustration of the calculation of the “annualised effects” for short term (1985 in the figure) and long term (1995 in the figure)

4 CASE STUDY DESCRIPTION

This chapter gives an overview of the case-studies to facilitate the comparative analysis of transport related impact. The overview takes the same form as the case study descriptions which are presented for each case study in appendix 1.

4.1 Case study

Apart from Delft, all investment are public transport projects. All are heavy investments and are accompanied by reorganisation of the network. Nearly half concern light rail and the rest relate to metro system and S-Bahns (Stuttgart and Zurich). More than half are concerned with the centre of the conurbation whilst the rest deal with connections between suburbs and between the suburbs and centre of the conurbation. For half of the projects accompanying measures have been taken to restrict the use of car and increase the benefit of the project.

| Case studies | Nature of the investment | Location of the investment | Length of the new infrastructure (km) | Accompanying measures |
|----------------------|---------------------------------|-----------------------------------|--|--|
| Athens | Metro line | Centre | 18 | Reorganisation of the network |
| Bratislava | Light rail + trolleybus lines | Centre | Light rail: 2.0 Trolleybus: 6.0 | Transition economy period |
| Brussels | Inner ring metro line | Centre | 8.2 | No |
| Delft | Extensive bicycle network | Whole town | - | No |
| Helsinki | Metro line | Suburbs to centre | 11.0 | Reorganisation of the bus-service network |
| Lyon | Metro driverless line | Centre | 15.0 | Reorganisation of the network |
| Madrid | Inner ring metro line | Centre | 7 | Reorganisation of the network |
| Manchester | Metrolink light rail | Suburbs to centre | 31 | No |
| Stuttgart | S-Bahn | Suburbs | 16 | Parking restriction + park and ride + interoperability |
| Tyne and Wear | Metro light rail | Suburbs to centre | 55.5 | Park and ride |
| Valencia | Light rail | Suburbs to centre | 9.7 | Urban regeneration + integrated ticketing |
| Vienna | Metro line | Centre | 8.2 | Parking restriction + park and ride + urban regeneration |
| Zurich | S-Bahn | Central City and Suburbs | 12 | Strong restriction on public parking + public transport priority |

Table 4-1: Case study description synthesis

4.2 Time scale project

Data are not always available for the required three time horizons. Furthermore the definition of the time horizon is not always identical between case studies. Impact analysis should take into account these elements.

| Case studies | Operation since | Before | Short term | Medium term | Long term |
|---------------|-----------------|---------|------------|--------------|-----------|
| Athens | 2000 | 1996 | 2002 | 2006 | n.a. |
| Bratislava | 1988/89 | 1985 | 1990 | 1995 | 2000 |
| Brussels | 1988 | 1987/88 | 1989/90 | 1991/94 | 1998/2000 |
| Delft | 1985/86 | 1979/82 | 1987/90 | 1991/94 | 1995/96 |
| Helsinki | 1982 | 1981 | 1983/1985 | 1986/1988 | 1992/1995 |
| Lyon | 1992 | 1985/86 | n.a. | 1995 | 1999 |
| Madrid | 1995 | 1987/88 | 1996 | 2000 | n.a. |
| Manchester | 1992 | 1991 | 1996 | 2001 | 2011 |
| Stuttgart | 1992 | 1990 | 1994 | 1995 or 1997 | 2000 |
| Tyne and Wear | 1984 | 1980 | 1983/84 | 1986/88 | 1992/2002 |
| Valencia | 1994 | 1991 | 1996 | 2001 | n.a. |
| Vienna | 1991 | n.a. | n.a. | n.a. | 2002 |
| Zurich | 1990 | 1980/90 | 1990/93 | 1995/98 | 1999/2001 |

Table 4-2: Time scale synthesis

4.3 Zoning

For the *TransEcon* project, the size of the conurbation varies from a small city like Delft to big conurbation like Madrid. Three groups can be identified:

- small city: Delft;
- medium conurbation: Bratislava, Helsinki, Lyon, Stuttgart, Tyne and Wear, Valencia, Vienna, Zurich;
- large conurbation: Athens, Brussels, Madrid and Manchester.

Several conurbations are the capital of their country and this explains some differences especially in term of financing the public transport network.

The sizes of the area included in (Z1 + Z2) are also very different. The area of Madrid and Brussels case studies are very large and are the biggest in terms of population. Stuttgart and Valencia are next with large Z1 + Z2 area (if smaller than Madrid and Brussels). For the other conurbations where the information is available, the surface of the study area is relatively comparable.

Big differences in terms of density are also observable. But the comparison is not, always easy because the surfaces of the study areas are different. Athens, Madrid and Valencia have the highest density in their conurbation centre. On the opposite

Zurich and Stuttgart for the centre of the conurbation have the lowest density. The situation is more comparable for the other conurbation.

| Case studies | Indicator | Whole conurbation | Zproject | Z1 zone | Z2 zone |
|--------------------------|---|-------------------|-----------------------|---------|---------|
| Athens | Population in 2002 (thousand) | 4 000 | 997 | 1 519 | 1 278 |
| | Surface in km ² | 636 | 32.5 | 129.8 | 473.9 |
| | Density in 2002 (inhab/km ²) | 6 289 | 30 674 | 11 698 | 2 596 |
| | Employment in 1996 (thousand) | n.a. | 384 | 565 | 447 |
| Bratislava | Population (thousand, in 1998) | 450 | Zp1: 0.4 Zp2: 30 | 422 | 27 |
| | Surface in km ² | 369 | Zp1: 2.0 Zp2: 4.5 | 218 | 149 |
| | Density (inhab/km ² , in 1998) | 1 218 | Zp1: 210 Zp2: 6556 | 1 932 | 179 |
| | Employment (thousand) | | Zp1: 4.5 Zp2: 22 | 212 | 23 |
| Brussels (2001) | Population (thousand) | 2 945 | n.a. | 954 | 1 980 |
| | Surface in km ² | 4 332 | n.a. | 161 | 4 170 |
| | Density (inhab/km ²) | 680 | n.a. | 5 980 | 475 |
| | Employment (thousand) | 1 353 | n.a. | 657 | 696 |
| Delft (2002) | Population (thousand) | n.a. | n.a. | 96.9 | n.a. |
| | Surface in km ² | n.a. | n.a. | 26.3 | n.a. |
| | Density (inhab/km ²) | n.a. | n.a. | 3 684 | n.a. |
| | Employment (thousand) | n.a. | n.a. | 50.8 | n.a. |
| Helsinki (2000) | Population (thousand) | 967 | 183 | 167 | 363 |
| | Surface in km ² | 764 | 43 | 39 | 117 |
| | Density (inhab/km ²) | 1 266 | 4 261 | 4 301 | 3 107 |
| | Employment (thousand) | 500 | n.a. | n.a. | n.a. |
| Lyon (1999) | Population (thousand) | 1 167 | 96 | 430 | 737 |
| | Surface in km ² | 487.2 | 8.6 | 65.3 | 421.9 |
| | Density (inhab/km ²) | 1 513 | 11 130 | 6 579 | 2 766 |
| Madrid (2000) | Population (thousand) | 5 205 | 190 | 2 882 | 2 322 |
| | Surface in km ² | 8 029 | 8.9 | 607.1 | 7 422 |
| | Density (inhab/km ²) | 648 | 21 356 | 4 748 | 312 |
| | Employment (thousand) | 2 036 | 102 | 1 402 | 633 |
| Manchester (1991) | Population (thousand) | 2 440 | 53 | 1 071 | 1 369 |
| Stuttgart (2000) | Population (thousand) | 1 376 | n.a. | 584 | 792 |
| | Surface in km ² | 2 066 | 16 | 207 | 1 859 |
| | Density (inhab/km ²) | 666 | n.a. | 2 816 | 426 |

| | | | | | |
|--|---|-------|--------|-------|-------|
| Tyne and Wear (1996) | Population (thousand) | 1 100 | n.a. | n.a. | n.a. |
| Valencia (2001) | Population (thousand) | 1 503 | 144 | 747 | 756 |
| | Surface in km ² | 1 231 | 20.2 | 99.7 | 1 131 |
| | Density (inhab/km ²) | 1 221 | 14 088 | 7 489 | 668 |
| Vienna (2001) | Population (thousand) | 1 562 | n.a. | 18 | 1 545 |
| | Surface in km ² | 418 | n.a. | 3 | 415 |
| | Density (inhab/km ²) | 3 765 | n.a. | 5 878 | 3 750 |
| Zurich (population 2000, employment 1998) | Population (whole conurbation = Canton of Zurich, thousand) | 1 207 | 34 | 334 | 133 |
| | Surface in km ² | 1 729 | 10.6 | 92 | 173 |
| | Density (inhab/km ²) | 698 | 3 285 | 3 634 | 766 |
| | Employment (thousand) | 693 | 21 | 315 | 58 |

Table 4-3: Zoning synthesis

Employment level are available for seven conurbation only. Except Athens, these conurbation show a strong concentration of the employment in the central area of the conurbation.

Of course these differences have strong consequences in terms of modal share. From the literature it is known that, anything else being equal, bigger conurbations have higher usage of public transport; higher density corresponds to higher use of public transport and higher concentration of employment in central area is synonymous of higher use of public transport.

4.4 Reference scenario

For analysis all projects, except Bratislava and Zurich, have adopted a do-minimum scenario i.e. a scenario where the investment would not have been built, but where all other elements of the transport policy (both for public and private transport and parking) would have to remain identical. Where a model was available, data have been estimated from modelling exercises. In other case studies this do-minimum scenario resulted from analysis of the evolution of some indicators of the conurbation combined with the comparison of the evolution of the same indicators in other area.

In many cases, multiple sources of data have been necessary which explain, in some cases, some apparent inconsistencies in data. Thus caution is always necessary in analysing the data.

Of course these differences in the definition of the reference scenario imply a reduction of the comparability of the data. Caution is therefore necessary in analysing the data. We often recommend to take more attention of the tendencies rather than the exact figures.

| Case studies | Reference scenario | Method of data production |
|--------------|--------------------|---------------------------|
|--------------|--------------------|---------------------------|

| | definition | for reference scenario |
|----------------------|-------------------|------------------------------------|
| Athens | Do minimum | Data analysis |
| Bratislava | Reference zone | Data analysis |
| Brussels | Do minimum | Modelling |
| Delft | Do minimum | Data analysis + evaluation studies |
| Helsinki | Do minimum | Data analysis |
| Lyon | Do minimum | Data analysis |
| Madrid | Do minimum | Modelling |
| Manchester | Do minimum | Modelling |
| Stuttgart | Do minimum | Modelling |
| Tyne and Wear | Do minimum | Data analysis |
| Valencia | Do minimum | Data analysis |
| Vienna | Do minimum | Modelling |
| Zurich | Reference zone | Data analysis |

Table 4-4: Reference scenario synthesis

5 COMPARATIVE ANALYSIS: URBAN TRANSPORT SYSTEM AND SUPPLY

Because of uncertainty and errors attached to measures and estimations of the effects the computation of "annualised effects" must not use too much precision thus "annualised effects" are calculated as the relative variation of the indicator, i.e. $(Data "with" - Data "RS") / Data "RS"$, then as a growth ratio per year on the time interval $Year Horizon - YearBefore$, the year horizon being for short, medium and long term (see paragraph 3.5). Thus results are given for annualised variation with a precision of $\pm 1\%$.

In the tables below the direction of the variation (generally the same for all horizons) and the amplitude for each horizon (short, medium and long term) are identified:

- the direction is marked as + for an increase effect, – for a decrease effect;
- when the effect is 0.0%, the variation is marked =.

5.1 Public transport system

| Case studies | Total amount of the investment (2002 cost base year) | Investment per kilometre (see Table 4-1) |
|---------------|--|--|
| Athens | 1 916 million Euro | 106 million Euro |
| Bratislava | 17 million Euro | 2 million Euro |
| Brussels | 357 million Euro | 44 million Euro |
| Delft | 13 million Euro (bicycle project) | |
| Helsinki | 425 million Euro | 39 million Euro |
| Lyon | 524 million Euro | 35 million Euro |
| Madrid | 258 million Euro | 37 million Euro |
| Manchester | 181 million Euro | 6 million Euro |
| Stuttgart | 30 million Euro | 2 million Euro |
| Tyne and Wear | 1 655 million Euro | 30 million Euro |
| Valencia | 93 million Euro | 10 million Euro |
| Vienna | 1 936 million Euro | 236 million Euro |
| Zurich | 421 million Euro | 35 million Euro |

Table 5-1: Amount of investment of the public transport projects (except Delft bicycle project)

Even if the investment is quite important for some conurbation, the increase in public transport supply expressed in number of seat*kilometre is quite limited when compared to the supply at the level of the whole conurbation except in the case of Tyne and Wear (Table 5-2). Project can be classified in relation with the progression of supply:

- low progression: Bratislava, Brussels, Madrid, Valencia and Vienna;
- medium progression: Helsinki, Lyon and Manchester;
- High progression: Tyne and Wear.

| Case study | Zone | Direction | Short term | Medium term | Long term | Comments |
|----------------------|----------|-----------|-------------|-------------|-------------|-------------------------------|
| Athens | | | | | | No data |
| Bratislava | | | 1990 | 1995 | 2000 | Before: 1985 |
| | Z1+Z2 | + | +0.5% | +0.3% | +0.1% | Light rail + trolleybus lines |
| | Zproject | + | +0.5% | +0.2% | +0.1% | |
| Brussels | | | | 1994 | 2000 | Before: 1987 |
| | Z1 | + | n.a. | +1 % | +0.5% | Inner ring metro line |
| | Z2 | = | n.a. | 0 | 0 | |
| Delft | | | 1987 | 1990 | 1995 | Before: 1979 |
| | Z1+Z2 | = | 0 | 0 | 0 | Extensive bicycle network |
| Helsinki | | | 1984 | 1986 | 1992 | Before: 1981 |
| | Z1+Z2 | + | +5% | +4% | +2% | Metro line |
| | Zproject | + | +35% | +18% | +8% | |
| Lyon | | | | 1995 | 1999 | Before: 1986 |
| | Z1+Z2 | + | n.a. | +2% | +2% | Metro line |
| Madrid | | | 1996 | 2000 | | Before: 1987 |
| | Z1+Z2 | + | +1% | +0.6% | n.a. | Inner ring metro line |
| | Zproject | + | +11% | +7% | n.a. | |
| Manchester | | | 1993 | 1996 | 2001 | Before: 1991 |
| | Zproject | + | +12% | +7% | +3% | Light rail |
| Stuttgart | | | | | | No data |
| Tyne and Wear | | | 1983 | 1986 | 1992 | Before 1980 |
| | Z1+Z2 | + | +22% | +9% | +9% | Light rail |
| Valencia | | | 1996 | 2001 | | Before 1991 |
| | Z1+Z2 | + | +1% | +0.6% | n.a. | Light rail |
| Vienna | | | | | 2002 | Before: 1991 |
| | Z1+Z2 | + | n.a. | n.a. | +0.5% | Metro line |
| | Z1+Z2a | + | n.a. | n.a. | +2% | |
| | Z1+Z2b | + | n.a. | n.a. | +0.2% | |
| | Zproject | + | n.a. | n.a. | +3% | |
| Zurich | | | | | | No data |

Table 5-2: Synthesis table of public transport capacity in number of seat kilometre (annualised variations)

The supply has not change in Delft which is a bicycle case study. The information is not available for the other case studies.

The impacts of the public transport investments on financial public transport indicators are always very limited (Table 5-3). At the level of the conurbation, the evolution is always smaller than the evolution of supply. For most case studies the evolution are so limited that they are probably inside the interval of confidence of the results.

It can only be observed greater evolution at the level of shorter zone directly concerned by the investment. But the information is available only for Bratislava, Helsinki, Madrid and Vienna. In all conurbations (except Bratislava) there is an increase of revenue for Zproject zone and also for trips inside Z1+Z2a zones which are the zones directly affected by the investment in case of Vienna. In the same time the increase of cost is more limited or even there is a decrease like in Helsinki which conduct to a reduction of public transport deficit and even an increase of benefice in case of Madrid.

In any case, the projects have very marginal consequences on contribution of the public authority to public transport finance.

| Case study | Zone | Direction | Short term | Medium term | Long term | Comments |
|-------------------------|----------|-----------|-------------|-------------|-------------|-------------------------------|
| Athens | | | | | | No data |
| Bratislava | | | 1990 | 1995 | 2000 | Before: 1985 |
| Annual fare revenues | Z1+Z2 | - | -0.2% | -0.1% | -0.1% | Light rail + trolleybus lines |
| | Zproject | +/- | +2% | +0.2% | -0.5% | |
| Annual operation costs | Z1+Z2 | + | +0.3% | +0.7% | +2% | |
| | Zproject | -/+ | -2% | -0.8% | +0.1% | |
| Annual operation result | Z1+Z2 | + | +0.6% | +1% | +2% | |
| | Zproject | - | -5% | -2% | -0.1% | |
| Brussels | | | | 1994 | 2000 | Before: 1987 |
| Annual fare revenues | Z1 | + | n.a. | +0.1% | +0.1% | Inner ring metro line |
| | Z2 | = | n.a. | 0 | 0 | |
| Annual operation costs | Z1 | - | n.a. | -0.0% | -0.0% | |
| Annual operation result | Z1 | - | n.a. | -0.1% | -0.4% | |
| Delft | | | | | | No data |
| Bicycle project | | | | | | |
| Helsinki | | | 1984 | 1986 | 1992 | Before: 1981 |
| Annual fare revenues | Z1+Z2 | = | 0 | 0 | 0 | Metro line |
| | Zproject | + | +0.6% | +0.3% | +0.2% | |
| Annual operation costs | Z1+Z2 | - | -0.8% | -0.5% | -0.2% | |
| | Zproject | - | -4% | -2% | -1% | |
| Annual operation result | Z1+Z2 | - | -2% | -1% | -0.4% | |
| | Zproject | - | -11% | -8% | -3% | |

| | | | | | | |
|--|----------|-----|-------------|-------------|-------------|-----------------------|
| Annual contribution of transport authority to public transport | Z1+Z2 | - | -4% | -1% | -0.4% | |
| Lyon | | | | 1995 | 1999 | Before: 1986 |
| Annual fare revenues | Z1+Z2 | + | n.a. | +2% | +1% | Metro line |
| Annual operation costs | Z1+Z2 | + | n.a. | +0.7% | +0.9% | |
| Annual operation result | Z1+Z2 | +/- | n.a. | -0.5% | +0.8% | |
| Annual investment | Z1+Z2 | = | n.a. | 0 | 0 | |
| Annual contribution of transport authority to public transport | Z1+Z2 | = | n.a. | 0 | 0 | |
| Madrid | | | 1996 | 1995 | | Before: 1987 |
| Annual fare revenues | Z1+Z2 | + | +0.7% | +1% | n.a. | Inner ring metro line |
| | Zproject | + | +10% | +4% | n.a. | |
| Annual operation costs | Z1+Z2 | + | +0.4% | +0.2% | n.a. | |
| | Zproject | + | +6% | +4% | n.a. | |
| Annual operation result | Z1+Z2 | +/- | +0.1% | -1% | n.a. | |
| | Zproject | +/- | -7% | +8% | n.a. | |
| Annual investment | Z1+Z2 | + | +0.6% | +0.4% | n.a. | |
| Annual contribution of transport authority to public transport | Z1+Z2 | + | +0.1% | +0.1% | n.a. | |
| Manchester | | | | | | No data |
| Data not available in a context of public transport deregulation | | | | | | |
| Stuttgart | | | | | | No data |
| Tyne and Wear | | | | | | No data |
| Data not available in a context of public transport deregulation | | | | | | |
| Valencia | | | 1996 | 2001 | | Before: 1991 |
| Annual fare revenues | Z1+Z2 | + | +0.5% | +0.5% | | Light rail |

| Vienna | | | | | | 2002 | Before: 1991 |
|--|----------|---|------|------|-------|----------------|---------------------|
| Annual fare revenues | Z1+Z2 | + | n.a. | n.a. | +0.2% | Metro line | |
| | Z1+Z2a | + | n.a. | n.a. | +1.9% | | |
| | Z1+Z2b | - | n.a. | n.a. | -0.9% | | |
| | Zproject | + | n.a. | n.a. | +4.2% | | |
| Annual operation costs | Z1+Z2 | + | n.a. | n.a. | +0.2% | | |
| | Z1+Z2a | + | n.a. | n.a. | +0.5% | | |
| | Z1+Z2b | + | n.a. | n.a. | +0.3% | | |
| | Zproject | + | n.a. | n.a. | +2% | | |
| Annual operation result | Z1+Z2 | + | n.a. | n.a. | 0.2% | | |
| | Z1+Z2a | - | n.a. | n.a. | -2.3% | | |
| | Z1+Z2b | + | n.a. | n.a. | 1.4% | | |
| | Zproject | - | n.a. | n.a. | -2.5% | | |
| Annual investment | Z1+Z2 | + | n.a. | n.a. | +0.6% | | |
| Annual contribution of transport authority to public transport | Z1+Z2 | + | n.a. | n.a. | +0.1% | | |
| Zurich | | | | | | No data | |

Table 5-3: Synthesis table of financial indicators of public transport (annualised variations)

5.2 Private transport system

Logically the public transport investments have no or very small effect on car ownership (Table 5-4). The effect of public transport policy on car ownership can be observed only on long term when a global and coherent transport policy at the level of the whole conurbation with important car use restriction is introduced. Furthermore the determinants of car ownership are not only related to urban car policy but also to the transport policy conducted at the national level and also of course to household revenues.

| Case study | Zone | Direction | Short term | Medium term | Long term | Comments |
|-------------------|-------------|------------------|-------------------|--------------------|------------------|-------------------------------|
| Athens | | | 2002 | | | Before: 1996 |
| | Z2 | - | -0.5% | n.a. | n.a. | Metro line |
| Bratislava | | | 1990 | 1995 | 2000 | Before: 1985 |
| | Z1 | +/- | -1% | +1% | +2% | Light rail + trolleybus lines |
| | Z2 | +/- | -1% | +1% | +2% | |
| Brussels | | | | 1994 | 1998 | Before: 1987 |
| | Z1 | = | n.a. | 0 | 0 | Inner ring metro line |
| | Z2 | = | n.a. | 0 | n.a. | |

| | | | | | | |
|----------------------|-------|-----|-------------|-------------|-------------|---------------------------|
| Delft | | | 1987 | 1990 | 1995 | Before: 1985 |
| | Z1 | +/- | +1% | -0.3% | -1% | Extensive bicycle network |
| Helsinki | | | 1985 | 1988 | 1995 | Before: 1981 |
| | Z1 | = | 0 | 0 | 0 | Metro line |
| | Z2 | = | 0 | 0 | 0 | |
| Lyon | | | | 1995 | 2000 | Before: 1985 |
| | Z1 | -/= | n.a. | 0 | -0.3% | Metro line |
| | Z2 | = | n.a. | 0 | 0 | |
| Madrid | | | 1996 | 2000 | | Before: 1987 |
| | Z1 | = | 0 | 0 | n.a. | Inner ring metro line |
| | Z2 | = | 0 | 0 | n.a. | |
| Manchester | | | | | | No data |
| Stuttgart | | | 1994 | 1997 | 2000 | Before: 1990 |
| | Z1 | = | 0 | 0 | 0 | S-Bahn |
| | Z2 | - | -0.1% | -0.1% | -0.1% | |
| | Z2a | - | -0.2% | -0.2% | -0.2% | |
| | Z2b | - | -0.1% | -0.1% | -0.1% | |
| Tyne and Wear | | | | | | No data |
| Valencia | | | 1996 | 2001 | | Before: 1991 |
| | Z1 | = | 0 | 0 | n.a. | Light rail |
| Vienna | | | | | 2002 | Before: 1991 |
| | Z1 | = | n.a. | n.a. | 0 | Metro line |
| | Z2 | = | n.a. | n.a. | 0 | |
| | Z2a | = | n.a. | n.a. | 0 | |
| | Z2b | = | n.a. | n.a. | 0 | |
| | Z1+Z2 | = | n.a. | n.a. | 0 | |
| Zurich | | | 1990 | 1995 | 2000 | Before: 1985 |
| | Z1 | - | -0.9% | -2% | -2% | S-Bahn |
| | Z2 | - | -0.5% | -0.2% | -0.1% | |
| | Z1 | - | -0.3% | -0.0% | -0.1% | |
| | Z2 | - | -1% | -0.6% | -0.3% | |

Table 5-4: Synthesis table of number of passenger cars per 1 000 inhabitants (annualised variations, see calculation section)

For all the conurbation, due to the definition of the reference scenario i.e. a do minimum scenario where the car policy remain unchanged, there is no change in the length of expressway, nor the construction of ring road, nor infrastructure investment nor traffic calming measure (Table 5-5).

But if the policy remain unchanged, it no more the case of car speed in four case studies (Athens, Bratislava, Lyon, Manchester, Stuttgart and Vienna). In Manchester

the evolution are too small to be really significant. In case of Athens, Lyon and Vienna which are metro project an increase of car speed is observed. This would mean that metro project may have a more favourable impact on car speed (by an increase of car speed) than light rail project. In the case of underground, the road infrastructure remains very often quite stable or even increases with less bus (in the Lyon case) or light rail (in the case of Vienna) in the traffic. Furthermore modal shift reduce car traffic at least at short term (because at more longer term induced traffic can limit the reduction). On the contrary with light rail project a part of the road infrastructure is suppressed for car traffic. Modal shift seems to compensate this decrease with in general a stable car speed or even decrease of the speed of car like in Bratislava.

| Case study | Zone | Direction | Short term | Medium term | Long term | Comments |
|---|----------|-----------|-------------|-------------|-------------|-------------------------------|
| Athens | | | 2002 | | | Before: 1996 |
| Average speed of trips by car (peak period) | Z1-Z1 | + | +0.5% | n.a. | n.a. | Metro line |
| | Z2-Z2 | + | +1% | n.a. | n.a. | |
| | Zproject | + | +2% | n.a. | n.a. | |
| Bratislava | | | 1990 | 1995 | 2000 | Before: 1985 |
| Average speed of trips by car | Z1-Z1 | - | -0.7% | -1% | -0.8% | Light rail + trolleybus lines |
| | Z1-Z2 | - | -0.6% | -0.6% | -0.5% | |
| | Z2-Z2 | - | -0.3% | -0.5% | -0.9% | |
| Length of the expressways | Z1+Z2 | + | +7% | +9% | +8% | |
| Investment expenditures for increasing urban road network | Z1+Z2 | -/+ | -0.3% | +0.1% | +0.9% | |
| Brussels | | | | 1994 | 1998 | Before: 1987 |
| Average speed of trips by car | Z1-Z1 | = | n.a. | 0 | 0 | Inner ring metro line |
| | Z1-Z2 | = | n.a. | 0 | n.a. | |
| | Z2-Z2 | = | n.a. | 0 | n.a. | |
| Length of the expressways | Z1+Z2 | = | n.a. | 0 | 0 | |
| Complete circular road with express way | Z1+Z2 | = | n.a. | 0 | 0 | |

| Delft | | | 1987 | 1990 | 1995 | Before: 1980 |
|---|-------|---|-------------|-------------|-------------|---------------------------|
| Average speed of trips by car | Z1-Z1 | = | 0 | 0 | 0 | Extensive bicycle network |
| Length of the expressways | Z1+Z2 | = | 0 | 0 | 0 | |
| Complete circular road with express way | Z1+Z2 | = | 0 | 0 | 0 | |
| Helsinki | | | 1985 | 1988 | 1995 | Before: 1981 |
| Average speed of trips by car | Z1-Z1 | = | 0 | 0 | 0 | Metro line |
| | Z1-Z2 | = | 0 | 0 | 0 | |
| | Z2-Z2 | = | 0 | 0 | 0 | |
| Length of the expressways | Z1+Z2 | = | 0 | 0 | 0 | |
| Complete circular road with express way | Z1+Z2 | = | 0 | 0 | 0 | |
| Investment expenditures for increasing urban road network | Z1+Z2 | - | -12% | -7% | -3% | |
| Lyon | | | | 1995 | 2000 | Before: 1985 |
| Average speed of trips by car | Z1-Z1 | + | n.a. | +0.6% | +1% | Metro line |
| | Z1-Z2 | + | n.a. | +1% | +0.8% | |
| | Z2-Z2 | + | n.a. | +0.9% | +0.4% | |
| Length of the expressways | Z1+Z2 | = | n.a. | 0 | 0 | |
| Complete circular road with express way | Z1+Z2 | = | n.a. | 0 | 0 | |
| | | | | | | |
| Madrid | | | 1996 | 2000 | | Before: 1987 |
| Average speed of trips by car | Z1-Z1 | = | 0 | n.a. | n.a. | Inner ring metro line |
| Length of the expressways | Z1+Z2 | = | 0 | 0 | n.a. | |
| Complete circular road with express way | Z1+Z2 | = | 0 | 0 | n.a. | |
| Investment expenditures for increasing urban road network | Z1+Z2 | = | 0 | 0 | n.a. | |

| Manchester | | | 1993 | 1996 | 2001 | Before: 1991 |
|---|---------|---|-------------|-------------|-------------|---------------------|
| Average speed of trips by car | Z1-Z1 | = | 0 | 0 | 0 | Light rail |
| | Z1-Z2 | + | +0.2% | +0.1% | +0.0% | |
| | Z2-Z2 | = | 0 | 0 | 0 | |
| Length of the expressways | Z1+Z2 | = | 0 | 0 | 0 | |
| Complete circular road with express way | Z1+Z2 | = | 0 | 0 | 0 | |
| Stuttgart | | | 1994 | 1995 | 2000 | Before: 1990 |
| Average speed of trips by car | Z1-Z1 | = | n.a. | 0 | n.a. | S-Bahn |
| | Z1-Z2a | + | n.a. | +0.2% | n.a. | |
| | Z2a-Z2a | + | n.a. | +0.1% | n.a. | |
| Length of the expressways | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2a | = | 0 | 0 | 0 | |
| | Z1-Z2b | = | 0 | 0 | 0 | |
| Tyne and Wear | | | | | | No data |
| Valencia | | | 1996 | 2001 | | Before: 1991 |
| Length of the expressways | Z1+Z2 | = | 0 | 0 | n.a. | Light rail |
| Complete circular road with express way | Z1+Z2 | = | 0 | 0 | n.a. | |

| Vienna | | | | | 2002 | Before: 1991 |
|---|----------|---|-------------|-------------|-------------|---------------------|
| Average speed of trips by car | Z1 | + | n.a. | n.a. | +0.9% | Metro line |
| | Z2a | + | n.a. | n.a. | +1.9% | |
| | Z2b | + | n.a. | n.a. | +1.4% | |
| | Z1 + Z2 | + | n.a. | n.a. | +1.5% | |
| | Z1 + Z2a | + | n.a. | n.a. | +1.7% | |
| | Z1 + Z2b | + | n.a. | n.a. | +1.4% | |
| | Zproject | + | n.a. | n.a. | +1.6% | |
| Length of the expressways | Z1-Z1 | = | n.a. | n.a. | 0 | |
| | Z1-Z2a | = | n.a. | n.a. | 0 | |
| | Z1-Z2b | = | n.a. | n.a. | 0 | |
| Complete circular road with express way | Z1-Z1 | = | n.a. | n.a. | 0 | |
| | Z1-Z2a | = | n.a. | n.a. | 0 | |
| | Z1-Z2b | = | n.a. | n.a. | 0 | |
| Road with traffic calming measures [km ²] | Z1 | = | n.a. | n.a. | 0 | |
| | Z2a | = | n.a. | n.a. | 0 | |
| Investment expenditures for increasing urban road network | Z1+Z2 | = | n.a. | n.a. | 0 | |
| Zurich | | | 1990 | 1993 | 1997 | Before 1989 |
| Length of the expressways | Z1 | = | 0 | 0 | 0 | S-Bahn |
| | Z2 | = | 0 | 0 | 0 | |
| | Z2a | = | 0 | 0 | 0 | |
| | Z2b | = | 0 | 0 | 0 | |

Table 5-5: Synthesis table of car infrastructure supply indicators (annualised variations)

Again there is no change (except Lyon case study) in parking supply. It's the result of the definition of the reference scenario which considers that the parking policy remains stable.

When the information is available, there is modification of parking use (except Lyon but the change is very small). It would be necessary to change radically parking policy at the same time than public transport investment to obtain significant change in parking behaviour. But this kind of policy was not decided in the definition of reference scenario of each case study (except Lyon, but again the policy was not really changed with an increase of parking capacity in reference scenario).

| Case study | Zone | Direction | Short term | Medium term | Long term | Comments |
|---|----------|-----------|-------------|-------------|-------------|--|
| Athens | | | | | | No data |
| Bratislava | | | | | | No data |
| Brussels | | | | 1994 | 1998 | Before: 1987 |
| Capacity of public (off street) car parks | Z1 | = | n.a. | 0 | n.a. | Inner ring metro line |
| On-street parking slots | Z1 | = | n.a. | 0 | n.a. | |
| Average on-street parking occupation rate | Z1 | = | n.a. | 0 | n.a. | |
| Number of parking slots of park and ride facilities | Zproject | = | n.a. | 0 | 0 | |
| | Z1 | = | n.a. | 0 | 0 | |
| Delft | | | | | | No data |
| Bicycle project | | | | | | |
| Helsinki | | | 1985 | 1988 | 1995 | Before: 1981 |
| Capacity of public (off street) car parks | Z1 | = | 0 | 0 | 0 | Metro line (*) there is no parking slots of park and ride facilities in reference but 750 in scenario with |
| On-street parking slots | Z1 | = | 0 | 0 | 0 | |
| Private supply | Z1 | = | 0 | 0 | 0 | |
| Average on-street parking occupation rate | Z1 | = | 0 | 0 | 0 | |
| On-street parking turnover rate | Z1 | = | 0 | 0 | 0 | |
| Number of parking slots of park and ride facilities | Zproject | + | * | * | * | |
| | | | | | | |

| Lyon | | | | 1995 | 2000 | Before: 1985 | |
|---|----------|---|------|-------------|-------------|--|---------------------|
| Capacity of public (off street) car parks | Z1 | - | n.a. | -3% | -2% | Metro line (*) there is no parking slots of park and ride facilities in reference but 2 046 in scenario with | |
| On-street parking slots | Z1 | = | n.a. | 0 | 0 | | |
| Average on-street parking occupation rate | Z1 | + | n.a. | +0.1% | +0.2% | | |
| On-street parking turnover rate | Z1 | + | n.a. | +0.2% | +0.1% | | |
| Number of parking slots of park and ride facilities | Zproject | + | n.a. | * | +13% | | |
| | Z1+Z2 | + | n.a. | +13% | +5% | | |
| Madrid | | | | 1996 | 2000 | Before: 1987 | |
| Capacity of public (off street) car parks | Z1 | = | 0 | 0 | n.a. | Inner ring metro line | |
| On-street parking slots | Z1 | = | 0 | 0 | n.a. | | |
| Private supply | Z1 | = | 0 | 0 | n.a. | | |
| On-street parking fee revenue | Z1 | = | 0 | 0 | n.a. | | |
| Number of parking slots of park and ride facilities | Zproject | = | 0 | n.a. | n.a. | | |
| Manchester | | | | 1993 | 1996 | 2001 | Before: 1991 |
| Capacity of public (off street) car parks | Z1 | = | n.a. | 0 | 0 | Light rail | |
| On-street parking slots | Z1 | = | n.a. | n.a. | 0 | | |
| Average on-street parking occupation rate | Z1 | = | 0 | 0 | 0 | | |
| On-street parking turnover rate | Z1 | = | 0 | 0 | 0 | | |
| Stuttgart | | | | | | | No data |
| Tyne and Wear | | | | | | | No data |

| Valencia | | | 1996 | 2001 | | Before: 1991 |
|---|----------|---|-------------|-------------|-------------|---------------------|
| Capacity of public (off street) car parks | Z1 | = | 0 | 0 | n.a. | Light rail |
| On-street parking slots | Z1 | = | 0 | 0 | n.a. | |
| Number of parking slots of park and ride facilities | Zproject | = | 0 | 0 | n.a. | |
| | Z1 | = | 0 | 0 | n.a. | |
| Vienna | | | | | 2002 | Before: 1991 |
| Capacity of public (off street) car parks | Z1 | = | n.a. | n.a. | 0 | Metro line |
| On-street parking slots | Z1 | = | n.a. | n.a. | 0 | |
| Private supply | Z1 | = | n.a. | n.a. | 0 | |
| Average on-street parking occupation rate | Z1 | = | n.a. | n.a. | 0 | |
| On-street parking turnover rate | Zproject | = | n.a. | n.a. | 0 | |
| Number of parking slots of park and ride facilities | Zproject | = | n.a. | n.a. | 0 | |
| | Z1 | = | n.a. | n.a. | 0 | |
| | Z2 | + | n.a. | n.a. | +6% | |
| | Z2a | = | n.a. | n.a. | 0 | |
| | Z2b | = | n.a. | n.a. | 0 | |
| Zurich | | | | | | No data |

Table 5-6: Synthesis table of parking supply and demand indicators (annualised variations)

6 COMPARATIVE ANALYSIS: MOBILITY, TRIP BEHAVIOUR AND TIME SAVINGS

Because of uncertainty and errors attached to measures and estimations of the effects the computation of “annualised effects” must not use too much precision thus “annualised effects” are calculated as the relative variation of the indicator, i.e. $(Data\ "with" - Data\ "RS") / Data\ "RS"$, then as a growth ratio per year on the time interval $Year\ Horizon - Year\ Before$, the year horizon being for short, medium and long term (see paragraph 3.5). Thus results are given for annualised variation with a precision of $\pm 1\%$.

In the tables below the direction of the variation (generally the same for all horizons) and the amplitude for each horizon (short, medium and long term) are identified:

- the direction is marked as + for an increase effect, – for a decrease effect;
- when the effect is 0.0%, the variation is marked =.

6.1 Comparative analysis on trip behaviour

Table 6-1 shows the mobility indicators for each case study.

First of all it appears that the annual effects are for the most part very low. This has to do with the geographical scales at which these effects are measured. These geographical scales vary widely between case studies: in particular Z1 areas can be CBD or whole city within an urban area, while Z2 is mostly the whole urban area. On the same time the transport investments considered are less heterogeneous in scope.

However the directions of the variations are consistent with what can be reasonably expected:

- there is an increase effect on the number of public transport trips for all case studies (or on bicycle trips for Delft);
- at the level of the city (Z1) or urban area (Z2) effects are mostly low as already said, except for Tyne and Wear and Stuttgart: in both cases the project is an important investment at the urban area level;
- when data is available more specifically for the project (Zproject or Project only) the annualised effects are sometimes quite important: +6-7% for trips Lyon, -18% for pass-km in Madrid (reduction of trip lengths for public transport users), +11% for trips and pass-km in Manchester, +5-6% in Stuttgart, +4-5% in Valencia, +4% for pass-km in Vienna;
- the impact is always strongly decreasing over time horizon which indicates that the impact on public transport use is mainly a short term impact. After this short term impact, the impact of the project is no more identifiable and mixed with the general trend of public transport use.

- there is generally a decrease effect on car trips and car-km for all case studies or absence of effect: however when present this effect is systematically very low, i.e. less than 1% per year;
- modal share is available only in the case of Helsinki and Manchester. Manchester shows a significant increase of public transport share in Z1 area (core centre). However for other case studies it can be deduced from car and public transport trips indicators that the whole mobility is rather increased by the new public transport projects even if this increase is very limited at the geographical scale of the conurbation: at the same time there is no or very low decrease of car mobility.

| Case study | Zone | Direction | Short term | Medium term | Long term | Comments |
|--|----------|-----------|-------------|-------------|-------------|-------------------------------|
| Athens | | | | | | No data |
| Bratislava | | | 1990 | 1995 | 2000 | Before: 1985 |
| Public transport trips per origin-destination | Z1-Z1 | + | +0.7% | +0.2% | +0.1% | Light rail + trolleybus lines |
| | Z1-Z2 | + | +0.7% | +0.2% | +0.1% | |
| | Z2-Z2 | + | +0.7% | +0.2% | +0.1% | |
| | Zproject | + | +9% | +4% | +2% | |
| Public transport passenger-km per origin-destination | Z1-Z1 | + | +1% | +0.5% | +0.2% | |
| | Z1-Z2 | + | +1% | +0.5% | +0.2% | |
| | Z2-Z2 | + | +1% | +0.5% | +0.2% | |
| | Z2-Z2 | + | +1% | +0.5% | +0.2% | |
| Car trips per origin-destination | Z1-Z1 | -/+ | -3% | +1% | +1% | |
| | Z1-Z2 | -/+ | -3% | +1% | +1% | |
| | Z2-Z2 | -/+ | -3% | +1% | +1% | |
| Car km per origin-destination | Z1-Z1 | -/+ | -3% | +1% | +2% | |
| | Z1-Z2 | -/+ | -4% | +0.7% | -0.2% | |
| | Z2-Z2 | -/+ | -4% | +4% | +3% | |
| Walk trips per origin-destination | Z1-Z1 | + | +0.5% | +0.1% | +0.6% | |
| Share of public transport per origin-destination | Z1-Z1 | +/- | +3% | -2% | -0.5% | |
| | Z1-Z2 | +/- | +2% | -2% | -0.9% | |
| Brussels | | | | 1991 | 2000 | Before: 1987 |
| Public transport trips per origin-destination | Z1-Z1 | + | n.a. | +0.2% | +0.1% | Inner ring metro line |
| | Z1-Z2 | + | n.a. | +0.2% | +0.1% | |
| | Z2-Z2 | = | n.a. | 0 | 0 | |
| Car trips per origin-destination | Z1-Z1 | - | n.a. | -0.2% | n.a. | |
| | Z1-Z2 | - | n.a. | -0.2% | n.a. | |
| | Z2-Z2 | = | n.a. | 0 | n.a. | |
| Car km per origin-destination | Z1-Z1 | - | n.a. | -0.2% | n.a. | |
| | Z1-Z2 | - | n.a. | -0.2% | n.a. | |
| | Z2-Z2 | = | n.a. | 0 | n.a. | |
| Delft | | | 1990 | 1994 | 1996 | Before: 1982 |

| | | | | | | |
|--|--------------|-----|-------------|-------------|-------------|---------------------------|
| Bicycle trips per origin-destination | Z1-Z1 | + | +2% | +1% | +0.9% | Extensive bicycle network |
| | Z1-Z2 | + | +2% | +1% | +0.8% | |
| Bicycle-km per origin-destination | Z1-Z1 | + | +2% | +1% | +1% | |
| | Z1-Z2 | + | +2% | +1% | +0.8% | |
| Car trips per origin-destination | Z1-Z1 | - | -0.9% | -0.8% | -0.8% | |
| | Z1-Z2 | - | -0.1% | -0.1% | -0.1% | |
| Car km per origin-destination | Z1-Z1 | - | -0.7% | -0.7% | -0.7% | |
| | Z1-Z2 | - | -0.1% | -0.0% | -0.0% | |
| Walk trips per origin-destination | Z1-Z1 | - | -0.6% | -0.4% | -0.4% | |
| | Z1-Z2 | - | -0.7% | -0.4% | -0.3% | |
| Helsinki | | | 1985 | 1988 | 1995 | Before: 1981 |
| Public transport trips per origin-destination | Z1-Z1 | = | 0 | 0 | 0 | Metro line |
| | Z1-Z2 | + | +0.2% | +0.1% | +0.1% | |
| | Z2-Z2 | - | -0.3% | -0.1% | -0.1% | |
| | Zproject | + | +0.4% | +0.2% | +0.2% | |
| Public transport passenger-km per origin-destination | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | + | +0.2% | +0.1% | +0.1% | |
| | Z2-Z2 | - | -0.3% | -0.1% | -0.1% | |
| | Zproject | - | -0.6% | -0.4% | -0.1% | |
| Car trips per origin-destination | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | - | -0.2% | -0.1% | -0.0% | |
| | Z2-Z2 | =/- | 0 | -0.1% | -0.1% | |
| Car km per origin-destination | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | - | -0.2% | -0.1% | -0.0% | |
| | Z2-Z2 | =/- | 0 | -0.1% | -0.1% | |
| Share of public transport among motorised trips | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | + | +0.2% | +0.1% | +0.1% | |
| | Z2-Z2 | - | -0.2% | -0.0% | -0.0% | |
| Lyon | | | | 1995 | 1999 | Before: 1984 |
| Public transport trips per origin-destination | Z1-Z1 | + | n.a. | +0.5% | +0.3% | Metro line |
| | Z1-Z2 | + | n.a. | +1% | +0.8% | |
| | Z2-Z2 | + | n.a. | +0.1% | 0 | |
| | Project only | + | n.a. | +7% | +6% | |
| Public transport passenger-km per origin-destination | Z1-Z1 | + | n.a. | +2% | +0.3% | |
| | Z1-Z2 | + | n.a. | +2% | +1% | |
| | Z2-Z2 | + | n.a. | +0.8% | +0.6% | |
| Car trips per origin-destination | Z1-Z1 | - | n.a. | -0.5% | -0.3% | |
| | Z1-Z2 | - | n.a. | -0.5% | -0.3% | |
| | Z2-Z2 | - | n.a. | -0.2% | -0.1% | |
| Car km per origin-destination | Z1-Z1 | - | n.a. | -0.5% | -0.3% | |
| | Z1-Z2 | - | n.a. | -0.5% | -0.3% | |
| | Z2-Z2 | - | n.a. | -0.2% | -0.1% | |

| Madrid | | | 1996 | 2000 | | Before: 1987 |
|--|--------------|-----|-------------|-------------|-------------|-----------------------|
| Public transport trips per origin-destination | Z1-Z1 | = | 0 | 0 | n.a. | Inner ring metro line |
| | Z1-Z2 | = | 0 | 0 | n.a. | |
| | Z2-Z2 | = | 0 | 0 | n.a. | |
| | Zproject | + | +0.1% | 0 | n.a. | |
| | Project only | + | +0.7% | +0.5% | n.a. | |
| Public transport passenger-km per origin-destination | Z1-Z1 | = | 0 | 0 | n.a. | |
| | Z1-Z2 | = | 0 | 0 | n.a. | |
| | Z2-Z2 | = | 0 | 0 | n.a. | |
| | Zproject | - | -0.0% | -0.1% | n.a. | |
| | Project only | +/- | +0.2% | -0.3% | n.a. | |
| Manchester | | | 1993 | 1996 | 2001 | Before: 1991 |
| Public transport trips per origin-destination | Z1-Z1 | + | +26% | +10% | +5% | Light rail |
| | Z1-Z2 | + | +3% | +1% | +0.8% | |
| | Z2-Z2 | + | +0.2% | +0.1% | +0.1% | |
| | Project only | + | +29% | +12% | +6% | |
| Public transport passenger-km per origin-destination | Z1-Z1 | + | +13% | +5% | +2% | |
| | Z1-Z2 | + | +2% | +0.9% | +0.4% | |
| | Z2-Z2 | + | +0.1% | +0.1% | +0.0% | |
| | Zproject | + | +29% | +11% | +5% | |
| Car trips per origin-destination | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | - | -0.4% | -0.2% | -0.1% | |
| | Z2-Z2 | = | 0 | 0 | 0 | |
| Car km per origin-destination | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | - | -0.3% | -0.1% | -0.1% | |
| | Z2-Z2 | = | 0 | 0 | 0 | |
| Walk trips per origin-destination | Z1-Z1 | - | -6% | -3% | -2% | |
| | Z1-Z2 | = | 0 | 0 | 0 | |
| Public transport modal share | Z1-Z1 | + | +11% | +4% | +2% | |
| | Z1-Z2 | + | +2% | +0.8% | +0.5% | |
| | Z2-Z2 | + | +0.1% | +0.1% | +0.0% | |

| Stuttgart | | | 1994 | 1995 | 2000 | Before: 1990 |
|--|----------|---|-------------|-------------|-------------|---------------------|
| Public transport trips per origin-destination | Z1-Z1 | + | n.a. | +5% | n.a. | S-Bahn |
| | Z1-Z2a | + | n.a. | +5% | n.a. | |
| | Z2a-Z2a | + | n.a. | +5% | n.a. | |
| Public transport passenger-km per origin-destination | Z1-Z1 | + | n.a. | +6% | n.a. | |
| | Z1-Z2a | + | n.a. | +6% | n.a. | |
| | Z2a-Z2a | + | n.a. | +6% | n.a. | |
| Car trips per origin-destination | Z1-Z1 | - | n.a. | -2% | n.a. | |
| | Z1-Z2a | - | n.a. | -1% | n.a. | |
| | Z2a-Z2a | - | n.a. | -0.5% | n.a. | |
| Car km per origin-destination | Z1-Z1 | - | n.a. | -0.2% | n.a. | |
| | Z1-Z2a | - | n.a. | -2% | n.a. | |
| | Z2a-Z2a | - | n.a. | -0.8% | n.a. | |
| Tyne and Wear | | | 1983 | 1986 | 1992 | Before: 1980 |
| Public transport trips per origin-destination | Z1-Z1 | + | +8% | +4% | +3% | Light rail |
| | Z1-Z2 | + | +8% | +5% | +3% | |
| | Z2-Z2 | + | +8% | +5% | +3% | |
| Public transport passenger-km per origin-destination | Z1-Z1 | + | +4% | +4% | +3% | |
| | Z1-Z2 | + | +9% | +5% | +2% | |
| | Z2-Z2 | + | +9% | +5% | +2% | |
| Car trips per origin-destination | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | - | -0.9% | -0.5% | -0.4% | |
| | Z2-Z2 | = | 0 | 0 | 0 | |
| Car km per origin-destination | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | - | -0.9% | -0.6% | -0.4% | |
| | Z2-Z2 | = | 0 | 0 | 0 | |
| Valencia | | | 1991 | 1996 | 2001 | Before: 1991 |
| Public transport trips per origin-destination | Z1-Z1 | = | 0 | 0 | n.a. | Light rail |
| | Zproject | + | +2% | +2% | n.a. | |
| Public transport passenger-km per origin-destination | Z1-Z1 | = | 0 | 0 | n.a. | |
| | Zproject | + | +5% | +4% | n.a. | |

| Vienna | | | | | 2002 | Before: 1991 |
|---|----------|---|------|------|-------------|---------------------|
| Public transport trips per origin-destination | Z1-Z1 | + | n.a. | n.a. | +0.3% | Metro line |
| | Z1+Z2 | + | n.a. | n.a. | +0.2% | |
| | Z1-Z2a | + | n.a. | n.a. | +0.5% | |
| | Z1-Z2b | + | n.a. | n.a. | +0.1% | |
| | Z2a-Z2a | + | n.a. | n.a. | +0.4% | |
| | Z2a-Z2b | + | n.a. | n.a. | +0.2% | |
| | Z2b-Z2b | + | n.a. | n.a. | +0.1% | |
| | Zproject | + | n.a. | n.a. | +0.6% | |
| Public transport passenger-km per zone | Z1 | + | n.a. | n.a. | +1.2% | |
| | Z2a | + | n.a. | n.a. | +1.8% | |
| | Z2b | - | n.a. | n.a. | -0.3% | |
| | Zproject | + | n.a. | n.a. | +3,6% | |
| Car trips per origin-destination | Z1-Z1 | - | n.a. | n.a. | -0.2% | |
| | Z1-Z2a | - | n.a. | n.a. | -0.6% | |
| | Z1-Z2b | - | n.a. | n.a. | -0.2% | |
| | Z2a-Z2a | - | n.a. | n.a. | -0.4% | |
| | Z2a-Z2b | - | n.a. | n.a. | -0.2% | |
| | Z2b-Z2b | - | n.a. | n.a. | -0.1% | |
| | Zproject | - | n.a. | n.a. | -0.7% | |
| Car km per zone | Z1 | - | n.a. | n.a. | -0.4% | |
| | Z2a | - | n.a. | n.a. | -0.7% | |
| | Z2b | - | n.a. | n.a. | -0.2% | |
| | Zproject | - | n.a. | n.a. | -0.7% | |

| Zurich | | | 1992 | 1995 | 2000 | Before 1989 |
|--|--|---|------|-------|------|-------------|
| Number of S-Bahn passengers entering and leaving the area of Zurich City (Z1 zone) on a working day | | + | +8% | +4% | +1% | S-Bahn |
| Number of passengers of local and regional busses at a selection of cross-sections of the networks | | + | +6% | +3% | n.a. | |
| Number of motor vehicles entering/leaving the area of Zurich city by highway from/to eastern part of the urban region (SN 1.4), in daily average (24h) | | + | +1% | +0.9% | n.a. | |

Table 6-1: Synthesis table of mobility indicators (annualised variations)

6.2 Comparative analysis on time savings

Table 6-2 shows the time savings indicators for each case study.

Here again most of the annualised effects are very low, for the same reasons quoted above for mobility indicators.

The directions of variations are also consistent with what is expected for public transport:

- there is a decrease annualised effect on travel time on the public transport network (or bicycle network for Delft) for all case studies;
- this decrease annualised effect is significant even important at the level of the project (Zproject or project only) for Athens (12-8%), Lyon (5-3%), Madrid (6-4%), Manchester (2%), Vienna (2%);
- this decrease annualised effect is significant at the level of the whole conurbation only for Stuttgart (6-8%) and Tyne and Wear (9-13% in short term, 5-7% in medium term).

However when it comes to road network, things are different. There is a stagnation and sometimes an annualised decrease effect on travel time by car on the road

network. This effect when present is very low (less than 1%) except in Athens at short term (-2 –4%), Lyon (-2% in Z1 area, the city) and in Vienna (-2% in Zproject).

| Case study | Zone | Direction | Short term | Medium term | Long term | Comments |
|--|--------------------------|-----------|-------------|-------------|-------------|-------------------------------|
| Athens | | | 2002 | 2006 | | Before: 1996 |
| Average trip travel time on the public transport network | Z1-Z1 | - | -4% | -3% | n.a. | Metro line |
| | Z1-Z2 | - | -4% | -3% | n.a. | |
| | Z2-Z2 | - | -2% | -1% | n.a. | |
| | Zproject | - | -12% | -8% | n.a. | |
| Average trip travel time on the road network | Z1-Z1 | -/+ | -4% | +0.3% | n.a. | |
| | Z1-Z2 | - | -2% | -2% | n.a. | |
| | Z2-Z2 | -/+ | -4% | +0.7% | n.a. | |
| Bratislava | | | 1990 | 1995 | 2000 | Before: 1985 |
| Average trip travel time on the public transport network | Z1-Z1 | + | +1% | +1% | +1% | Light rail + trolleybus lines |
| | Z1-Z2 | + | +0.9% | +0.4% | +0.7% | |
| | Z2-Z2 | =/-/+ | 0 | -1% | +0.3% | |
| | Zproject 1 (tram) | =/- | 0 | -1% | -1% | |
| | Zproject 2 (trolley-bus) | =/-/+ | 0 | -0.6% | +0.1% | |
| Average trip travel time on the road network | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | - | -0.8% | -2% | -2% | |
| | Z2-Z2 | -/+ | -1% | +0.2% | +0.3% | |
| Brussels | | | | | | No data |
| Delft | | | 1990 | 1994 | 1996 | Before: 1982 |
| Average trip travel time on the bicycle network | Z1-Z1 | +/- | -1% | +0.4% | -0.4% | Extensive bicycle network |
| | Z1-Z2 | - | -0.4% | -0.4% | -0.2% | |
| Average trip travel time on the road network | Z1-Z1 | = | 0 | 0 | 0 | |
| | Z1-Z2 | = | 0 | 0 | 0 | |
| Helsinki | | | 1983 | 1988 | 1995 | Before: 1981 |
| Average trip travel time on the public transport network | Z1-Z2 | =/- | 0 | -0.0% | -0.0% | Metro line |
| | Zproject | +/- | +3% | -0.1% | -0.3% | |
| Average trip travel time on the road network | Z1-Z2 | = | 0 | 0 | 0 | |

| Lyon | | | | | 1995 | 1999 | Before: 1986 |
|--|--------------|---|-------|-------------|-------------|-----------------------|---------------------|
| Average trip travel time on the public transport network | Z1-Z1 | – | n.a. | -1% | -0.3% | Metro line | |
| | Z1-Z2 | – | n.a. | -0.8% | -0.2% | | |
| | Z2-Z2 | = | n.a. | 0 | 0 | | |
| | Zproject | – | n.a. | -5% | -3% | | |
| Average trip travel time on the road network | Z1-Z1 | – | n.a. | -2% | 0 | | |
| | Z1-Z2 | – | n.a. | -0.6% | 0 | | |
| | Z2-Z2 | – | n.a. | -0.6% | 0 | | |
| Madrid | | | | 1996 | 2000 | | |
| Average trip travel time on the public transport network | Z1-Z1 | = | 0 | 0 | n.a. | Inner ring metro line | |
| | Z1-Z2 | = | 0 | 0 | n.a. | | |
| | Z2-Z2 | = | 0 | 0 | n.a. | | |
| | Zproject | – | -0.2% | -0.2% | n.a. | | |
| | Project only | – | -6% | -4% | n.a. | | |
| Manchester | | | | 1993 | 1996 | 2001 | Before: 1991 |
| Average trip travel time on the public transport network | Z1-Z1 | = | 0 | 0 | 0 | Light rail | |
| | Z1-Z2 | – | -0.2% | -0.1% | -0.0% | | |
| | Z2-Z2 | = | 0 | 0 | 0 | | |
| | Zproject | – | -4% | -0.8% | -0.6% | | |
| Average trip travel time on the road network | Z1-Z1 | = | 0 | 0 | 0 | | |
| | Z1-Z2 | – | -0.4% | -0.8% | -0.0% | | |
| | Z2-Z2 | = | 0 | 0 | 0 | | |
| Stuttgart | | | | 1994 | 1995 | | 2000 |
| Average trip travel time on the public transport network | Z1-Z1 | – | n.a. | -0.3 | n.a. | S-Bahn | |
| | Z1-Z2a | – | n.a. | -6% | n.a. | | |
| | Z2a-Z2a | – | n.a. | -8% | n.a. | | |
| Average trip travel time on the road network | Z1-Z1 | – | n.a. | -0.4% | n.a. | | |
| | Z1-Z2a | – | n.a. | -0.4% | n.a. | | |
| | Z2a-Z2a | – | n.a. | -0.6% | n.a. | | |
| Tyne and Wear | | | | 1983 | 1986 | 1992 | Before: 1980 |
| Average trip travel time on the public transport network | Z1-Z1 | – | -2% | -2% | n.a. | Light rail | |
| | Z1-Z2 | – | -13% | -7% | n.a. | | |
| | Z2-Z2 | – | -9% | -5% | n.a. | | |
| Valencia | | | | 1996 | 2001 | | Before: 1991 |
| Average trip travel time on the public transport network | Z1-Z1 | = | 0 | 0 | n.a. | Light rail | |
| | Zproject | = | 0 | 0 | n.a. | | |

| Vienna | | | | | 2002 | Before: 1991 |
|--|----------|---|------|------|-------------|---------------------|
| Average trip travel time on the public transport network | Z1-Z1 | – | n.a. | n.a. | -0.8% | Metro line |
| | Z1+Z2 | – | n.a. | n.a. | -0.5% | |
| | Z1-Z2a | – | n.a. | n.a. | -1.9% | |
| | Z1-Z2b | – | n.a. | n.a. | -0.6% | |
| | Z2a-Z2a | – | n.a. | n.a. | -1.3% | |
| | Z2a-Z2b | – | n.a. | n.a. | -0.6% | |
| | Z2b-Z2b | – | n.a. | n.a. | -0.2% | |
| | Zproject | – | n.a. | n.a. | -2.3% | |
| Average trip travel time on the road network | Z1-Z1 | – | n.a. | n.a. | -0.3% | |
| | Z1+Z2 | – | n.a. | n.a. | -0.2% | |
| | Z1-Z2a | – | n.a. | n.a. | -0.3% | |
| | Z1-Z2b | – | n.a. | n.a. | -0.2% | |
| | Z2a-Z2a | – | n.a. | n.a. | -0.5% | |
| | Z2a-Z2b | = | n.a. | n.a. | -0.3% | |
| | Z2b-Z2b | – | n.a. | n.a. | -0.2% | |
| | Zproject | – | n.a. | n.a. | -1.5% | |
| Zurich | | | | | | No data |

Table 6-2: Synthesis table of time savings indicators (annualised variations)

7 COMPARATIVE ENVIRONMENT ANALYSIS: TRANSPORT

Because of uncertainty and errors attached to measures and estimations of the effects the computation of “annualised effects” must not use too much precision thus “annualised effects” are calculated as the relative variation of the indicator, i.e. $(Data "with" - Data "RS") / Data "RS"$, then as a growth ratio per year on the time interval $Year Horizon - YearBefore$, the year horizon being for short, medium and long term (see paragraph 3.5). Thus results are given for annualised variation with a precision of $\pm 1\%$.

In the tables below the direction of the variation (generally the same for all horizons) and the amplitude for each horizon (short, medium and long term) are identified:

- the direction is marked as + for an increase effect, – for a decrease effect;
- when the effect is 0.0%, the variation is marked =.

7.1 Environmental pollution

The volume of air pollutants cannot be considered because the spatial area of observation is very different between cities. Furthermore, the technical methods of measure vary between the countries.

The difference between transport projects as the implementation of a light rail line or an underground line should be taken into account to compare the environmental impacts.

The **TranSEcon** data are available only for nine case studies (Bratislava, Delft, Helsinki, Lyon, Madrid, Stuttgart, Tyne and Wear, Valencia and Vienna) limiting the possibility of a comparative analysis. Furthermore, among these nine case studies, for three case studies partners estimate that change in emissions are null (or too small to be able to calculate them). However, data collected from the case studies are presented in the following table.

In all the case studies, the environmental impact of transport infrastructure was positive or null if we consider a negative variation of pollutants. In all case studies this reduction of effluent emissions is related to a decrease in car use. But except in the case of Bratislava, Helsinki and Vienna, it should be noted that the evolution are very small and probably not very significant. Therefore except for these conurbation, results should be taken with important caution. For these three conurbation there is an important decrease of emission for all effluents.

| Case study | Zone | Direction | Short term | Medium term | Long term | Comments |
|-------------------|------------|-----------|-------------|-------------|-------------|-------------------------------|
| Athens | | | | | | No data |
| Bratislava | | | 1990 | 1995 | 2000 | Before: 1985 |
| CO | (Z1 + Z2) | - | -2% | -2% | -2% | Light rail + trolleybus lines |
| NOx | | - | -3% | -4% | -5% | |
| Brussels | | | | | | |
| Delft | | | 1987 | 1990 | 1995 | |
| CO | Delft city | - | -0.2% | -0.5% | -0.3% | |
| CO2 | | - | -0.2% | -0.4% | -0.2% | |
| SOx | | - | -0.1% | -0.4% | -0.2% | |
| NOx | | - | -0.1% | -0.3% | -0.1% | |
| Lead | | - | -0.2% | -0.5% | -0.2% | |
| VOC | | - | -0.3% | -0.7% | -0.3% | |
| PM10 | | - | n.a. | n.a. | -0.2% | |
| Helsinki | | | 1985 | 1988 | 1995 | Before: 1981 |
| CO | (Z1 + Z2) | - | -3% | -2% | -1% | Metro line |
| CO2 | | - | -0.9% | -0.6% | -0.2% | |
| SOx | | + | +10% | +7% | +5% | |
| NOx | | - | -3% | -2% | -1% | |
| Lead | | | n.a. | n.a. | n.a. | |
| VOC | | - | -4% | -2% | -1% | |
| PM10 | | - | -3% | -2% | -1% | |
| Lyon | | | | 1995 | | |
| CO | (Z1 + Z2) | = | n.a. | 0 | n.a. | Metro line |
| CO2 | | = | n.a. | 0 | n.a. | |
| SOx | | = | n.a. | 0 | n.a. | |
| NOx | | = | n.a. | 0 | n.a. | |
| Lead | | = | n.a. | 0 | n.a. | |
| VOC | | = | n.a. | 0 | n.a. | |
| PM10 | | = | n.a. | 0 | n.a. | |
| Madrid | | | 1996 | 2000 | | Before: 1987 |
| CO | (Z1 + Z2) | = | 0 | 0 | n.a. | Inner ring metro line |
| CO2 | | = | 0 | 0 | n.a. | |
| SOx | | = | 0 | 0 | n.a. | |
| NOx | | = | 0 | 0 | n.a. | |
| Lead | | = | 0 | 0 | n.a. | |
| VOC | | = | 0 | 0 | n.a. | |
| PM10 | | | | n.a. | n.a. | |

| Manchester | | | | | | No data |
|----------------------|---|-----|-------------|-------------|-------------|-------------------------|
| Stuttgart | | | | 1995 | 1999 | Before: 1990 |
| CO | SK Stuttgart, LK Boeblingen LK Calw, LK Tuebingen | - | n.a. | -0.4% | -0.3% | S-Bahn |
| CO2 | | - | n.a. | -0.4% | -0.4% | |
| SOx | | +/- | n.a. | +0.1% | -2% | |
| NOx | | - | n.a. | -0.1% | -0.5% | |
| Lead | | | | n.a. | n.a. | |
| VOC | | | | n.a. | n.a. | |
| PM10 | | | | n.a. | n.a. | |
| Tyne and Wear | | | 1983 | 1986 | 1992 | Before: 1980 |
| CO | Z1 + Z2 | - | - 0.3% | -0.1% | -0.1% | Light rail |
| CO2 | | - | -0.5% | -0.2% | -0.1% | |
| SOx | | - | -0.6% | -0.3% | -0.1% | |
| NOx | | | n.a. | n.a. | n.a. | |
| hydrocarbon | | - | -1% | -0.4% | -0.2% | |
| VOC | | | n.a. | n.a. | n.a. | |
| PM10 | | -/= | -2% | 0 | 0 | |
| Valencia | | | 1996 | 1999 | | Before: 1991 |
| CO | Z1 + Z2 | | n.a. | n.a. | n.a. | Light rail |
| CO2 | | | n.a. | n.a. | n.a. | |
| SOx | | = | 0 | 0 | n.a. | |
| NOx | | | n.a. | n.a. | n.a. | |
| Lead | | | n.a. | n.a. | n.a. | |
| VOC | | | n.a. | n.a. | n.a. | |
| PM10 | | | n.a. | n.a. | n.a. | |
| Vienna | | | | | 2002 | Before: 1991 |
| CO | Z1 + Z2 | - | n.a. | n.a. | -0,5% | Metro line |
| CO2 | | - | n.a. | n.a. | -0,4% | |
| SOx | | - | n.a. | n.a. | -0,4% | |
| NOx | | - | n.a. | n.a. | -0,2% | |
| Lead | | | n.a. | n.a. | 0,0% | |
| VOC | | - | n.a. | n.a. | -0,4% | |
| PM10 | | - | n.a. | n.a. | -0,4% | |
| Zurich | | | | | | No data |

Table 7-1: Synthesis table of emission indicators (annualised variations)

7.2 Road safety

Again, data are available for 8 case studies only. Furthermore, there is no variation for four of them.

For this other five case studies, road safety has been improved thanks to car use reduction. These five case studies corresponds to different public transport investment. It should be noticed that except in the Bratislava case study, the variation are very small and probably not significant.

From these results, it is difficult to learn a lot about the safety benefits of transport infrastructure and to do definitive conclusions. The nature of the investment cannot explain a more positive impact than another investment. Accompanying measures can be as important as the infrastructure itself.

| Case study | Direction | Short term | Medium term | Long term | Comments |
|----------------------|-----------|-------------|-------------|-------------|--|
| Athens | | | | | No data |
| Bratislava | | | | | No data |
| Brussels | | | 1991 | 1998 | Before: 1988 |
| Fatalities | = | n.a. | 0 | 0 | Inner ring metro line |
| Injured persons | = | n.a. | 0 | 0 | |
| Casualties | = | n.a. | 0 | 0 | |
| Delft | | 1987 | 1990 | 1995 | Before: 1980 |
| Fatalities | - | -1% | -0.2% | -0.1% | Data for Delft city Extensive bicycle network |
| Injured persons | - | -1% | -0.2% | -0.1% | |
| Casualties | - | -1% | -0.2% | -0.1% | |
| Helsinki | | 1985 | 1988 | 1995 | Before: 1981 |
| Casualties | - | -2% | -1% | -0.4% | Metro line |
| Lyon | | | | | No data |
| Madrid | | | 1996 | 2000 | Before: 1987 |
| Fatalities | = | n.a. | 0 | 0 | Inner ring metro line |
| Injured persons | = | n.a. | 0 | 0 | |
| Casualties | = | n.a. | 0 | 0 | |
| Manchester | | | | | No data |
| Stuttgart | | 1994 | 1995 | 1999 | Before: 1990 |
| Fatalities | - | -1 | -0.4% | -0.5% | S-Bahn |
| Injured persons | - | -0.7% | -0.3% | -0.4% | |
| Casualties | | n.a. | n.a. | n.a. | |
| Tyne and Wear | | 1983 | 1986 | 1992 | Before: 1980 |
| Fatalities | = | 0 | 0 | 0 | Light rail |
| Injured persons | = | 0 | 0 | 0 | |
| Casualties | = | 0 | 0 | 0 | |

| | | | | | |
|-----------------|---|-------------|-------------|-------------|---------------------|
| Valencia | | 1996 | 1999 | | Before: 1991 |
| Fatalities | = | 0 | 0 | n.a. | Light rail |
| Injured persons | = | 0 | 0 | n.a. | |
| Casualties | = | 0 | 0 | n.a. | |
| Vienna | | | | 2002 | Before: 1991 |
| Fatalities | - | n.a. | n.a. | -0.3% | Metro line |
| Injured persons | - | n.a. | n.a. | -0.3% | |
| Casualties | - | n.a. | n.a. | -0.3% | |
| Zurich | | | | | No data |

Table 7-2: Synthesis table of safety indicators for the whole conurbation (annualised variations)

8 CONCLUSIONS

Nearly all the case studies within *TranSEcon* are public transport projects except for Delft case study which is a bicycle project. However beyond this common aspect there is great variety.

These public transport projects include rather heavy systems going from light rail (a third of the case studies: Bratislava, Manchester, Tyne and Wear, Valencia) to underground or S-Bahn type (the other two third: Athens, Brussels, Helsinki, Lyon, Madrid, Stuttgart, Vienna, Zurich). Some projects are accompanied by reorganisation of the public transport network (Athens, Bratislava, Helsinki, Lyon, Madrid) while the others are accompanied by specific parking policies such as park and ride or parking restrictions (Stuttgart, Tyne and Wear, Vienna, Zurich). Some of these transport projects are also integrated in a more global project of urban regeneration (Bratislava, Valencia, Vienna).

As regards the spatial aspects the size of the conurbation is very different from a small city like Delft (100.000 inhabitants) to a big conurbation like Madrid: most of the case studies concern medium conurbation (Bratislava, Helsinki, Lyon, Stuttgart, Tyne and Wear, Valencia, Vienna, Zurich, 0.5 to 1.5 million inhabitants) while others are large conurbations (Athens, Manchester, Brussels, Madrid, 2 to 5 millions inhabitants.)

However the length of public transport infrastructure studied here are not always correlated to the size of the conurbation: the longest ones are for Tyne and Wear (55 km) and Manchester (31 km) and the smallest ones for Bratislava (2 + 6 km) and Madrid (7 km). This combined with the size of conurbations explains partly why the effects on transport supply and demand are so different between case studies.

About half of these transport projects are located in the centre of the conurbation while the others deal with connection within suburbs or between suburbs and the centre.

All the project except Bratislava and Zurich have adopted a do-minimum scenario i.e. a scenario where the investment would not have been built and all other elements of the transport policy (both for public and private transport and parking) would have remained identical. Where a model was available data have been estimated from modelling exercises (Brussels, Madrid, Manchester, Stuttgart and Vienna). In other case studies data resulted from analysis of the evolution of some indicators of the conurbation combined with the comparison of the evolution of the same indicators in other area. Due to the variety of data sources used some caution is required when drawing conclusions from the data analysis.

Even if the investment is quite important for some conurbations, the increase in public transport supply expressed in number of places*kilometre is quite limited when compared with the supply at the level of the whole conurbation (Z1+Z2) except for the case of Tyne and Wear. The projects can be classified by their level of supply increase:

- low progression: Bratislava, Brussels, Madrid, Valencia and Vienna;

- medium progression: Helsinki, Lyon and Manchester;
- High progression: Tyne and Wear.

Since in most case studies public transport is fully integrated at the level of the conurbation or deregulated as in UK, data on financial consequences specific to these projects are scarce. When available they show no significant variation at the level of the conurbation. However at the level of the project (Helsinki, Madrid and Vienna) they show a positive effect: revenue increases far more than the costs, yielding a reduction of public transport deficit and even an increase of benefice in case of Madrid, but limited to the project catchment area.

The reference scenarii for all the conurbations have assumed an unchanged policy for private transport (road infrastructure, traffic calming and parking policy). However the impact of new supply in public transport may change the car travel conditions by indirectly improving car speed: this is the case in Athens, Lyon and Vienna, which are underground projects, while for the other projects there is no significant increase. This would mean that underground project may have a favourable impact on car speed. However this conclusion should be considered cautiously here and must be confirmed by taking into account other accompanying measures which may affect car travel. Anyway this conclusion might be explained simply by the fact that there is no suppression of road capacity per se when an underground is built and that modal shift from car to public transport reduces car traffic at least in short term.

The data analysis in this workpackage is meant to evaluate the impact of public transport project on mobility behaviour, measured by “hard data” such as public transport and car trips, distance travelled, modal share, travel times, accidents and emissions. As such they provide only a partial view of the socio-economic impacts of these projects, which will be complemented by other *TranSEcon* workpackages.

First of all it appears that the annualised effects on mobility behaviour are for the most part very low. This has to do with the geographical scales at which these effects are measured: these geographical scales vary widely between case studies.

However it can be said that the effects on public transport mobility are positive, and significant when related with the scope of the project. Medium sized projects such as light rails or metros of a few kilometres length have an important impact on public transport mobility in the vicinity of the project. Larger scale projects like suburban light rail of more than a few ten kilometres length have in addition a significant impact on this mobility at the whole conurbation level.

The effects on time savings are very low, for the same reasons quoted above for mobility indicators. However there is a consistent decrease of travel time on public transport network (or bicycle network for Delft): this decrease annualised effect is significant even important at the level of the project for Athens, Lyon, Madrid, Manchester, and Vienna; it is significant at the level of the whole conurbation for Stuttgart and Tyne and Wear.

Generally speaking the impact on car use is generally very low or insignificant. Travel times by car on the road network are unchanged and car mobility also.

As regard atmospheric emissions, in the case studies where data are available the environmental impact of transport infrastructure is positive or null. In all case studies this reduction of effluent emissions is related to a decrease in car use. However these impacts are very low and quite insignificant, except for Bratislava, Helsinki and Vienna where an important decrease of emission for all effluents is observed.

For accidents data are available for nine case studies only and there is no effect on accidents for four of them. Again, the variations are very small and probably not significant. From these results, it is difficult to learn a lot about the safety benefits of the projects studied here and to make definitive conclusions. The nature of the investment cannot explain a more positive impact than another investment. Accompanying measures can be as important as the infrastructure itself.

It looks as if for all case studies the conditions of travel have been improved for public transport (or bicycle in Delft) with no degradation (and perhaps improvement) for road travel time by car. This can be explained by the fact that all these projects are underground rail or transformation of existing heavy rail lines into light rail. For all these projects there is no explicit shrinkage of road capacity available for cars. Public transport mobility is improved and since car mobility is unchanged, the whole mobility increases and negative effects or car traffic are unchanged or only slightly reduced.

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10 ABBREVIATIONS

| Abbreviation | Description |
|------------------|--|
| Before | Scenario before |
| CBD | Central Business District |
| Inhab. | Inhabitant |
| n.a. | Data non available |
| Project | The public transport investment to be assessed |
| PT | Public Transport |
| RS | Reference scenario |
| TranSEcon | Urban Transport and local Socio-Economic Development |
| With | Scenario with |
| Zproject | Zone of the project (see section 3.1.2) |
| Z1 | Zone directed impacted by the project (see section 3.1.2) |
| Z2 (Z2a, Z2b) | Zone concerned by the project (see section 3.1.2) |
| Z3 | Control area zone not concerned by the project (see section 3.1.2) |