SUMMA

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EXECUTIVE PUBLISHABLE SUMMARY

There is an increasing demand for transport and mobility in our society. At the same time there is a desire for a clean environment, preserving nature, and concern for the welfare of future generations. Policymakers have to accommodate these conflicting desires by balancing the positive and negative impacts of transport. SUMMA helps policymakers to do so by helping to develop more efficient and effective transport policies that cater to the need for mobility while reducing transport's adverse impacts to acceptable levels.

SUMMA was designed to support policymakers by providing them with a consistent framework for making trade-offs, where appropriate, among the economic, environmental and social components of sustainability. To do so the objectives of SUMMA were to:

1. Define and operationalise sustainable mobility and transport, develop an appropriate system, and defined a set of indicators for monitoring the environmental, economic and social dimensions of sustainable transport and mobility;
2. Assess the scale and scope of the problems of sustainability in the transport sector;
3. Assess policy measures in the White Paper on transport policy, as well as other policy measures, that are to be found in the literature, for promoting sustainable transport and mobility at the national, regional, and city levels.

To realize these objectives, SUMMA: 1) Defined the goals of transport policy and measures (from the EC's White Paper on transport and other sources) for achieving these goals; 2) developed a monitoring system to monitor the transport system as well as the performance of policy measures in promoting sustainable transport, 3) developed a tool (the Fast Simple Model) for doing integrated assessments (covering the social, environmental, and economic impacts) of the of policies, and 4) used the FSM to assess the performance of policies in promoting sustainable transport.

DEFINING SUSTAINABILITY

The starting point for SUMMA was the definition of sustainability adopted by the European Union's Ministers of Transport at their meeting on April 4-5, 2001 which stated that a sustainable transport system is one that:

- *Allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promises equity within and between successive generations*
- *Is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development*
- *Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable resources at or below the rates of development of renewable substitutes while minimizing the impact on land and the generation of noise.*

DEFINING THE POLICY GOALS

In SUMMA, the overarching goal (drawn form the White Paper) is to facilitate sustainable transport and mobility. In order to identify outcomes of interest, however, this high-level goal had to be operationalised by relating it to more concrete goals. We identified three pillars of sustainable development – economic, environmental, and social. Each of these pillars has its own subgoals. For example, economic subgoals include improving economic development and efficiency; environmental goals include improving biodiversity and reducing air pollution; social goals include reducing poverty and improving intergenerational equity.

The White Paper is targeted on its own set of goals, some of which match sustainability subgoals (e.g., reduce air pollution) and some of which do not (e.g., make transport users pay the full costs of their activities). In order to assess the performance of a policy relative to its desired effects, we first had to identify the desired effects. As already mentioned, some of the desired effects are already captured in the sustainability outcome indicators. For those that are not, we had to define additional outcome indicators with which to assess the policies. For example, one of the most important goals of the White Paper policies is to shift transport off the roads and onto other modes, thereby bringing the modes more into balance. Of course, shifting transport off the roads will help to achieve some of the sustainability goals, such as reducing pollutant emissions. But, mode shift is an intermediate goal (toward the higher-level goals of reducing air pollution or reducing energy consumption), not an end in itself. In order to assess the effects of some of the White Paper policies, we need to identify these intermediate goals and specify outcome indicators to estimate the extent to which the policies might help to achieve the White Paper goals and subgoals.

The overarching goal of the European Transport Policy as described in the White Paper is to achieve "a modern transport system which is sustainable from an economic and social as well as an environmental viewpoint" (EC, 2001, p.10). In order to achieve this goal, four major 'policy guidelines' are listed (EC; 2001; p.4-5):

1. Shifting the balance between modes of transport
2. Eliminating bottlenecks
3. Placing users at the heart of transport policy
4. Managing the globalisation of transport

Within most of these guidelines, the White Paper described policy goals. The set of goals and subgoals that we derived from the White Paper are shown in the table below:

Goals and sub-goals analysed in SUMMA

1. Shifting the balance between modes of transport	
1.1 Improving quality in the road sector	*FSM*
1.2 Revitalising the railways	*FSM*
1.3 Controlling the growth in air transport	
1.4 Adapting the maritime and inland waterway transport system	*FSM*
1.5 Linking up the modes of transport	*FSM*
2. Eliminating bottlenecks	
3. Placing users at the heart of transport policy	
3.1 Unsafe roads	
3.2 The facts behind the costs to the user	*FSM*
4. Managing the globalisation of transport	FSM
5. Rationalising urban transport[1]	FSM
6. Achieving a sustainable transport system	FSM

Out of the goals and subgoals we identified, we were able to evaluate the contribution of policies to eight sets of policy goals (the goals for which there is an FSM in the above table)

DEFINING THE POLICY MEASURES

Three types of policy measures were defined; measures for influencing transport at a EU-wide level, measures for influencing urban transport, and "other" policies promote sustainable transport, but not by directly influencing targeting transport choices (see tables below).

The EC White Paper was the primary source for the EU-wide policy measures. The transport plans (including investment plans) of the urban regions for which we had models were the primary source for defining the policy measures for influencing urban transport. The policy measures used in different Member States was the source for the policies in the category "other."

MONITORING THE SYSTEM AND PERFORMANCE OF POLICIES

SUMMA defined two types of indicators, system indicators and outcome indicators. A system indicator is a proxy for what takes place inside the system. System indicators are important for two reasons:

[1] In the White Paper, this is a goal within Policy Guideline 3 (Placing users at the heart of transport policy). But, since we are doing separate policy analyses at the European and urban levels, we decided to make this a separate goal category.

1. For monitoring purposes it is not enough to have outcome indicators alone. A change in the value of an outcome indicator provides no information about whether the change is due to a change in policy or due to some other reason (i.e. a system indicator can be important to understand what is going on in the system), and
2. For estimating the value of outcome indicators. An outcome indicator may be calculated from several system indicators. The outcome indicators monitor the outcomes of interest for policy makers.

System indicators and their location in the transport system

System indicator	Influenced box in the transport system
Percentage of people with work location outside household	Activities
Percentage of people currently in education	
Age distribution	
Percentage of population owning a car	
Disposable income distribution	
Regional distribution of industries	Spatial and time structure
Percentage of population living in urban areas	
Regular shop opening hours	
Mean distance to closest public transport stop	
Residential space per person	
Fuel/energy usage per 100 km	Transport means and services
Emission of air pollutants by transport mean	
Space per passenger on public transit	
Vehicle fleet mix by mode	
Age distribution of vehicle fleet	
Fixed and variable costs by mode per passenger	
Percentage of surface covered by infrastructure by mode	Infrastructure
Numbers of vehicles that can be operated per km per day	
Price of infrastructure use (tolls, parking fees, etc.)	
Emissions of air pollutants by industries related to transport	General - several boxes
Raw material use by industries related to transport	
Average storage capacity of gas stations	
Number of vehicles produced by mode per year	

The outcome indicators are needed to monitor or describe changes in the outcomes of interests. The outcomes of interest represent the impacts of the transport system that the policymakers are interested in. Since the outcomes of interest themselves are usually not measurable nor can they be monitored, one or several indicators have been chosen to represent the changes taking place in the outcomes of interest. In SUMMA the outcomes of interest were selected to cover the main elements in the definition of sustainable transport and to cover the three dimensions, social, environmental, and economic, of sustainability. The relationship between the selected outcomes of interest and the aspects of sustainability, and the coverage of the three dimensions are shown in the tables below.

Links between SUMMA outcomes of interest and sustainability

Element from the definition of sustainability	Related Outcome of Interest (OoI)	Dimension
Basic access	Accessibility	Economic, social
Development needs	Accessibility Cost / benefits to economy Productivity / Efficiency Transport operation costs Social cohesion	Economic, social
Safety	Safety and security Working conditions in transport sector	Social
Human health	Safety and security Fitness and health Liveability, amenity Emissions to air, soil and water	Social, environmental
Ecosystem health	Direct ecological intrusion Emissions to air, soil and water	Environmental

	Waste	
Equity	Equity	Social
Affordable	Accessibility (incl. affordability)	Social
Fairness	Accessibility (by mode) Equity Transport operation costs	Economic, social
Efficiency	Productivity / efficiency Transport operation costs	Economic
Transport modes	Accessibility	Economic, social
Competitive economy	Accessibility Transport operation costs Costs and benefits to the economy Productivity / efficiency	Economic
Emissions	Emissions to air, soil, water Emissions of noise	Environmental
Waste	Waste	Environmental
Renewable and non-renewable resource use	Resource use	Economic, environmental
Impacts on land	Resource use (incl. land take) Direct ecological intrusion (incl. fragmentation)	Environmental
Noise	Emission of noise	Environmental

Outcomes of interest

Economic outcomes of interest	Environmental outcomes of interest	Social outcomes of interest
Accessibility Transport operation cost Productivity / Efficiency Costs to economy Benefits to economy	Resource use Direct ecological intrusion Emissions to air Emissions to soil and water Noise Waste	Accessibility and affordability Safety and security Fitness and health Liveability and amenity Equity Social cohesion Working conditions in transport sector

For each of the outcomes of interest in the table above, one or more indicators were selected. The main criteria used in identifying the indicators were their importance, relevance and completeness in measuring and monitoring the outcomes of interest. Availability of data or methods to calculate these indicators was not taken as a decisive factor, although it certainly has had an impact on the selection. Thus, the indicator selection in this report is a **wish list** of indicators that are needed to monitor the performance of the transport system and its impact on sustainability. The list of indicators is too numerous to repeat here, thus the interested reader is referred to Appendix D for the complete listing of indicators.

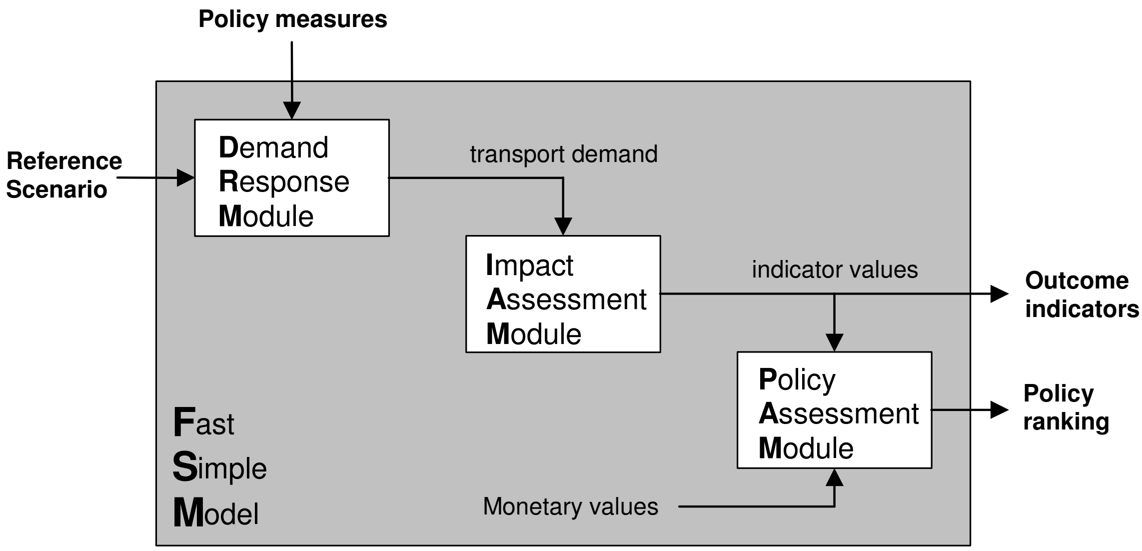
THE FAST SIMPLE MODEL (FSM)

Ideally, a model to represent the transport system would be able to model all policy measures and provide the outcomes of interest with sufficient detail and accuracy. Additionally the model would cover all of Europe and be fast, simple and accurate enough to be able to support policy makers in their decision-making. The SUMMA project did not have the resources to build an entirely new model. Thus, the FSM is based on an existing model called EXPEDITE. The EXPEDITE model system calculates the impact of transport policies on transport demand for the whole of Europe. It does this so quickly that it allows the development of a policy assessment instrument that can be used by policy makers from behind their own desks.

Using the EXPEDITE model as the basis, SUMMA developed a new model for quantifying the impacts of transport policies. The model is called the Fast Simple Model (FSM). The FSM is a user-friendly computer tool that enables the calculation of the impacts of various policy measures and policy packages. It includes three sub-modules:

(1) A Demand Response Module (DRM), which generates forecasts of demand for passenger and freight transport based on a Reference Scenario and influenced by policy changes,
(2) An Impact Assessment Module (IAM), which estimates the environmental, economic, and social impacts of the transport demand, and

(3) A Policy Assessment Module (PAM), which produces an aggregate measure of the "sustainability" of the policies being assessed. The FSM is illustrated in the following figure.



Structure of the Fast Simple Model

The three modules will be discussed separately in the following sections. Following that, the Reference Scenario and the policy levers for the FSM will be discussed. More detailed descriptions of all FSM components can be found in appendixes A and B.

The Demand Response Module - The DRM calculates the demand for both passenger and freight transport. For passenger transport it calculates the number of trips made and the number of kilometres driven. The trips and kilometres are disaggregated by mode, by purpose, by population group, and by distance band. For each of the modes the shares of different vehicle types are calculated. For freight transport, the transport volumes are calculated in tonnes and ton-kilometres. The tonnes and ton-kilometres are disaggregated by mode, commodity, and distance band. For each of the modes the shares of different vehicle types are calculated. The (EXPEDITE based) FSM is a meta-model. A meta-model is a simple aggregate model that approximates more complex and disaggregate behaviour. Based on calculations with more detailed transport models for a (as much as possible) representative set of countries, a model is estimated that represents transport in the whole of Europe. The FSM is not a network model. Thus, the FSM has been supplemented with a set of regional and city level models. For additional details about EXPEDITE and the FSM the reader is referred to the SUMMA Deliverable D5 and (de Jong et al., 2002).

The Vehicle Stock Model - The EXPEDITE meta-model on which the DRM is based generates transport demand by mode, but not by vehicle type. Without vehicle types it is not possible to calculate environmental impacts of transport demand with a reasonable level of accuracy. Given that emissions are an important concern for policymakers, it was decided to develop a new to disaggregate the transport demand by mode to demands by vehicle type. This new model is called the Vehicle Stock Model (VSM). The VSM is based on the TREMOVE model, see Appendix A6 (Griet de Ceuster et al., 2004). The VSM calculates the share of different vehicle types in the total vehicle-kilometres for each mode in 1995 as well as in 2020. These shares allow disaggregating the transport activities by vehicle type instead of by mode. As shown in the table below, the vehicle stock composition is very detailed for road transport, while there is no disaggregation for the maritime and air modes.

Vehicle stock composition

Road	Rail	IWW	Maritime	Air
Passenger cars (10)	Locomotives (4)	Tanker Vessel (7)	Ship (1)	Airplane (1)
Light Duty Trucks (2)	Rail cars (4)	Pusher Craft (7)		
Mopeds (1)	High Speed Train (1)	Dry Cargo Vessel (7)		
Motorcycles (4)				
Heavy Duty Trucks (4)				
Busses/Coaches (2)				

Between brackets the number of vehicle types.

Regional and city level models – The DRM was used to generate transport demand for all of Europe. These demands then formed the basis for assessing policy measures at the European level. Sustainability, however, also has a strong local aspect; what is sustainable in city or region is not necessarily sustainable in another city or region. Thus, it was decided to also assess policy measures at a city/regional level to see whether there were differences in the performance of policy measures across regions. To do this we needed to generate transport demand at the city/regional level. In SUMMA we used two city models and two regional models for passenger transport, namely for:

- Hamburg (DE) — regional model (freight and passenger)
- Paris (FR) — city model
- Prague (CZ) — city model
- Randstad (NL) — regional model: three NUTS 2 zones in the centre of the Netherlands (North Holland, South Holland and Utrecht).

The relevant information from the above mentioned regional and city level models have been integrated into the FSM. This is done on a policy-by-policy basis — the regional and city level models only provide relevant information if they have been run for a policy. When for a certain policy information is available from a regional or city level model it replaces the estimate from the EXPEDITE meta-model; When for a certain policy no information is available from a regional or city level model (the policy was not run) then the estimate for the subsequent NUTS2 zone is set to 0 (hence the estimate from the EXPEDITE meta-model is never used (for consistency reasons).

The Impact Assessment Module - The Impact Assessment Module estimates the impacts of policy measures by calculating the values of the outcome indicators. The objective was to be able to assess the impact of policy on all the indicators included in the “wish list” that we had developed. However, due to the lack of availability of data, we were unable to assess the effect of policy measures on all of the indicators. Most of the indicators we are able to estimate in the IAM are based on the results of the DRM (transport demand and vehicle stock composition). Some indicators do not depend on the demand; these have been defined using other relevant data sources.

CONCLUSIONS

SUMMA was designed to create a tool for helping policymakers. This tool is now available in the form of the FSM. There is, however, room for improving the FSM. Nevertheless, in creating the FSM we learned many valuable lessons relevant for both researchers studying sustainable transport and mobility and policymakers responsible for promoting sustainable transport.

To start it should be noted that the concept of sustainability, however defined, is an inherently political issue. It is very difficult, if not impossible, to define sustainability in a way that is acceptable to everyone. The reason for this lack of consensus about what constitutes sustainability is that depending on the definition, there are different sets of winners and losers. Given this, it becomes even more important to deepen our understanding of the facts underlying the various aspects of sustainability so as to facilitate the making of trade-offs and reaching a compromise.

Next, the work in SUMMA was seriously hindered by the lack of data for studying social, and to some extent environmental, issues related to sustainability. We were unable to use all the indicators that we developed because of the lack of data. Thus, the lack of data for studying sustainability needs to be remedied.

An important area where much additional research is needed is in the area of social equity and social cohesion. A lot of additional research is still needed in order to understand these issues and to devise policy measures for addressing them.

Given that sustainability has multiple dimensions, it is important for policy makers to consider all the dimensions in an integrated manner rather than individually. Therefore, policy measures should be dealt with in integrated manner for understanding their combined effects. When sustainable mobility and transport are discussed, the need for holistic and systemic approach is evident. There is a strong demand to better understand cause-effect relations in the transport system and policy making, for example severe efforts on reducing road traffic may lead to increase in air traffic. Furthermore, reaching sustainable transport requires not only technical measures but also great attention to decoupling and changes in the behaviour of individuals.

Also given these multiple dimensions, it is unlikely that any single policy measure can by itself help attain a sustainable transport system. Thus, policy makers should try to develop policy packages (sets of policy measures) to address the different dimensions of sustainability.

In another project (ASTRA) it was shown that even with its integrated policy programs, environmental sustainability e.g. in terms of CO_2 emissions would not be reached. None of the policy packages that were evaluated were able to lead to compliance with the Kyoto levels for greenhouse gases emissions. Thus, it becomes even more important to develop policy packages that are not just limited to measures related to transport policy, but include a wider range of policy measures enabling simultaneously, for example, management of land use and technological development.

The responsibility of a policy decision rests with the policy-maker and can never be overruled by a decision support method. Therefore, in the projects policy makers were recommended to use various models and tools. Scenario building and systems modelling tools and other integrated approaches require considerable efforts compared to conventional incremental policy-making, which has proved to be conflict laden and not particularly effective. This is so partly because they often have a too short time perspective. In a longer time perspective the gains of specific measures will be more visible.

Integration of measures should also be supplemented with integration of different sectoral policies. In a number of projects the interdependency of transport and other sectors was recognised and the inefficiency of the transport policies alone to tackle the demands of sustainable mobility. Special attention should be paid on linking transport policies with other policy areas in society.

Transport has both large positive and negative impacts. Thus, policymakers are faced with the conundrum of simultaneously stimulating the positive effects and mitigating the negative effects. Given this, we asked the question as to why progress towards the, admittedly ambitious, goal of having a sustainable transport system is not faster. In response, we came to the conclusion that the following factors are contributing to perpetuating current trends:

- The externalities, both the negative and positive environmental and social impacts, of transport are usually not included in the monetary calculations of transport costs. Thus, decision-makers lack information about the total effects of their decisions on the transport system and on society. Similarly, users do not have to pay for the environmental and social damage resulting from their use of the transport system and their transport choices. Since information about, and awareness of the impacts costs is not complete, responsibility for the negative effects is not assigned to anyone, in short the costs of the negative impacts are ignored.
- Transport and mobility are an integral part of society. Thus, it is extremely difficult to bring about changes in the transport choices made by people and in the functioning of the transport system and move towards a more sustainable transport system as long as changes are not made in the non-transport choices of people and in other sectors of the economy.
- Existing structures are resistant to change. Innovations are only slowly adopted in the transport market and the capacity of the political system to reflect the increasing need for political measures is limited. Established structures also hold back behavioural patterns of transport choices from changing.
- Finally, due to the fact that there are large and many positive and negative impacts of transport, there are also a number of conflicting interests: the interests of environment are in conflict with those of the economy and interests of individuals conflict with the interests of society as a whole. These differing interests disperse the willingness and capacity of the society to tackle the problems of the transport sector.

1 Shift the balance between modes of transport	
1.1 Improving quality in the road sector	
1.1.1	Harmonise inspections and penalties
1.1.2	Increase the number of checks that Member States are required to carry out on compliance with driving times and drivers' rest periods
1.1.3	Keep the road transport profession attractive by promoting the necessary skills and ensuring satisfactory working conditions
1.1.4	Harmonise the minimum clauses in contracts governing transport activity in order to allow tariffs to be revised should costs increase (e.g., a fuel price rise)
1.2 Revitalising the railways	
1.2.1	Gradually open up the railway market in Europe by
1.2.2	Step up rail safety by proposing a directive and setting up a Community structure for railway interoperability and safety
1.2.3	Create rail freight freeways
1.2.4	Get rail industries to reduce adverse environmental impacts (through dialogue)
1.3 Controlling the growth in air transport	
1.3.1	Introduction of a "Single Sky" by
1.3.2	Airport policies:
1.3.3	New slot allocation system
1.3.4	Replacement for current open skies agreements
1.3.5	Air transport taxation policies (kerosene tax and differential en route air navigation charges)
1.4 Adapting the maritime and inland waterway transport system transport.	
1.4.1	Developing infrastructure for "Motorways of the Seas"
1.4.2	New regulatory framework for maritime and inland waterway transport
1.4.3	New regulatory framework for safety controls for cruise ship passengers
1.4.4	Modifications in maritime safety rules
1.4.5	Reflag ships to Community registers
1.4.6	Improve inland waterway transport by:
1.4.7	Development of a European maritime traffic management system
1.5 Linking up the modes of transport	
1.5.1	Building and promoting multi-modal transport networks and terminals, for freight and passenger transport.
1.5.2	Marco Polo programme (to promote alternative solutions to road transport)
1.5.3	Develop the profession of freight integrator
1.5.4	Standardise transport units and freight loading techniques

2 Eliminating bottlenecks	
2.1	Revise the trans-European network guidelines to encourage corridors with priority for freight, a rapid passenger network, traffic management plans for major roads, and additional projects (29 specific projects listed in this subcategory)
2.2	Change the funding rules for the trans-European network
2.3	Revise the trans-European network to integrate the networks of the Accession countries, introduce the concept of 'motorways of the seas', develop airport capacities, and improve territorial cohesion
2.4	Establish a Community framework to channel revenue from charges on competing routes towards the building of new infrastructure
2.5	Harmonise safety standards for road and rail tunnels belonging to the trans-European network

3 Placing users at the heart of transport policy	
3.1 Unsafe roads	
3.1.1	Reduce by half the number of people killed on European roads by 2010
3.1.2	Harmonise rules governing checks and penalties concerning speeding in international commercial transport on the trans-European road network
3.1.3	Harmonise rules governing checks and penalties concerning drink driving in international commercial transport on the trans-European road network
3.1.4	Harmonise sign- posting of hazardous locations on trans-European routes
3.1.5	Obligation for seat belts in new manufactured coaches
3.1.6	Encourage responsible driving through training and education schemes (particularly for young drivers)
3.1.7	Combat drink-driving and solve problems of use of drugs and medicines
3.1.8	Encourage independent technical investigations
3.2 The facts behind the costs to the user	
3.2.1	Guarantee the interoperability of means of payment on the trans-European road network
3.2.2	Establish an infrastructure charging system
3.2.3	Propose uniform taxation for commercial road transport fuel
3.3 Right and obligations of users	
3.3.1	Increase air passengers' rights concerning denied boarding due to overbooking, delays, and flight cancellations
3.3.2	Introduce regulations concerning requirements relating to air transport contracts
3.3.3	Extend the Community measures protecting passengers' rights to include other modes of transport in particular railway, maritime transport, public transport service concerning:
3.3.4	Adjust procedures for notifying State aid
3.3.5	Clarify the general principles that should govern services of general economic interest in the field of transport

4 Managing the effects of transport globalisation	
4.1	*Mobilise private sector finance to link the Accession countries to the trans-European network in particular railway sector*
4.2	*Ensure adequate public funding of infrastructure in the Accession countries*
4.3	*Develop the administrative capacities of the Accession countries by training inspectors and administrative staff responsible for enforcing transport legislation*
4.4	*Become full members in the main international transport organisations*
4.5	*Develop an EU satellite navigation system (Galileo)*

POLICY		EXPLANATION
5.1	Impose a speed limit of 30 km/h on intra-urban streets, except main radial roads	To make cities more attractive and to reduce noise and accidents in urban areas
5.2	Reduce parking facilities in the city centre	To shift trips to public transport
5.3	Restrict the use of big trucks in the city centre	To make cities more safe and attractive and to move the heavy trucks to main road
5.4	Introduce low-priced tickets for employees to use all public transport means in an urban region ('job tickets')	To shift commuting trips to public transport
5.5	Increase the frequency of scheduled services	To make the public transport system more attractive
5.6	Sponsor car-sharing	To make more efficient use of the transport means in urban areas
5.7	Concentrate new settlements (housing, commercial, employment zones) near existing public transport infrastructure	To support the use of existing public transport systems
5.8	Promote residential functions in commercial areas	To reduce the need for car travel
5.9	Place constraints on settlements in suburban areas	To reduce travel distances and the need for car travel
5.10	Promote city logistic centres in the surrounding of populated areas	To reduce and bundle heavy truck transport
5.11	Introduce road-pricing for trucks and cars in city centres	To reduce congestion and encourage the use of public transport
5.12	Increase parking fees	To shift trips to public transport
5.13-5.15	Extend inland waterways, rail-trucks and transit streets	To encourage the use of environmentally-friendly modes and to shift transit traffic from urban streets to main roads
5.16-5.18	Extend cycling and walking paths and places for Park and Bike / Bike and Ride	To encourage the use of non-motorised transport means
5.19	Extend the use of city logistic centres	To improve goods delivery and reduce congestion in urban areas
5.2	Increase service frequency for non-road freight transport	To shift freight transport to non-road modes
5.21	Allow bigger trucks for long-haul transport	To make road transport more efficient
5.22	Add road infrastructure	To increase the amount of road infrastructure in order to reduce congestion
5.23	Implement cordon pricing	To reduce congestion and encourage the use of public transport
5.24	Implement congestion pricing	To reduce congestion and encourage the use of public transport

Policy option		Policy category
6.1.1P	Subsidise energy efficient car purchase (for passenger transport)	Increasing sustainability
6.1.2P	Subsidise energy efficient car technologies (for passenger transport)	Increasing sustainability
6.2F	Increase / make uniform time windows (for freight transport)	Rationalising urban transport (cat 5)
6.3F	Subsidise environmentally friendly transport modes (for freight transport)	Increasing sustainability
6.4P	Make PM filter mandatory (for passenger transport)	Increasing sustainability
6.5P	Change fixed price of car ownership (for passenger transport)	Increasing sustainability
6.6F	Subsidise rail transport (for freight transport)	Increasing sustainability
6.7F	Increase service frequency for non-road modes (for freight transport)	Linking up the modes of transport (cat 1.5)

CONTENTS

1. OBJECTIVES OF THE PROJECT

There is an increasing demand for transport and mobility in our society. At the same time there is a desire for a clean environment, preserving nature, and concern for the welfare of future generations. Policymakers have to accommodate these conflicting desires by balancing the positive and negative impacts of transport. SUMMA helps policymakers to do so by helping to develop more efficient and effective transport policies that cater to the need for mobility while reducing transport's adverse impacts to acceptable levels.

The SUMMA project is designed to support policymakers by providing them with a consistent framework for making trade-offs, where appropriate, among the economic, environmental and social components of sustainability. SUMMA will provide an assessment of policy options for promoting sustainable transport and mobility. To achieve this, SUMMA will

1) Define and operationalise sustainable mobility and transport, develop an appropriate system, and define a set of indicators for monitoring the environmental, economic and social dimensions of sustainable transport and mobility;
2) Assess the scale and scope of the problems of sustainability in the transport sector;
3) Assess policy measures in the White Paper on transport policy, as well as other policy measures, that are to be found in the literature, that can be used to promote sustainable transport and mobility at the national, regional, and city levels.

This is the final report of SUMMA. Thus, it follows the structure laid out by the European Commission for Final Reports of EC financed projects. The remainder of this report is structured as follows. Chapter 2 reports on the scientific and technical aspects of the project and its results. Chapter 3 lists the deliverables that have resulted from the project. Chapter 4 compares the initially planned activities with the work that was actually carried and explains the differences. Chapter 5 reports on the management and coordination of the project. Finally, Chapter 6 provides the results and conclusions of the complete project.

2. SCIENTIFIC AND TECHNICAL DESCRIPTION OF THE RESULTS

To realize its objectives SUMMA adopted a two-step approach. In the first step the problem was analysed and a conceptual design for monitoring and modelling sustainable transport and mobility was developed, without fully taking into account the feasibility of its implementation. In the second step, the conceptual design was implemented, given the limitations of data and information, as fully as possible and then used to assess the contribution of several policies to promoting and realizing sustainable transport.

The remainder of this chapter is divided into 6 sections covering the different workpackages of SUMMA and the results. Section 2.1 defines sustainability, investigates the contribution of transport to problems of sustainability vis-à-vis other economic sectors, and examines the marginal costs of abatement of various environmental problems. Section 2.2 presents the policy assessment framework that was developed and used in SUMMA. Section 2.3 desribes how the Outcomes of Interest (for policy makers) were translated into indicators that could be measured and used for monitoring the performance of the transport system. Section 2.4 describes the Fast Simple Model. Section 2.5 defines the policy goals, the policy measures, and the use of the FSM to assess the performance of these policy measures. Finally, Section 2.6 provides the results from the policy assessment.

2.1. SUSTAINABLE TRANSPORT AND MOBILITY

2.1.1. Definition of sustainability

Given that the term sustainability has many different aspects, the aim of this section is to review these different aspects and distil what is relevant for sustainable transport. This section starts reviews the various definitions of sustainable transport and then briefly discusses the impacts, both positive and negative, of transport on sustainability.

2.1.1.1. Defining sustainable transport

At their meeting on April 4-5, 2001, the European Union's Ministers of Transport adopted a slightly revised version of a definition originally proposed by the Centre for Sustainable Transport[2]. The definition adopted by the Minister's of Transport states that a sustainable transport system is one that:

Allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promises equity within and between successive generations;

Is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development;

Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable resources at

[2] The definition developed by the Centre for Sustainable Transportation (CST) in 1997 states that a sustainable transportation system is one that:

Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.

Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy.

Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, reuses and recycles its components, and minimizes the use of land and the production of noise. (CST 2002.)

The main differences between the version adopted by the EU ministers and the CST's definition are that the former one has expanded certain phrases: "access needs of individuals" to "access and development needs of individuals, companies and societies" as well as the system should support "balanced regional development" as well as the economy in general. Content wise the most notable difference is in the reference to limited environmental resources: phrases "minimizes consumption of non-renewable resources, reuses and recycles its components" were replaced by the terminology familiar from Herman Daly's management rules "uses renewable resources at or below their rates of generation, and, uses non-renewable resources at or below the rates of development of renewable substitutes".

or below the rates of development of renewable substitutes while minimizing the impact on land and the generation of noise. (Council of the EU 2001.)

Compared to many other definitions of sustainable transport, this definition is more concrete and comprehensive and does well in bringing out the complex and multifaceted nature of this subject. It spells out the interests of individuals and society, and takes into account the health of both human beings and ecosystems. Finally, it is based on the "management principles" of Herman Daly, principles that are commonly accepted as the basis for sustainability. Furthermore, and importantly, this definition has been accepted by the Ministers of Transport of the EU in the so-called "April Resolution." As this definition has undergone an elaborate vetting process and then been politically accepted, it has a validity which is missing from other definitions.

Some examples of definitions of sustainable transport and mobility

A recent project undertaken by the World Business Council on Sustainable Development defined sustainable mobility as:

"The ability to meet the needs of society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values today or in the future." (http://www.wbcsdmobility.org)

The PROSPECTS (Procedures for Recommending Optimal Sustainable Planning of European City Transport Systems) project, funded under the European Commission's FP5, defines sustainable urban transport and land use as:

"A sustainable urban transport and land use system provides access to goods and services in an efficient way for all inhabitants of the urban area, protects the environment, cultural heritage and ecosystems for the present generation, and does not endanger the opportunities of future generations to reach at least the same welfare level as those living now, including the welfare they derive from their natural environment and cultural heritage." (Minken et al 2001.)

In the EXTRA project sustainable mobility was defined in practical terms as:

"A transport system and transport patterns that can provide the means and opportunities to meet economic, environmental and social needs efficiently and equitably, while minimizing avoidable or unnecessary adverse impacts and their associated costs, over relevant space and time scales."(European Commission 2001a)

For the need of operationalisation the EXTRA and PROSPECTS projects, as well as the Centre for Sustainable Transportation (CST) have elaborated further their definitions of sustainable transport. In general, environmental issues, natural resource use, ecological limits and health have been given adequate attention in all three definitions, while the definition from the PROSPECTS project gives land-use the most attention. Although economic aspects and economic management, such as transport investments are emphasized in the objectives for sustainable transport defined in the EXTRA project, the PROSPECTS project is the only one to actually spell out the objective of economic growth. However, although present in the objectives, social aspects of sustainability are the least well defined. For example, the CST definition includes broader social concerns like avoiding stress on the social fabric and human scale development.Finally, special attention should be paid to what the EXTRA project has listed as the last objective to "ensure the economic and social acceptability of new measures", this will be a crucial point in the implementation of measures to achieve all sustainability objectives.

Operationalising and defining sustainability is a complicated task and this is clearly reflected in these examples. Rather than defining clearly what kind of state sustainability is, it is easier to agree about the direction of development, what should be reduced and what increased. But to define concrete measures and exact limits, to what extent and how much, these are questions that are far more difficult to answer. This is due largely to the fact that sustainability is dependent on place and time;

practical and operational definitions should leave enough space for application to varying environments and transport systems.

2.1.1.2. Impacts of transport in terms of sustainability

The various definitions of sustainability illustrate just how wide ranging and diverse the issues related to sustainable transport are. For example, consider the life cycle of vehicle production and use shown in Figure 2.1. In considering the environmental impacts of vehicles, most often only the fuel use and the service stage, such as infrastructure need and pollution are included in the analysis. However, there are a number of other impacts that ought to be included, for example the use of natural resources in the manufacturing stage, as well as all waste generated during the life-cycle. The use of life-cycle analysis is not, however, a very practical approach for analysing the impacts of transport systems. Using the life-cycle approach for doing so would require collecting and analyzing information that is so detailed and complex that it would be impractical. Instead, the life-cycle approach can be be used as a framework for considering impacts from different points of view and for checking that all important aspects have been considered in an analysis.

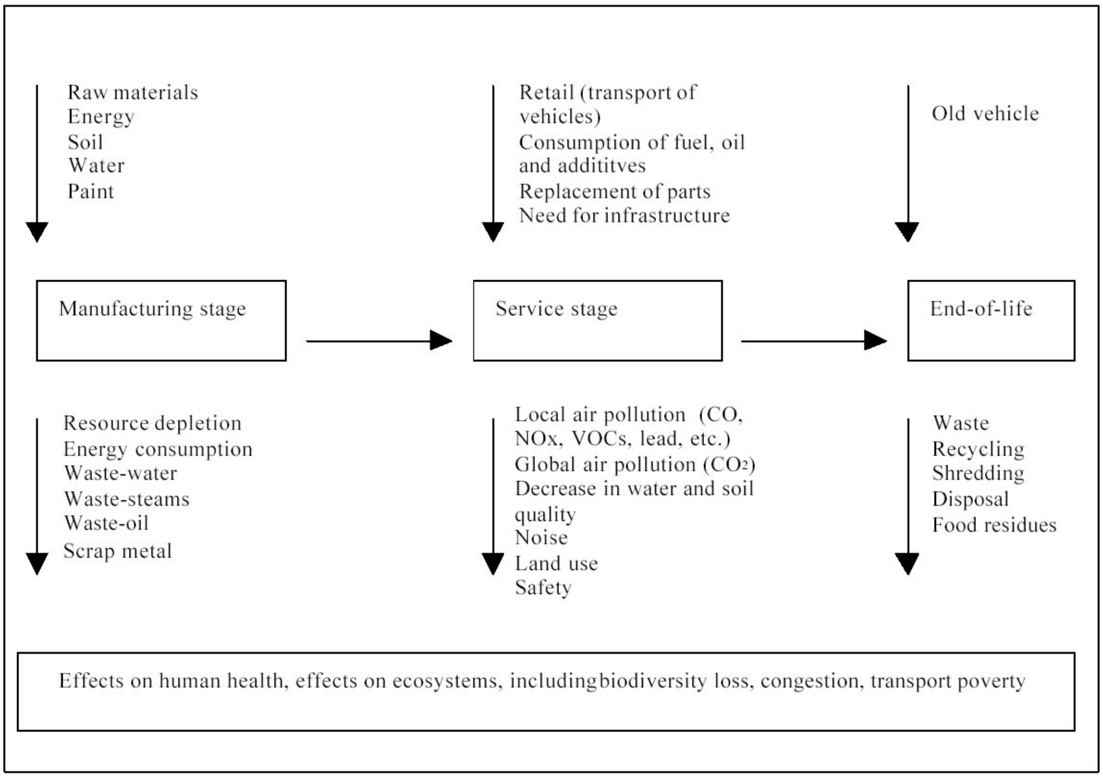


***Figure 2.1** – Life-cycle of vehicle production and use (UNEP 2001)*

Next, we discuss the issues and problems of sustainable transport, are discussed. The subsequent discussion is not all-inclusive; rather it attempts to give an overview of the wide range of issues and impacts of transport.

Environmental impacts of transport

The functioning of the transport sector needs a large amount of natural and, mostly, non-renewable resources. In terms of energy use, the transport sector is responsible for about one quarter of the world's total energy use. For fossil fuels, and especially oil, the transport sector accounts for about half of the world's total demand for oil (UNEP 2001). Producing transport vehicles requires all sorts of plastics, metals and chemicals, all potential pollutants.[3]

Another natural resource that is needed for transport is land. Land is needed not only for transport routes, but also for parking, maintenance and manufacturing facilities. Good agricultural land and

[3] See USEPA 1999 for an account of the inputs needed for transport infrastructure and vehicle construction.

green areas are converted to transport use[4], which in turn may further increase the demand for transport: agricultural products need to be transported from further away, and urban dwellers have to travel further to enjoy green areas. This contributes to the phenomena of urban sprawl.

Transport infrastructure has various impacts on the habitat, species populations, as well as water management. Building of transport routes fragments green areas and reduces the living areas of species and the resilience of ecosystems. Paving large areas of surface disrupts the natural flows of water, and thereby decreasing the levels of ground water in some areas. Another effect is that paving increases the flushing of pollutants into water channels rather than pollutants slowly dispersing through the natural drainage system (OECD 1996). Transport accidents causing large spills of oil or chemicals may destroy living conditions for certain species and ecosystems over unknown periods of time.

Typically, most studies consider the impacts of pollution caused by transport on ecosystem and human health; the effects of various substances being released in the atmosphere vary widely depending on their nature, the duration of the emissions, timing and geographic scale. Air pollution is usually given the most attention. Other forms of pollution are caused by releasing chemicals, either in manufacturing, use or spills from transport as well as emissions of noise[5], waste and light. Pollution contributes significantly to the health of humans by causing different types of diseases and to the health of ecosystems by reducing biodiversity and causing acidification, eutrophication as well as climate change.[6] These other forms of pollution are given less attention.

In addition to the wide ranging environmental impacts of transport, there is also the issue of the rate at which natural resources are consumed. The current rates at which natural resources are being consumed is not sustainable. If current rates of consumption continue, future generations will be left with far smaller stocks of natural resources than we have now[7]. Therefore, at least from the point of view of strong sustainability, the question of intergenerational equity should be linked to the need for minimizing natural resource use.

Social impacts of transport

In the last section the impacts of transport have been mentioned mainly in negative terms. The main reason for the transport system to exist is to provide services and basic functions to the individuals and society. From this point of view, there are a number of positive impacts as well.

Transport contributes to the development of society by enabling access, and thus cultural exchange, information flows, business opportunities, scientific development and innovations, labour mobility and so on.
In today's society the citizens are dependent on access; to jobs, friends, services hobbies and holidays. Optimally these services should be attainable and equal to all. Unfortunately this is often not the case, marginal groups and disadvantaged people may not have services available to them, the prices may be too high for people from low-income groups, and certain areas are better serviced than others. This may lead to exclusion from the activities of society and rather than supporting the well-being of individuals it hinders it[8].

Transport infrastructure building has also social impacts, it disrupts existing patterns or structures, physically and mentally. Fragmentation and building of transport routes break urban structures and landscapes. Disrupting old transport patterns in favour of "car society", increases the risk of accidents

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[4] For example, in the US, the area dedicated to roads and car parking covers approximately 16 million hectares compared to the 21 million hectares planted in wheat (UNEP 2001).
[5] According to OECD, transportation has been identified as the main cause of environmental noise. In OECD countries, 16 per cent of the population is exposed to noise levels from transportation capable of severely disturbing sleep and communication, and thereby contributing to disease; an additional 50 per cent is exposed to "unsatisfactory" noise levels from transportation (OECD 1996).
[6] For an account of the effects of (mainly air) emissions from transport see UNEP 2001 and OECD 1996.
[7] For example, see discussion on the ecological footprint by Wackernagel & Rees 1996, or http://www.ecouncil.ac.cr/rio/focus/report/english/footprint/.
[8] Although transport is not the main cause for social exclusion, it may have some effect on it. It has been argued that there are seven types of sources of exclusion caused by transport: physical barriers, geographical inaccessibility, exclusion from facilities, economic barriers, time-based barriers, fear-based exclusion and security & space management (Church et al 1999).

and affects human health: functional walking and cycling is replaced by motorized forms of transport in people's daily routines and the general level of fitness declines[9].

Transport influences the quality of life of most people: vehicles, transport routes and infrastructure have become part of our daily environment. This is not only positive, most means of transport are not safe, walking and bicycling in the street is full of dangers, car-free environments are getting scarce, visual pollution increases and the livability of urban areas is threatened. Many areas reserved for transport services are places, where people feel fear (huge parking houses, docksides, tube stations, etc.). Also the social structures of communities are fragmented, when inhabitants are no more tied to their locations of living, but commuting from one area to another for the day and night. This loosens the social cohesion and sense of community amongst the members of society[10].

An important requirement for the transport system is that it ought to deliver its services equally to different regions, interest groups and also, across generations. Similarly, the negative impacts should be distributed fairly amongst all the users, which at the moment does not happen. Certain groups of people, certain areas, carry more of the consequences than others. From the social point of view it is important that these services are delivered at affordable price.

A contradictory issue in terms of human well-being is the question of independence and possibility to choose; how they should be considered in terms of transport and mobility. Quality of life is easily decreased if the choices of individuals are limited, but which choices we should we be able to make? Choices of some individuals may jeopardize the choices of others: increase in use of motorized transport leads to urban structures, which in turn increase transport-dependency, thus making "pedestrian life" impossible by locating services far from living areas.

Economic impacts of transport

Transport is a necessity for the society, and especially, the economy as part of society, to function. It delivers services without which the modern society would not manage to prosper. Transport provides access to material and information flows, business opportunities, scientific development and innovations, labour mobility and so on. This in turn creates economic growth and wealth. Over the past 50 years transport sector has been the growing in industrialised countries (UNEP 2001). However, this growth cannot continue indefinitely. There are some signs that continued growth may well lead to economic inefficiency rather than adding value[11]. Thus one of the important policy objectives of the Commission is the decoupling of economic growth and transport growth (European Community 2001).

Another important issue to consider is the issue of transport cost. Inefficiencies in the system increase costs, for example the time lost because of traffic jams lowers productivity. By managing the costs of using the transport system, transport has the potential to influence the distribution of income among different socio-economic groups, as well as influence the demand for other commodities and services. A large part of the costs of transport are borne by governments in terms of investments in infrastructure, its maintenance and renewal. Finally, transport generates revenues for governments through various taxes and charges.

The transport sector itself is also a major employer, which brings up some controversial issues. The need to minimise the impacts of transport on natural resources and human and ecosystem health could mean the overall reduction in transport volumes, which in turn can mean unemployment and cuts in the sector. Also the rights and working conditions of the employees contribute to the welfare of society (EXTRA 2001d).

[9] For an overview of the various health effects of transport see Morton 2003.

[10] See Adams 2001 and Morton 2003 for a discussion on the effects of transport and increasing mobility to the social environment and interactions in neighbourhoods.

[11] According to the White paper - European transport policy for 2010 congestion may risk the economic competitiveness of Europe. If nothing is done, the costs attributable to congestion will increase by 142 % by 2010. (European Commission 2001.)

Changing the trends in transport

Transport has both large positive and negative impacts. Thus, policymakers are faced with the dilemma of how to reduce the negative effects and increase the positive effects. There are four factors that are contributing to the current state of affairs.[12] There are described below.

First, neither the positive and negative externalities, nor the social impacts of transport are included in the monetary calculations of transport costs. Decision-makers lack information on the effects of their transport decisions. Similarly, users do not face the total costs of their transport choices.

Second, transport and mobility are an integral part of the society. It is difficult to change the trends in the transport sector towards more sustainability, if activities in other sectors of the economy do not change at the same time. For example, the imperfections of the market system are common in all sectors, not only in transport, thus common cross-sectoral efforts are needed to tackle many of the problems.

Third, existing structures are often resistant to change. New transport innovations only diffuse slowly into a market and the capacity of the political system to reflect the increasing needs of political measures is limited. Continuing the example of market imperfections, including all the externalities of transport to costs in that sector at once would result in a chaos: the economics of transport would be changed radically and indirect effects of the changes to society would be immediate. The question remains as to what is the proper speed for changes.

Finally, due to the fact that there are so many positive and negative impacts of transport, there are also a number of conflicting interests: the interests of environment are in conflict with those of the economy and interests of individuals are opposing the interests of society and so on. These varying interests disperse the willingness and capacity of the society to tackle the problems; changing the distribution of negative impacts amongst actors is more difficult than dealing with the status quo.

2.1.1.3. Integrated approach

Litman and Burwell (1999) from the Victoria Transport Policy Institute argue that there are two main perspectives to solving the problems of unsustainable transport. The question is either of a small number of individual problems, which can be addressed by proper transportation planning; e.g. travel volumes may grow if the vehicles are designed better. Or the question is of a larger number of integrated problems, which cannot be solved through sectoral measures; e.g. reduction of total travel is necessary. From these perspectives Litman and Burwell derive five different types of approach as to how sustainable transport can be achieved:

- **Technical** vision relies on improvements on specific technical problems, for example alternative fuel and increasing highway capacity.
- **Demand Management** vision emphasises changes in travel behaviour, including shifts in travel time, mode, etc. Policy measures aim to increase transport choice and support economically efficient travel patterns.
- **Economic Reform** vision aims in optimising the transportation market through pricing, investments and taxing.
- **Alternative Modes** envision a future with notable improvements to public transit, non-motorized transport and telecommuting.
- **Land Use/Community Design Changes** relies on changing land-use patterns and thus reducing travel distances and increasing modal choice.

Although listed as separate “visions” Litman and Burwell acknowledge the fact that in practice most of these approaches are and should be combined in transport planning and management. Similar thoughts can be found in the thinking of the EXTRA project, which claims that the solution for sustainable transport lies in an integrated approach, combining different types of instruments affecting transport. This integrated perspective emphasizes the need for simultaneous impact analysis of different policy measures and dealing with possible conflicts between them. Solutions

[12] For a more thorough account of the barriers to attainment of environmentally sustainable transport can be found in OECD report Policy Instruments for Achieving Environmentally Sustainable Transport (2002).

are often looked for from policy packaging. According to EXTRA the following aspects should be combined (for additional details see Deliverable D2):

- A change in people's transport behaviour and the way they live (affecting travel demand, land-use patterns etc.);
- Technological improvements to raise efficiency while reducing environmental impacts and improving safety;
- A pricing regime which incorporates the true costs of transport into decision-making, thereby influencing the overall consumption of transport services and promoting the least damaging mode of transport;
- A focus on accessibility, intermodality and mobility management, to meet transport needs with the most efficient traffic volumes and patterns, while respecting quality and other social goals such as safety and security. (EXTRA 2001a.)

Remaining challenges

In this section nine European-wide research projects on sustainable transport and mobility were selected and reviewed. The specific projects were selected because of how they operationalised sustainable mobility and transport and/or because of their methods allowing integration of various policy measures and objectives (integrated perspective). The integrated perspective has been introduced by the EXTRA project, which claims that the solution for sustainable transport lies in an integrated approach, combining instruments affecting transport behaviour and way of life, technological improvements, pricing regime as well as accessibility, intermodality and mobility. This integrated perspective emphasizes the need for simultaneous impact analysis of different policy measures and dealing with possible conflicts between them. (EXTRA 2001a.)

Most of the nine analysed projects focused on one or two dimensions of sustainable mobility and transport (economic, environmental and/or social sustainability). However, all three dimensions of sustainable mobility and transport were covered by two projects: SAMI and PROSPECTS. The SAMI-project included these three aspects because of its inclusive research approach, and because the sustainable mobility approach used was built on the definition of Common Transport Policy. PROSPECTS-project, instead compiled its own project definition for sustainable planning of European city transport systems as its aim was to provide a comprehensive guidance for decision-makers and practitioners. Subsequently, the three dimensions of sustainable transport and mobility are discussed based on the projects reviewed.

2.1.1.3.1.1 Environmental sustainability

Most of the projects focused on the health of the ecosystem, especially pollution and land take and impacts on human health such as harmful pollution levels. Measuring impacts and pressures of the transport system on health of the ecosystem has a long tradition in transport research and policy. Targets and their indicators can often be defined based on scientific evidence and internationally agreed standards, goals, and guidelines. Therefore, the reason that some of the projects did not analyse health of the ecosystem may have been not because it is difficult, but because of the focus that was chosen for the project. Remaining problems in measuring environmental impacts are often related to linking the cause and effect, in other words what are the specific impacts on the ecosystem of the transport system compared to other factors in society.

Information concerning use of natural resources is also often raised in general discussion, but measuring has been limited to land use indicators, or indicators measuring the indirect impacts of use of natural recourses, such as CO_2-emissions referring to use of fossil fuels. In a wider perspective, the use of natural resources in the transport system would require taking the whole life cycle of different parts of the system (e.g. of cars or a road network) into consideration. Life-cycle analysis (LCA) of the whole transport system would become, therefore, extremely complicated. Furthermore, for the time being LCA is a fairly new approach in transport research and much less data is available compared to measuring the outputs of transport system to environment, e.g. pollution.

2.1.1.3.1.2 Social sustainability

Social sustainability was often discussed in terms of access to transport services by zone and regional equity. In the projects, individual wellbeing is often limited to measuring the price of transport services or access. Quality of life aspects such as pedestrian friendly streets and other car free environments, rights of transport sector employees or social networks receive limited, if any attention at all. Issues related to individual issues are often approached in a larger context.

2.1.1.3.1.3 Economic sustainability

Economic sustainability is dealt with in many projects. The importance of transport systems for economic activity is generally recognized and the decoupling of economic and transport growth is recognized as an important policy target to curb harmful impacts of transport. Particular attention is given to the performance and efficiency of the transport systems. In economic terms, use of resources and intergenerational equity were discussed in a few projects in light of discounting potential future incomes or costs.

2.1.1.4. Summary on Sustainable Transport

Sustainability and sustainable development are relatively new concepts. And thus the tools for dealing with them are not quite fully developed as yet. Sustainable development is now generally viewed as having three dimensions, economic, environmental, and social. The analysis of the interaction between the economic and environmental dimensions of sustainability, while far from complete, is quite far advanced. The available tools and approaches for analysing the interaction of the economy and environment come largely from classical economics and focus on welfare optimisation. However, in order to apply these tools and approaches to analysing issues of sustainability and sustainable development, many assumptions have to be made, assumptions that are, more often than not, debatable. Compared to the tools and approaches for analysing economy-environment interactions, the analysis of the interactions of the social dimension with the other two dimensions is just beginning. The primary difficulty to be overcome before progress can be made in analysing the interactions and effects of the social dimension is in defining and measuring social capital.

2.2. POLICY ASSESSMENT FRAMEWORK

2.2.1. An Overview of the Systems Approach

For policymakers to determine whether or not their current policies or changes in policy would lead toward sustainability, they would need to know what aspects of world need to be sustained, and how to measure these aspects. Then, if some of these aspects are determined to be not sustainable, the policymakers need to decide what policy measures to apply to influence these aspects in a positive direction. Operationalising this process requires a theoretical framework and a structured approach. The approach that we are using in SUMMA, which we call the **systems approach** (see Findeisen and Quade, 1985), is particularly useful for analysing problems involving complex systems about which there is insufficient knowledge and which are characterised by uncertainty. The approach is well suited to helping us understand how the transport system might respond to policy changes and changes in external factors, and how it can be changed to make it more sustainable. In particular, the systems approach is an ideal starting point for understanding the interrelationships among the elements of the system and how policies might be designed to steer the system toward sustainability.

As shown in Figure 2.2, the systems approach is built around an integral system description of a policy field. At the heart of the system description is a ‘diagram’ of the transport system. The transport system diagram clarifies the system by (1) defining its boundaries, and (2) defining its structure – the elements, and the links, flows, and relationships among them. Two sets of external forces act on the transport system: external forces outside the control of the actors in the policy domain, and policy changes. Both sets of forces are developments outside the transport system that can affect what happens inside the system (and, hence, the outcomes of interest to the policymakers and other stakeholders).

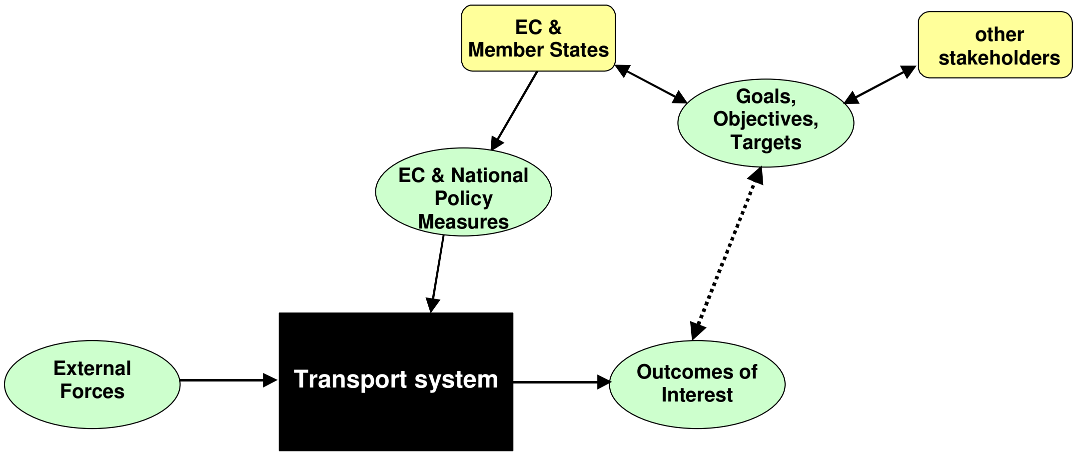


***Figure 2.2* – The policy assessment framework**

Applying the systems approach, we need to do two things:

1. Specify the components of the policy assessment framework, including the goals and objectives, the outcomes of interest, the external forces, and the system diagram (identifying the boundaries of the transport system, the elements of the transport system, and the relationships among the elements);
2. Determine the tools for assessment of the performance of the system, including performance indicators and their monetisation.

The value of the assessment (point 2 above) depends to a large extent on the validity of the specification of the transport system (point 1 above). If the specification of the transport system is inadequate, no matter how good the indicators are, the result will be less valuable. Therefore a good system diagram is paramount.

2.2.1.1. The Policy Assessment Framework

An important step in the systems approach is the design of a system diagram that reflects all factors relevant for understanding the impacts of changes in the external forces and policies on the outcomes of interest. An integral description of the transport system as used in this project has four main advantages:

1. It serves as a structuring tool to support a better understanding of the system and the processes within it.
2. It can stimulate the generation of new ideas and help locate policy intervention points
3. It can help to identify developments both inside and external to the system that are relevant for the outcomes of interest, so that they can be modelled and monitored
4. It can be used as a communication tool by making visible the gaps between diverging and conflicting views and help to overcome them.

As stated above, the specification of the system diagram includes an identification of the boundary of the system. The boundary of the system is determined in large part by the outcomes of interest, which are, in turn, determined by the goals and objectives of the policymakers and other stakeholders and by the scope of the policy measures under the control of the policymakers. If we were assessing policy measures for reducing congestion on European highways our system boundary would be different from the boundary we will define for assessing policy measures related to sustainable transport. For example, the system would not need to include non-road modes, nor would it need to include vehicle characteristics related to emissions.

Thus, in order to specify the system diagram, we need to specify three things: the outcomes from the system that are of interest, the system itself, and the inputs to the system (which change the system, and thereby lead to changes in the outcomes). These are briefly described below.

Outcomes of interest are system outcomes related to the actors' goals and objectives that policymakers are interested in either reducing (adverse effects) or increasing (positive effects). A goal is a generalised, non-quantitative policy objective (e.g., "reduce air pollution" or "ensure traffic safety"). Policy actions are intended to help meet the goals. In SUMMA, the policymakers' overarching goal is to facilitate sustainable transport and mobility. In order to identify outcomes of interest, however, this high-level goal had to be operationalised by relating it to more concrete goals. In Deliverable 2 [2003], we identified three pillars of sustainable development – economic, environmental, and social. Each of these pillars has its own subgoals. For example, economic subgoals include improving economic development and efficiency; environmental goals include improving biodiversity and reducing air pollution; social goals include reducing poverty and improving intergenerational equity. The identification of the outcomes of interest related to the goal of sustainable transport and mobility was based on expert discussion and reflections on the European Council definition of sustainable transport.

Defining the **transport system** includes describing the physical elements of the system, the actors, their behaviour (i.e., the choices they make), and their mutual relationships. For example, the physical elements of the system include the locations of residences, offices, distribution centres, retail stores, the transport vehicles, and the transportation infrastructure. The actors include governments, people, and transport companies. The behaviour of the actors consists of describing how the actors make choices within the system, while their mutual relationships provide information on the interactions among the actors. Businesses, governments, households, and individuals make choices that are relevant for and have impacts on the demand and supply of transport. Within the system, we will be identifying the choices that the various actors make.

Although passenger transport and freight transport overlap in some aspects (e.g., they use much of the same infrastructure), the actors, their behaviour, and their relationships are quite different. We, therefore, developed different system diagrams for the passenger and freight transport systems.

A **Force Driving System Change (FDSC)** acts on the system to change it. The policymakers do not determine the goals, objectives, and targets of the transport system in a vacuum. The FDSC can be a technological, political, regulatory, economic, or societal development. An example of an FDSC might be changing consumer behaviour reflected, for example, in a 50% increase in e-shopping and a decline in the number of grocery stores. It can also be a policy outside the transport policy domain (e.g., tax policy). The impact of an FDSC can be to change the physical elements of the system (e.g., new infrastructure), the behaviour of the actors within the system (e.g., more use of public transport), and/or their mutual relationships. For example, increasing affluence could change the tastes of individuals in terms of wanting more space, resulting in changes to the spatial structure of cities. Important FDSCs (the ones we will be defining) are those that are likely to have the largest and most significant impacts on the outcomes of interest. In Figure 2.3, EU and national policy measures are shown separately from other external forces (which are not under the control of EU and national policymakers). This is due to the focus of the SUMMA project, which intends to help EU and national policymakers to design appropriate policy measures. At further stages of SUMMA these policies will be analysed in more detail.

2.2.1.2. Tools for assessment

In order to be useful for policy analysis and monitoring purposes, the descriptions of the outcomes of interest, the FDSCs, and relevant elements of the system need to be related to measurable indicators. We therefore define the following types of indicators:

- **Outcome indicator** — An outcome indicator can be used to describe or monitor changes in an outcome of interest. Each outcome of interest is associated with a set of outcome indicators.
- **System indicator** — System indicators are sometimes outcomes of interest in themselves; but they are usually intermediate variables that are used to estimate the values of the outcome indicators. A system indicator can also be used to monitor changes and developments in the system.
- **FDSC indicators** — An FDSC indicator can be used to describe or monitor changes in the Forces Driving System Change.

There are some fundamental differences among the three types of indicators. The system and FDSC indicators are mainly needed to understand and analyse the functioning of the system, but have little importance in policy assessment. They may, however, provide important information about the steps between the implementation of a policy measure and the resulting changes in the outputs of the system. For example, there may be an assumption that CO2 emissions will decrease if there is an increase in vehicle taxes. Understanding the resulting changes in the system will help to explain why this might or might not happen. We are not interested in defining indicators for all external forces or all system data. We are interested in defining indicators for those forces and system characteristics that, if they were to change significantly, would lead to significant changes in one or more of the outcomes of interest.

The outcome indicators are of primary interest for transport policy assessment. The outcomes of interest are the observable output of the system. The outcome indicators give information about how sustainable the state of the present transport system is and whether it is moving towards a more sustainable state or not. An outcome indicator is a proxy for an outcome of interest. The outcome indicators are 'proxies' for two reasons: (1) the outcome indicator is usually not the same as the outcome of interest but is related to it, and (2) there are other factors (external to the system) that also contribute to the outcome of interest. This is illustrated in Figure 2.3. For instance, CO2 emissions are produced by transport, but also by industry.

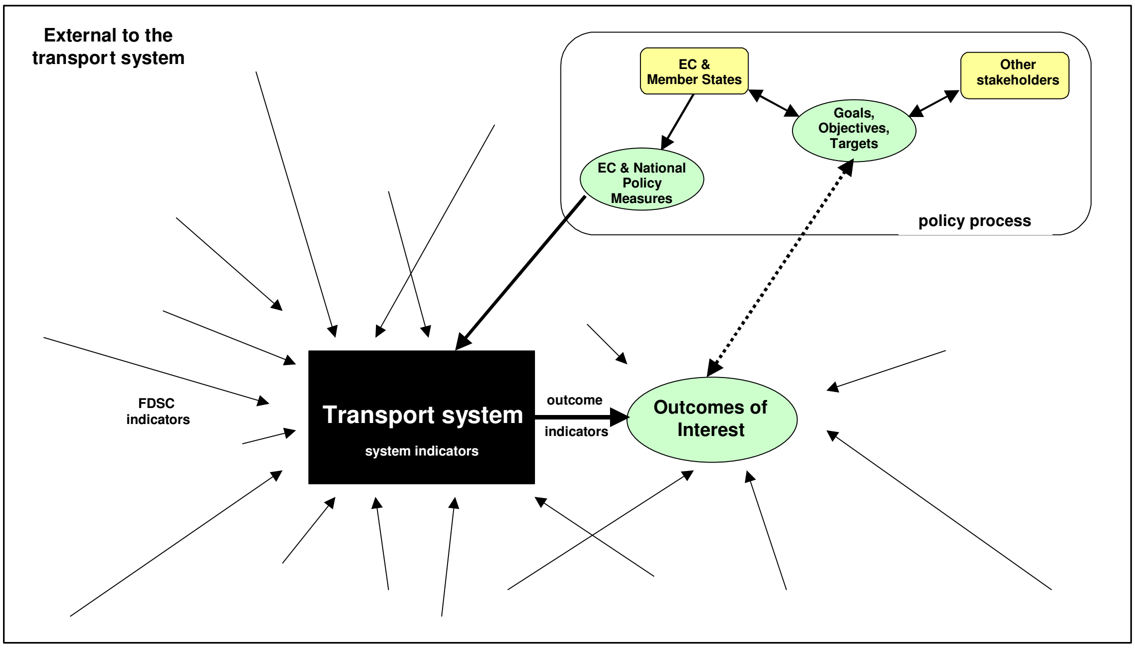


***Figure 2.3* – Relationship between the outcome indicators and the outcomes of interest**

Once indicators are selected and their values known, there is a need to make comparisons among the different outcomes of the transport system. This requires the quantification of the impacts in comparable units. In SUMMA, monetary valuation will form the basis for comparing the magnitudes of the very different types of effects. Monetisation is based on the framework of welfare economics, and has many advantages over other ways of weighting. For example, it facilitates the aggregation of diverse impacts. Since the environmental, social and economic impacts of transport are complex, their interchangeability in some cases is questionable, and research in many fields is not yet developed very far, the quantification of some impacts will necessarily be restricted to non-monetary terms.

2.2.2. Defining the Transport System

As explained in earlier, an important step in the systems approach is the design of a system diagram that reflects all factors relevant for understanding the impacts of changes in the external forces and policies on the outcomes of interest. In this chapter, the transport system used in SUMMA will be described in detail, both for passenger and freight transport, the boundaries of the system, the external forces, and their relationships to the outcomes of interest and policies will be explained, the dynamics of the system over time will be described, and descriptions will be given of the variables and indicators related to the system itself and to the outcomes from the system.

2.2.2.1. A three-market representation of the transport system

In the past, policymaking in the area of transport focused strongly on accommodating the demand for transport by adopting and expanding the transport infrastructure. Policymakers were mainly orientated towards providing accessibility to destinations like shops, businesses, residences, recreation areas, etc., while on the other hand trying to deal with the negative effects of transport. The answer to increased demand was an increase in supply, which only stimulated a further increase in demand and did not provide an adequate solution to the problem. Realizing that this orientation was not sufficient to avoid future problems, the policy focus was broadened to include mode choice, in order to take into account for example impacts on safety and the environment. Transport modes such as public transportation for passenger transport and rail, waterways, and pipelines for freight transport, were promoted. The main objective of this broadening of focus was to limit road transport, which was considered to be the mode contributing the biggest share of negative impacts, and to decrease congestion on the roads. But this expanded focus is still insufficient for coming up with policies that can lead to long-term sustainability. Therefore, policymakers have begun to expand the focus further to include ways to affect the demand for transport by influencing the numbers of trips and their origins and the destinations. This expanded focus needs to be captured in the transport system diagram.

The description of the transport system used in SUMMA is based on a representation that assumes that the process of generating traffic streams can be divided into three steps.[13] The three markets on which choices are made that influence the final determination of traffic streams are: the *movement market*, the *transport market* and the *traffic market* (see Figure 2.4). A market represents an action space where demand meets supply and choices are made. Therefore it consists of three elements: demand, supply and output. The result of the dynamic interaction of the three elements is: a realized supply, a realized demand and an allocation of the realized demand to the realized supply. The three elements of each of the three markets is described below.

The movement market

In the movement market the demand side consists of the activities to be performed. This means the individual decisions taken after making trade-offs among different activity needs. The time and the location for these activities are at this stage unknown. For example the demand side includes the individual deciding to go shopping without having fixed a time or a location where this shall happen. The supply side represents the spatial and temporal structure of society as well as the perception of these elements. It contains the distribution of the locations where these activities could be performed, defining for example operating hours and location of shops. The output of this market is the set of movement patterns covering the location and time dimension (origin/destination matrix by time).

The transport market

In the transport market, the demand side is the output from the movement market — the movement patterns. These patterns define the need for vehicles to transport passengers and freight, and are specified by an origin-destination matrix by time. On the supply side, the available vehicles and services to accommodate these movement demands and the perception of these vehicles and services are given. The elements to be found here comprise travel time, convenience, price etc. The main decision in this market is the choice of mode. The output of the market is the set of transport patterns (origin/destination matrix by time and mode).

The traffic market

In the traffic market, the demand side contains the aggregated output of the transport market: the transport patterns. These patterns (origin/destination matrix by time and mode) define the need for infrastructure to accommodate the vehicles and services. The supply side consists of the available infrastructure, their attributes and how the infrastructure is perceived. The output of this market is the allocation of the transport vehicles and services to the infrastructure: the set of realised traffic patterns or the traffic streams. These traffic streams lead to the ultimate outcomes of interest from the transport system, such as congestion, emissions, etc.

[13] The following general description of a three market model is based on *Van de Riet*. A System's View on the Transportation System from a Dutch Policy Perspective (1998).

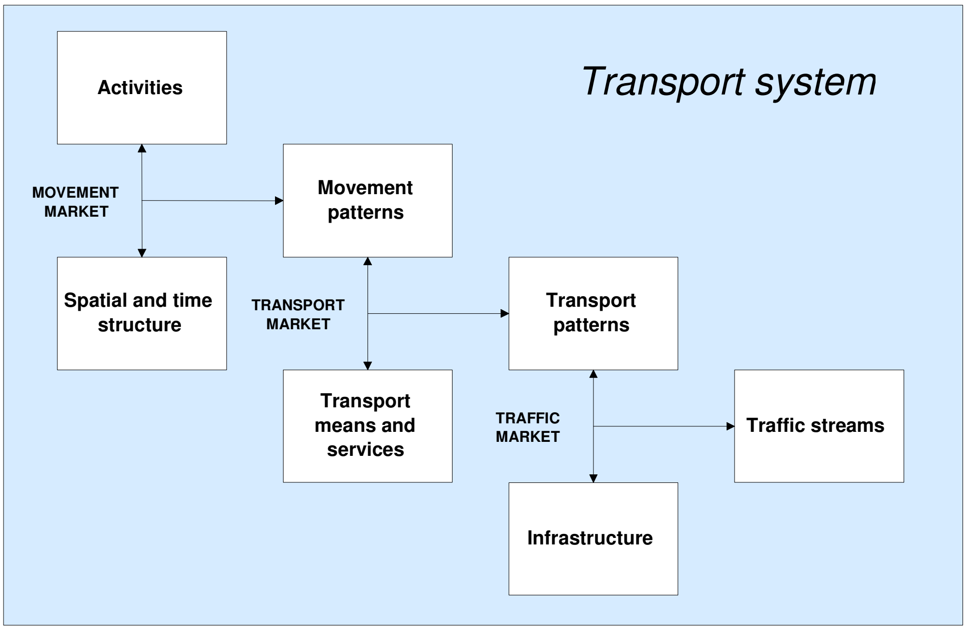


***Figure 2.4* – Three-market representation of the transport system**

The three-market representation of the transport system described above and illustrated in Figure 2.4 provides a useful framework for understanding this new approach in policymaking, which focuses on anticipating problems rather than on reacting to them. Initially, by reacting to the increased demand for transport by increasing the infrastructure supply, the policymakers were focusing only on the third market, the traffic market. The next step was expanding their interest to the second market, where the mode choice is made. The last step integrates another market, the movement market, where demand for transportation from a certain origin to a certain destination is generated.

The transport system as we described it above consists of seven elementsthat are directly related to the elements of each market (supply, demand and output). The elements are described in Table 2.1.

Table 2.1 — Elements of the transport system

System element	Description
Activities to be performed	Number of activities per type and duration
Spatial and time structure	Places, in terms of location and time, where activities can be performed
Movement patterns	Number of movements per type, location and time unit (person and ton kilometres assigned to origins and destinations)
Transport means and services	Available supply of transport means and services in terms of type, location and time
Transport patterns	Use of transport means in terms of type, location and time (person and ton kilometres assigned to transport means and services)
Infrastructure and its attributes	Available supply of infrastructure elements in terms of type, location and time
Traffic patterns	Use of infrastructure in terms of type, location and time (person and ton kilometres assigned to infrastructure)

Different actors interact within each of the markets. These actors make trade-offs and choices that produce the output of the market. In addition to the different sets of actors within each market, some actors are external to the market but influence it, such as the government and interest groups. Of course there are also relationships among the actors within the different markets, and some actors might act in more than one market.

Table 2.2 shows the sets of major actors by market. “P” indicates the actors in the passenger transport system; “F” indicates the actors in the freight transport system.

Table 2.2 — Actors in the transport system

Market	Actors on the demand side	Actors on the supply side
Movement	Potential travellers (P) Shippers (F)	Suppliers of activity facilities (schools, shops, etc.) (P+F)
Transport	Travellers (P) Shippers (F)	Suppliers of transport means and services, and transport facilities (transporters, providers of logistical services, etc.)
Traffic	Operators of manned or unmanned transport means (P+F)	Infrastructure providers (managers of rail, road and other modes of transport) (P+F)
All three	Governments (P+F) Interest groups (P+F)	Governments (P+F) Interest groups (P+F)

The choices that are made in the course of generating traffic streams, and which determine the outcomes of interest from the system, are therefore:

- Activity choice
- Settlement choice
- Destination choice
- Time-of-day choice
- Mode choice
- Route choice

One aspect that also has to be taken into consideration in understanding these markets is that the choices have different time horizons. Let us look for example at two different choices in the transport market: the decision to acquire a train ticket has a short time horizon while the purchase of a car has a relatively long time horizon.

The markets are not independent. There are feed-forwards and feedbacks among the markets. People making a choice in one market will, for example, anticipate what might happen in a later market. On the other hand, an improvement in the infrastructure connecting a residential area with a shopping mall might, for example, lead to a higher demand by people who want to go to the mall. (For a description of the many feed-forwards and feedbacks among the markets, see the next section)

In the following subsections we define the transport system in detail, explaining which elements are to be found within the system boundaries and which elements are exogenous. We identify the factors that drive each of the markets. Since the general structure of describing the transport system as it was explained above is applied to the two different transport sectors —passenger transport and freight transport, which differ in some of their basic characteristics and processes— separate descriptions of the two transport systems and the interactions within the three markets are presented for passenger and freight transport.

2.2.2.2. Dynamics of the transport system

Over time, systems undergo changes as a result of outside forces (FDSCs). As described in this chapter so far, the changed framework may change the outcomes of the system as well as the complete structure of the system. New actors may appear and lead to a segmentation of the markets or new inventions may unlink dependencies within certain processes. It is therefore important to realize that the system described in this chapter reflects the current transport system and the existing interactions. As the world changes it might be necessary to adapt the system description or even to come up with a totally new one that corresponds better to the new transport system.

Among the forces that might lead to changes in the transport systems are its interactions with the economic system and the social system. The transport system, over time, has an influence on the economy, which in turn has an influence on the transport system (the available options, the choices made, etc). Likewise, the developments in the transport system have an influence on the social system (people's behaviour changes, new social networks arise, others disappear, etc.), and vice versa, the changes in the social system will influence the transport system (the activities of the participants, their choices made, etc.). Many of the interactions between the economic and social system and the transport system will be long-term interactions, which are hard to identify, let alone to define or model. It is however very important to recognize the fact that these interactions exist. Within the limited context of SUMMA, these interactions cannot be captured. But more research in this area is clearly required.

In addition to interactions between the system and the external forces, there are also interdependencies within the system. In this case, changes in one market have an impact on another market. The effect can be a feed-forward effect (e.g., if the expectations regarding something happening in a later market influence the decision made in an earlier stage) or a feedback effect (in which a realised output of a market influences an earlier market).

Figure 2.5 indicates the various feedbacks within the transport system. Congestion has a long-term feedback on the infrastructure since, due to congestion on the network, the infrastructure might be expanded to reduce the delays. Congestion also has a short-term feedback to mode choice, since it is the basis of the service characteristics on a certain day. The infrastructure has a long-term feedback to mode choice, since by increasing the infrastructure for a certain mode the network characteristics, which have an impact on the service characteristics, are changing. There is a long-term feedback from transport means and services to the activities and spatial structure of society, since the service characteristics are going to have influence on the choice of activities. There is also a short-term feedback coming from transport means and services on the time of day when an individual decides to perform an activity (e.g. going to sports in the off-peak period). A look at the feedbacks presented in Figure 2.5 shows how complex the transport system is and why an integral comprehensive description like the one we have provided through the systems approach is a helpful tool for assessing policy measures and their impacts on the outcomes of interest.

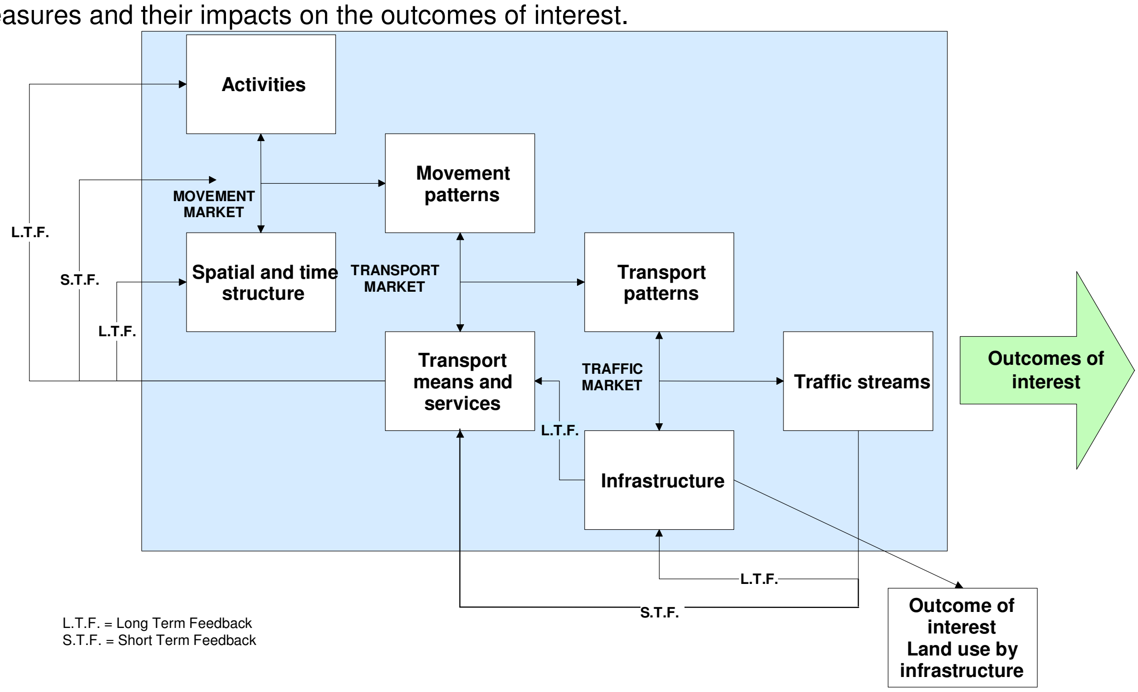


***Figure 2.5* – Feedbacks within the transport system**

2.2.2.3. Boundaries and forces driving system change

So far we have described the transport system without defining the system boundary. The boundary of the transport system divides what is considered to be inside the system from what is considered to be outside. What is inside the system can be described as a 'snapshot' of the system at a given point in time. In other words, the transport system is defined by the activities that people perform, the places at which they perform them, the places at which they live, the times at which they perform their activities, the modes of transport, the vehicles used (including vehicle technologies), the transport infrastructure, the choices concerning departure time, mode of transport, etc. Everything that is not encompassed by the above description will not be considered to be part of the transport system.

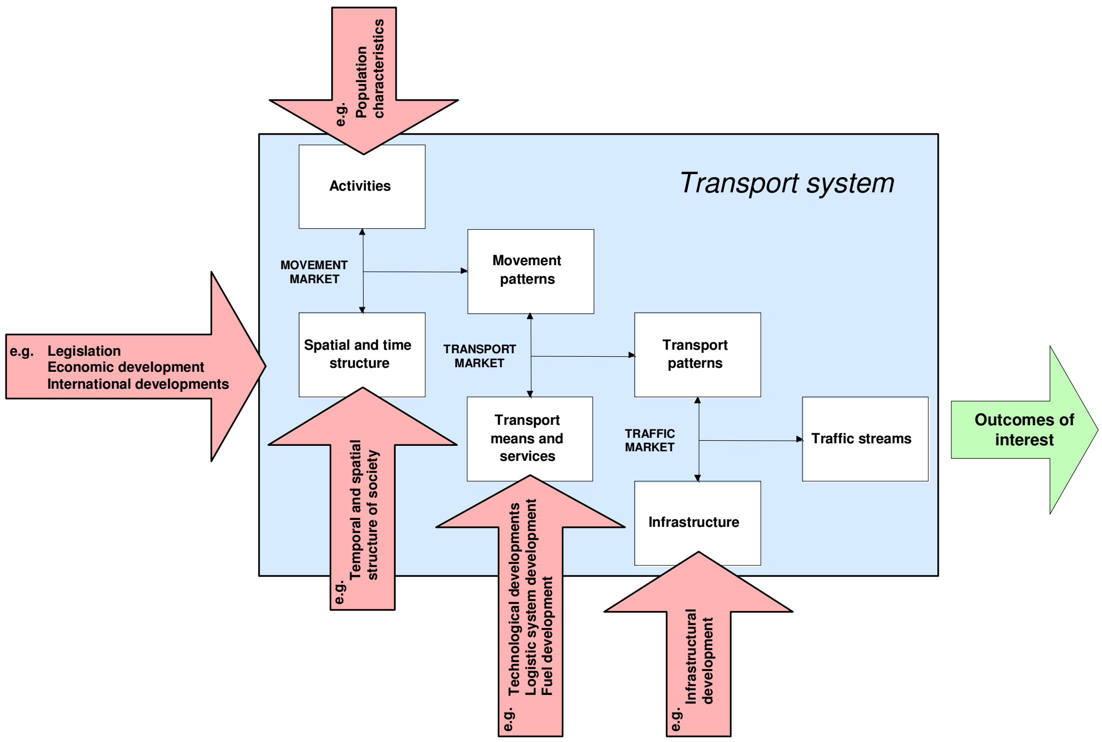


***Figure 2.6* – Forces Driving System Change**

Forces driving system change (FDSCs) are factors outside the transport system that act on the system to change it. They can be of different natures, including technological, political, regulatory, market, and societal developments. Within the forces driving system change, two groups can be identified: (1) FDSCs outside the control of the policymakers (external forces), and (2) FDSCs that can be influenced by the policymakers (through the implementation of policies). In Figure 2.2 these two groups were called: (1) external forces and (2) policy measures. Both groups of forces act on the transport system and, over time, change it. These changes in the system produce changes in the outcomes of interest.

Important FDSCs are those for which changes will lead to significant changes in the outcomes of interest. These are FDSCs that should be monitored. Another reason for identifying important FDSCs is to identify leverage points for policy measures in cases in which the FDSCs belong to the group that policymakers can influence by their decisions. Some of the FDSCs will be inside the policy domain (e.g. research and development, as discussed in the above example). Contributions to an outcome of interest coming from outside the policy domain will not be taken into account.

Figure 2.6 shows how FDSCs act on the transport and mobility system. They generally act on one of the markets and influence one or more outcomes of interest. To understand the factors influencing the outcomes of interest, one has to understand the linkages and interactions among all the involved elements, including the FDSCs. Figure 2.6 gives only a few examples of FDSCs. A more complete listing of FDSCs is given in Table 2.3. This table relates an FDSC to the box within the transport system that it influences. The same list of FDSCs, extended to include FDSC indicators and other details, can be found in Annex 1. The list of FDSCs will be improved upon and updated in the future work of SUMMA.

Table 2.3 — Forces Driving System Change (FDSC) and the location of their influence on the transport system

Force Driving System Change	Influenced box in the transport system
Demographic development	Activities
Income development	
Labour force development	
Labour force participating	
Job market development	
Changes in economic structure	
Changes in the cultural characteristics of society	
Land market development	Spatial and time structure
Time routine development	
Changes in logistics systems	
Changes in location of activities	
Fuel and energy development	Transport means and services
Development of vehicle technologies	
Infrastructure development	Infrastructure
Consumer demand development	General - several boxes
Legislation	
International developments	
Climate changes	
Changes in GDP	
Innovations in vehicle and fuel technologies	
Political changes	

As we can see, these drivers come from outside the transport system, since the labour market, technical innovations, the changing concepts of business management, and the legal and political background are not themselves elements of the transport system. But they have strong impacts on the functioning of the system, which lead to strong impacts on the outcomes of interest.

2.2.3. Defining the outcomes of interest

The outcomes of interest of the transport system are a formulation of the general goals of sustainable transport in more concrete terms. They describe the issues that we are interested to know when observing the impacts of the transport system on society. To define the outcomes of interest we need to identify the necessary components, which all together influence the sustainability performance of the transport system and which have to be monitored in order to assess its status.

There are many such components mentioned in the above definition, and they can be used as the starting point. Classified under the three aspects of sustainability, we can find the following goals for the transport system from the definition:

- *Economic interests:* Basic access, Development needs, Fairness, Efficiency, Competitive economy, Balanced regional development, Use of renewable and non-renewable resources.
- *Social interests:* Basic access, Development needs, Safety, Health, Equity, Affordability, Fairness, Choice of mode.
- *Environmental interests:* Ecosystem health, Emissions, Waste, Use of renewable and non-renewable resources, Impacts on land, Noise.

The list generated from the definition above has many abstract goals and concepts, which needed to be concretised. To ensure the completeness of the outcomes of interest (OoI) and their validity related to the recent research, the OoI were discussed in two expert workshops and revised based on literature reviews. The division between the three pillars of sustainability: environmental, economic and social was used as the basic classification and way to give structure to the outcomes of interest. The reason for using these three aspects was based on their common acceptance and wide usage, although we recognise some problems with the classification as well.[14] The final list of outcomes of interests is shown in Table 2.4.

Table 2.4 — Selected outcomes of interest

Economic outcomes of interest	Environmental outcomes of interest	Social outcomes of interest
Accessibility Transport operation cost Productivity / Efficiency Costs to economy Benefits to economy	Resource use Direct ecological intrusion Emissions to air Emissions to soil and water Noise Waste	Accessibility and affordability Safety and security Fitness and health Liveability and amenity Equity Social cohesion Working conditions in transport sector

The links between the different SUMMA outcomes of interest and the goals listed in the definition of sustainability can be compared in the Table 2.5. It is clear that some of the outcomes of interest represent several aspects or goals of sustainability. Therefore they are mentioned twice or more in the table. "Affordability" is explicitly an OoI, whereas the element "fairness", "efficiency", "offering a competitive economy" are monitored by several OoI: Costs and prices as indicator for fairness, accessibility in the sense of having a sufficient access to all important places for business, production and social needs, productivity / efficiency monitor whether the transport system works economically, equity says something about fairness and quality of public transport is addressed to the mode choice problem.

While many of the goals of sustainable transport system mentioned in the definition of the European Council are the nearly the same as the outcomes of interest, there are some cases where they differ from each other. The differences concern basically three goals or concepts: development needs, competitive economy and human and ecosystem health.

The definition starts with a goal for the transport system to "*allow development needs of individuals, companies and societies",* which requires some more concreteness in order to be used as an outcome of interest. Development for individuals means that they can live according to their capabilities. Therefore in SUMMA we need to monitor how the transport system enables this individual development. Concerning companies, the development needs are partly concretised in the definition's requirement of the transport system to *"support competitive economy",* in other words it has to provide conditions that firms are able to be competitive in the long run. Development needs for societies, in turn, are very much dependent on the welfare of the economy and it's individuals. These could be measured by an overall welfare index and its dependencies on the transport system. Thus the development needs are concretised in the following outcomes of interest: accessibility, costs and benefits to economy, productivity/efficiency, transport operation costs and social cohesion.

Concerning the "*manner consistent with human and ecosystem health"*, these terms were considered to be overall goals of sustainable development and there are several ways how the outcomes of the transport system contribute to that by minimising harmful impacts on nature, human environment and increasing safety. Thus impacts of the transport system on human and ecosystem health are captured in the following outcomes of interest: safety and security, fitness and health, liveability and amenity, direct ecological intrusion, emissions to air, soil and water and waste.

Table 2.5 — Links between SUMMA outcomes of interest and sustainability

Element from the definition of sustainability	Related Outcome of Interest (OoI)	Dimension
Basic access	• Accessibility	Economic, social
Development needs	• Accessibility • Cost / benefits to economy • Productivity / Efficiency	Economic, social

[14] For example, the three pillar approach emphasises the conflicts between the three aspects rather than brings up the synergies. Also, it may be argued that the economic sustainability is the means to achieve environmental and social sustainability rather than an end in itself.

	• Transport operation costs • Social cohesion	
Safety	• Safety and security • Working conditions in transport sector	Social
Human health	• Safety and security • Fitness and health • Liveability, amenity • Emissions to air, soil and water	Social, environmental
Ecosystem health	• Direct ecological intrusion • Emissions to air, soil and water • Waste	Environmental
Equity	• Equity	Social
Affordable	• Accessibility (incl. affordability)	Social
Fairness	• Accessibility (by mode) • Equity • Transport operation costs	Economic, social
Efficiency	• Productivity / efficiency • Transport operation costs	Economic
Transport modes	• Accessibility	Economic, social
Competitive economy	• Accessibility • Transport operation costs • Costs and benefits to the economy • Productivity / efficiency	Economic
Emissions	• Emissions to air, soil, water • Emissions of noise	Environmental
Waste	• Waste	Environmental
Renewable and non-renewable resource use	• Resource use	Economic, environmental
Impacts on land	• Resource use (incl. land take) • Direct ecological intrusion (incl. fragmentation)	Environmental
Noise	• Emission of noise	Environmental

A specific point is the goal of "*equity between successive generations*" mentioned in the definition. That is related to several issues. For example, resource use is conceptually very close to the core questions of intergenerational equity: Minimising the consumption of non-renewable resources of the present generation so that the world does not run out of them and the future generations can enjoy them too, is one of the key issues of intergenerational equity. Being one of the key concepts of sustainability, resource use is intertwined into all three aspects, social, environmental and economic sustainability. Socially it describes the inter-generational and intra-generational distribution of wealth, economically it reflects the limited availability of factors of production and environmentally it describes the sensitivity of nature and earth on human activity. Thus, equity is related to the question about the optimal path from today into the future, selecting a "policy mix" that will treat all generations equally. This is difficult to concretise into a specific outcome of interest, it is rather a question of taking into account all the positive and negative impacts and reaching a balance between them.

Similarly, the "*balanced regional development*" is not covered by a one or few outcomes of interest, but by disaggregating relevant impacts of the transport system to the different regional levels – urban, regional, national, EU-wide. How to "balance" the regional development is a problem of weighting the impacts of the transport system on different geographical levels and it will be the topic of the following work package of SUMMA.

2.2.4. System indicators and outcomes

In this section we discuss the indicators or proxies that provide information on what we need to know about what is going on inside the system and what comes out of it for the policy assessment.

A system indicator is a proxy for what takes place inside the system. System indicators are important for two reasons:

1. For monitoring purposes it is not enough to have outcome indicators alone. A change in the value of an outcome indicator provides no information about whether the change is due to a change in policy or due to some other reason (i.e. a system indicator can be important to understand what is going on in the system), and
2. For estimating the value of outcome indicators. An outcome indicator may be calculated from several system indicators.

A list of the system indicators, their description/definition, and their units are provided in Annex 2. As with the FDSC indicators, it is a list under development, which will be improved and updated in the future work of SUMMA.

In this paragraph we will give an example of a system indicator used for monitoring. Suppose there is a monitoring system observing two countries, A and B. Both countries are quite similar in terms of income level, infrastructure etc, but country A has twice as many cars as country B. Both countries have the same policy that discourages car ownership. The (unfounded) conclusion could be that the policy does not work in country A. Without additional information this cannot be concluded. One reason for the difference might be that the percentage of people having a driving license in country B is half of that in country A. The percentage of the population with a driving licence would then be a useful system indicator.

The outcomes from the system are basically what the system produces. In the case of the transport system, the outcomes are passenger (and freight) trips and kilometres, congestion, loss of time, etc. Passenger kilometres are not really of interest, but they are needed to calculate the emissions produced by the transport system. We therefore distinguish between two types of outcomes (and therefore outcome indicators). The first group are the real outcome indicators that are proxies for the outcomes of interest. This group will be the subject of the remainder of this report. The second group are the intermediate outcome indicators that are of little or no interest by themselves (to the policymaker). The second group is, however, needed to compute the first group of outcome indicators.

Below a list is given of some intermediate outcome indicators.

- Total distance travelled by mode
- Load factor by mode
- Speed distribution by mode
- Location of accidents
- Number of vehicles involved in an accident
- Intensity of traffic streams
- Trip length distribution by mode
- . . .

Table 2.6 provides some examples of system indicators. This table relates the indicator to the box within the transport system where it can be found. A more complete listing is contained in Annex 2.

Table 2.6 — System indicators and their location in the transport system

System indicator	Influenced box in the transport system
Percentage of people with work location outside household	Activities
Percentage of people currently in education	
Age distribution	
Percentage of population owning a car	
Disposable income distribution	
Regional distribution of industries	Spatial and time structure
Percentage of population living in urban areas	
Regular shop opening hours	
Mean distance to closest public transport stop	
Residential space per person	
Fuel/energy usage per 100 km	Transport means and services
Emission of air pollutants by transport mean	
Space per passenger on public transit	
Vehicle fleet mix by mode	
Age distribution of vehicle fleet	

Fixed and variable costs by mode per passenger	
Percentage of surface covered by infrastructure by mode	Infrastructure
Numbers of vehicles that can be operated per km per day	
Price of infrastructure use (tolls, parking fees, etc.)	
Emissions of air pollutants by industries related to transport	General - several boxes
Raw material use by industries related to transport	
Average storage capacity of gas stations	
Number of vehicles produced by mode per year	

2.3. TRANSLATION OF OUTCOMES OF INTEREST TO INDICATORS

2.3.1. Introduction to the outcome indicators

In this part of the report the outcomes of interest and the selected indicators are described.

The outcome indicators are needed to monitor or describe changes in the outcomes of interests. The outcomes of interest represent the impacts of the transport system that the policymakers are interested in. Since the outcomes of interest themselves are usually not measurable nor can they be monitored, one or several indicators have been chosen to represent the changes taking place in the outcomes of interest.

The main criterion used in identifying the indicators has been their importance, relevance and completeness in measuring and monitoring the outcomes of interest. Availability of data or methods to calculate these indicators was not taken as a decisive factor, although it certainly has had an impact on the selection. Thus, the indicator selection in this report is a **wish list** of indicators that are needed to monitor the performance of the transport system and its impact on sustainability.

In what follows the indicators are discussed according to the classification into three types of impacts of the transport system: economic, social and environmental which influence the sustainable development of the society. However, in some cases the outcomes of interest or indicators do overlap and relate to more than one aspect of sustainability. These overlaps are discussed in the § 2.3.1.1 below.

A detailed account of the individual outcome indicators can be found in the indicator sheets placed in the Appendix C. Most of the impacts are highly dependent on the conditions where they occur[15]. In the indicator sheets the necessary levels of analysis are identified. The outcomes of interest and the related indicators presented here are mainly based on existing work and research done by European and international organisations. A wide set of literature has been reviewed in the development process. The results were also explored, reviewed and developed further in two workshops involving experts and policymakers.

The outcomes of interest as well as indicators have been given code numbering. The first part of the code is formed of the two letters of the aspect they are related to, e.g. EC for economic, EN for environmental and SO for social. The second part of the code is a number, of which the first is related to the outcome e.g. "Resource use" is EN1, "Direct ecological intrusion" is EN2, and the second number is assigned to the indicator, e.g. "Land take" is EN13.

2.3.1.1. Interrelations between outcomes and indicators

One of the most difficult questions and problems in the development and use of sustainability indicators deals with the interrelations between outcomes of interest and different indicators. When using sustainability indicators for different purposes it should be avoided that:

- the same costs and benefits are taken into account twice or even several times (the problem of double or multiple counting);

[15] To capture the effects at most levels and to understand the interactions between them, SUMMA uses integrated approach. Thus all geographical levels (urban, regional, national and EU wide) and all modes (air, marine and land transport) are considered.

– the same or strongly related indicators have incongruent relation to sustainability and sustainable mobility (the problem of contradiction or ambivalence in terms of the impact in relation to sustainability).

As it can be seen in the following chapters, there may be several similar or even same indicators listed under different aspects of sustainability. This is due to the fact that although the same topic is included twice there may be different reasons for inclusion; the two indicators may actually be describing a different problem.

Even though it can be said that all outcomes of interest listed in Table 2.4 above are related to each other, for three topics this relation is stronger and will be dealt with explicitly in the following three paragraphs. It will be discussed whether the same or strongly related indicators have the same meaning from the economic, environmental and social point of view and whether there are actual overlaps, contradictions or ambivalence with regard to the relation between the indicator and sustainability.

Accessibility and affordability

"Accessibility" and "affordability" have been identified as both economic and social outcomes of interest. At the general abstract level both concepts have slightly different meaning from an economic and social perspective: "Economic accessibility" refers to the ease of transport between places without reference to their social desirability. Each possible ("accessible") connection has the same value from this point of view. "Social accessibility", on the other hand, distinguishes between connections of different desirability; of special positive value are connections or access to sites, facilities and services which helps to reduce and overcome social exclusion and disparities. Regarding "affordability" of transport and transport services, in social perspective this means that people can pay for their necessary and socially beneficial mobility; whereas from an economic perspective the affordability concept means more of safeguarding of the purchasing power, in order to enable the consumption of other goods and services.

When these general concepts are made concrete using indicators, we see a complete identity between the indicators EC13 and SO11 "Access to basic services" and EC14 and SO12 "Access to public transport". Similarly the indicators EC22 "Transport related expenditures of households" and SO14 "Affordability of transport and transport services" have different titles, but the same content and definition. The relation between all these indicators with sustainability and sustainable mobility are congruent, they do not contradict each other in terms of their content. In all four cases (EC13, SO11, EC14 and SO14) an improvement in access to basic services and in access to public transport as well as growing affordability or decrease in transport expenditures is seen as a sign of growing sustainability of the transport system.

The only problem which has to be taken into account - and is dealt with in SUMMA - is the question how to avoid the double counting and multidimensionality of the same accessibility and affordability aspects covered by more than one of the suggested indicators. Since the indicators EC13 and SO11, EC14 and SO12 as well as EC22 and SO14 are identical in their form and content, they should be counted only once and it does not make any difference if it happens in connection with the environmental or social indicators of SUMMA.

Costs and financing of transport

This topic is included under two outcomes of interest, economic EC4 “Costs to economy” and social SO5 “Equity”, and can be seen in the strongly overlapping indicators EC42 "Public subsidies" and SO51 "Horizontal equity". Both indicators have to do with the costs of transport and the share of transport users and the state in financing and bearing these costs. In detail there are some important differences between the two indicators. One example of these differences is the fact, that SO51 takes into account *direct mobility costs* in the first place whereas EC42 concentrates on the financing of the *indirect costs in transport and mobility related sectors* (e.g. for development of vehicles, mobility related information and communication technologies, research and transport operations, etc.

With regard to their relation to sustainability and sustainable mobility these indicators are congruent: High horizontal equity means high-degree of "self-financing" of transport costs by the users and thus low state subsidies - and both are considered as a sign and positive pre-condition of sustainable mobility. This means that for this relation only the problem of multidimensionality has to be taken into account and solved in subsequent workpackages of SUMMA; one possibility how to separate the contents of both indicators and avoid the problem of double counting would be - as indicated above - a strict restriction to direct costs in connection with SO51 and to indirect costs in connection with EC42.

Natural resource use

Resource use is an integral issue of sustainability, since we are supposed to develop our society to the direction that the future generations can also utilise and enjoy these limited resources. The use of natural resources has both economic and environmental importance. Although the headlines are different, there is substantial overlap between the outcomes of interest EC4 “Costs to the economy” and EN1 “Resource use”. In environmental terms, the use and extraction of natural resources has harmful impacts such as pollution, habitat impairment and loss of biodiversity, whereas from the economic point of view the consumption of some resources to the point of extinction causes high costs and requires the development of alternative sources.

Most clearly the overlapping of these outcomes of interest can be seen in indicators EC44 and EN11 "Energy consumption", which have the same content and definition. The economic costs of energy consumption are relatively high in the transport sector and for this reason it has been included as one of the individual cost factors of transport. Regarding the environmental indicators EN12 "Consumption of solid raw materials" and EN13 "Land take", they also have an economic cost component, but in these cases the economic costs are included in more general economic indicators EC43 "External transport costs" and EC41 "Infrastructure costs".

Concerning the definitions of the two indicators there should be no contradiction with regard to their relation to sustainability and sustainable mobility, in both cases the economic and environmental costs should be low. However, there may be contradictions, if the prices do not, for example, correctly reflect all external costs, which is often the case in practice. In this case the weaknesses of the pricing system have to be taken into account in the final assessment.

Although the resource use and cost indicators are overlapping in content, there should not be a problem with double-counting, if it is remembered that the economic effects (resource depletion) are described with the economic indicators and the environmental effects (damage caused by resource extraction and production) should be covered by the environmental indicators.

2.3.2. Economic Impacts

2.3.2.1. Overview of economic outcomes of interest and indicators

The main purpose of the transport sector is to enable mobility of people and goods. The transport sector does not serve any natural purpose by itself. It mainly yields service to other economic activities, like some production process, which e.g. can increase its economic efficiency by spatially separating the processing. The transport sector does not support any natural capital build up. On contrary it consumes large amounts of natural capital (in the form of energy consumption and physical outputs such as pollution, noise, damaged land, etc.). The sector itself could therefore never satisfy strong sustainability criteria. It could only be justified in its relation to other sectors.

The transport system has a service function and supports the mobility needs of people and goods. On the other hand a great amount of resources are needed which produce costs for the society, individuals and firms.

Concerning these facts from the economic point of view the main questions are:

- How efficient does the transport system work
- What are the costs and the benefits for the society and the individuals.

The economic outcomes of interest and the related indicators have the purpose:

- To monitor these effects and
- To evaluate the economic impacts of transport policies – or in general – changing of the system.

There is no common agreement on indicators for the evaluation of a sustainable transport system in general. Due to this the SUMMA framework is closely based to the definition of the Council of

European Union for a sustainable transport system (Council of the EU 2001). The main economic objectives of the definition- e.g. basic access, affordability, fairness, competitive economy and efficiency are the fundamentals of the development for a general theoretical approach of the selection of economic outcomes of interest and related outcome indicators. Therefore in SUMMA the following economic outcomes of interest have been identified:

- Accessibility
- Transport operation costs
- Productivity/ Efficiency
- Costs to Economy
- Benefits to Economy

The selection of corresponding indicators, which provide detailed information about the outcomes of interest, has the purpose to arrange a complete and consistent list of economic indicators.

However there is a need for a specific indicator systematics, which includes individual and general aspects in order to meet the following requirements (based on Gallopín (1997)):

- To assess conditions and changes;
- To compare across place and situations;
- To assess conditions and trends in relation to goals and targets;
- To provide early warning information; and,
- To anticipate future conditions and trends.

Furthermore there is also a general requirement for a methodological framework or guideline for the measurement and identification of outcomes of interest and related indicators.

“Indicator frameworks, organising individual indicators or indicator sets, in a coherent manner, have several additional uses. They can guide the overall data and information collecting process. They are useful tools to decision-makers, summarising key information from different sectors. They suggest logical groupings for related sets of information promoting their interpretation and integration. They can help to identify data collection needs. Finally, indicator frameworks can help to spread reporting burdens, by structuring the information collection, analysis and reporting process across many issues and areas that pertain to sustainable development.” (UN CSD 1996).

In order to meet the requirements and advantages of a coherent framework, and to take into account the specifics of the economic dimension of sustainability, the Driving force-State-Response model (DSR) model of UN Commission for Sustainable Development (UN CSD) has been adopted as basis and criteria for the selection and development of economic outcomes of interest and indicators. The DSR- model is an advancement of the OECD- Pressure-State-Response (PSR) model (OECD 1998), which allows for a better inclusion of non-environmental variables. The replacement of the term “pressure” in the PSR framework by the term “driving force” was motivated by the desire to include economic, social and institutional aspects of sustainable development. Another aspect of the DSR framework, which separates it from its predecessor, is that there is no assumption of causality between indicators in each of the categories.

In the framework, driving force indicators represent human activities, processes and patterns that have an impact on sustainable development. These indicators provide an indication of the causes of positive and/or negative changes in the state of sustainable development. Examples of driving force indicators are mainly grouped in the economic outcome of interests of “accessibility”, e.g. “accessibility of origins/ destinations (EC12)” and “access to basic services (EC13/ SO11)”, and in the economic outcome of interests of “transport operation costs”, e.g. “transport related expenditures of households (EC22)” and “transport prices (EC23)”.

State indicators provide an indication of the state of sustainable development, or a particular aspect of it, at a given point in time. In the economic dimension state indicators are provided in the outcome of interest of “productivity/ efficiency”, e.g. “energy efficiency (EC 34)”.

Response indicators indicate policy options and other responses to changes in the state of sustainable development. These indicators provide a measure of the willingness and effectiveness of a society in providing responses. Some responses to changes in the state of sustainable development can be legislation, regulation, economic instruments, information activities etc. Examples of response indicators for the economic dimension of the SUMMA framework include in general the outcome indicators of “costs to economy” and “benefits to economy” e.g. “public revenues from taxes and traffic system charging (EC52)” and “benefits of transport (EC53)” (Mortensen 1997).

According to this background an elaborate review of concepts and methods for evaluation of sustainability has been done to prepare the framework for the selection of economic outcomes of interest and the relating outcome indicators. Below there is a list of main references concerning the selection and development of the economic outcomes of interest and the economic outcome indicators16. Integrated transport planning of North Rhine- Westphalia (Integrierte Gesamtverkehrs-planung Nordrhein- Westfalen).

This project aimed to create a sustainable traffic system in North Rhine- Westphalia –Germany- till 2015. The performance will be evaluated on the basis of a target system, which contains indicators concerning economic, environmental and social dimension of sustainability.

The links between outcomes of interest (OoI) and the understanding and description of “sustainability” has been discussed earlier. Therefore we refer to these findings and focus in the following text on the description of outcome indicators.

The clear allocation of outcomes of interest to the three pillars of sustainability (economic, environmental and social) is not always possible. E.g. accessibility as a common objective of sustainable mobility can be regarded as an outcome of interest in social and economic point of view. Due to this, overlapping indicators in the three pillars cannot be prevented.

To give a complete picture of the economic related outcomes of interests and indicators, all relating indicators with definition, units and relation to sustainable transport can be found in the Table 5.1. More detailed information of the indicators can be found from the indicator sheets in the Appendix C.

Table 2.7 — Economic outcomes of interest and related indicators

Outcomes of Interest	Indicator name	Indicator definition	Units and relation to the economic aspect of sustainability	
EC1 ACCESSI-BILITY	**EC11 Intermodal Terminal facilities**	Terminal facilities with access by intermodal traffic system (road, rail, waterway)	Percentage of terminals with access by more than one mode	↑
	EC12 Accessibility of origins/ destinations	Accessibility Index between important economical centres and regions by mode	Index value (Aij)	↑
	EC13 Access to basic services (SO11)	Average travel time for households to reach “basic” purposes	Minutes	↓
	EC14 Access to public transport (SO12)	Percentage of households living within walking distance of 5 minutes from the next stop of public transport	Percentage of households	↑

16 European Environment Agency EEA – TERM report —The concept of an indicator-based transport and environment reporting mechanism (TERM) aimed to develop an regular indicator-based report which monitored the effectiveness of transport and environment integration strategies.
UNIfication of accounts and marginal costs for Transport Efficiency – UNITE project. UNITE aimed to supply policymakers with state-of-the-art cost estimates to enable the integration of full social costs and benefits of transport into fair and efficient pricing of transport infrastructure use.
SAVE ODYSSEE PROJECT – The European project on energy efficiency indicators is aimed to review national achievements in energy efficiency and CO2 emissions at a sectoral level. SUMMA energy efficiency indicators were derived in order to provide the comparability.
NISTRA- Indicators for sustainable road infrastructure projects. NISTRA – a project of the Swiss government-aimed to develop an instrument that enables the evaluation of sustainable road infrastructure projects.

Integrated transport planning of North Rhine- Westphalia (Integrierte Gesamtverkehrsplanung Nordrhein-Westfalen). This project aimed to create a sustainable traffic system in North Rhine- Westphalia –Germany- till 2015. The performance will be evaluated on the basis of a target system, which contains indicators concerning economic, environmental and social dimension of sustainability.

EC2 TRANSPORT OPERATION COSTS	**EC21 Supplier operating costs**	Monetary costs of transport operators (fixed and variable components)	Euro per year	↓
	EC22 Transport- related expenditures of households (SO14)	Average transport- related share of household expenditures by type of household	Percentage of expenditures	↓
	EC23 Transport prices	Transport prices for passenger transport by mode	Euro per passenger- km (public transport)	↓
			Euro per vehicle- km (private transport)	↓
		Transport prices for freight transport by mode	Euro per tonne- km	↓
EC3 PRODUCTIVITY/ EFFICIENCY	**EC31 Freight haulage-related costs on product costs**	Average share of freight haulage costs on product cost by sector	Percentage of product costs	↓
	EC32 Utilisation rates	Average occupancy rate in passenger vehicles	Number of passengers per car trip (private transport)	↑
			Percentage of capacity (public transport)	↑
		Average loading rate of freight vehicles	Percentage of capacity	↑
		Average utilisation rate of transhipment terminals	Percentage of capacity	↑
	EC33 Energy consumption efficiency of transport sector	Energy consumption per unit of GVA generated by transport sector	Joule/ Euro GVA	↓
	EC34 Energy efficiency	Energy consumption intensities for passenger transport by mode	toe/ passenger- km	↓
		Energy consumption intensities for freight transport by mode	toe/ tonnes-km	↓
EC4 COSTS TO ECONOMY	**EC41 Infrastructure costs**	1 Traffic system- related public and private construction costs by mode	Euro/ km per year (traffic network)	↓
			Euro/ tonne per year (transhipment terminals)	↓
		Traffic system- related public and private; improvement and maintenance costs by mode	Euro/ km per year (traffic network)	↓
			Euro/ tonne per year (transhipment terminals)	↓
	EC42 Public subsidies	Public expenditures/ investments in transport and mobility- related sector e.g. for development of vehicles, transhipment technologies, mobility-related information and communication technology, research and transport operation	Euro per year	↓
	EC43 External transport costs	Accident costs by mode	Euro per year	↓
		Delay costs due to congestion by mode	Euro per year	↓
		Environmental costs by mode	Euro per year	↓
	EC44 Energy consumption (EN11)	Final energy consumption in transport by mode and by energy source	Million tonnes of oil equivalents	↓
		Share of final energy consumption in transport produced from renewable energy sources	Percentage	↑

EC5 BENEFITS TO ECONOMY	**EC51 Gross value added**	Share of an economy's gross value added (GVA) generated by transport	Percentage of GVA	↑
	EC52 Public revenues from taxes and traffic system charging	Public revenues from traffic system charging (tolls and user charges)	Euro per year	↓
		Public revenues from transport sector related taxes (petroleum, vehicle and emission taxes)	Euro per year	↓
	EC53 Benefits of transport	Indirect positive growth and structure effects realised by the transport sector	Euro per year	↑

Summarised there are 4 groups of outcomes of interest:

- Accessibility as an important function of the transport system. The two aspects:
  - Accessibility of regions for goods and people as a driver for regional economic development, and
  - Accessibility to important national and international destinations.
- Transport operation costs with the aspects:
  - Market prices for transport services,
  - Individual costs for private households and for companies, and
  - Coverage of external costs.
- Productivity / Efficiency with aspects:
  - The general impacts for the whole economy, and
  - The individual expenditure.
- Costs and benefits of the Economy like:
  - Investment in the transport system,
  - Maintenance costs,
  - Revenues from the transport sector.

In the following sections the economic outcomes of interests and the relating indicators, including the definition, measurable unit, background and relevance, will be explained and described.

2.3.3. Environmental Impacts

2.3.3.1. Overview of environmental outcomes of interest and indicators

Environmental impacts of transport are the most studied of the three kinds of impacts covered in this report, the economic, social and environmental. Even then finding a systematic framework for classification is not simple: there are many of them around, but not one that would be widely used and accepted. The environmental outcomes of interest identified in SUMMA were listed earlier and linked to the goals mentioned in the EU definition of sustainable transport. Although very similar, the terms were not entirely the same.

In order to ensure the comprehensiveness of the different outcomes, an input-output framework was used for the classification of the environmental outcomes of interest. This framework, presented in the Figure 2.7, is a modification of one developed by Gudmundsson (2002). Important in this framework is the differentiation between 1) the inputs needed *from* the environment to the transport system, and 2) outputs from the transport system *into* the environment. Both the inputs and outputs have mainly harmful impacts. Another important issue in this framework is the differentiation between two different types of outputs: a) direct or immediate ones and the b) indirect or secondary outputs. For example: The emissions of air pollutants are a direct impact, whereas the effects of the emissions to human health or to ecosystems are indirect impacts.

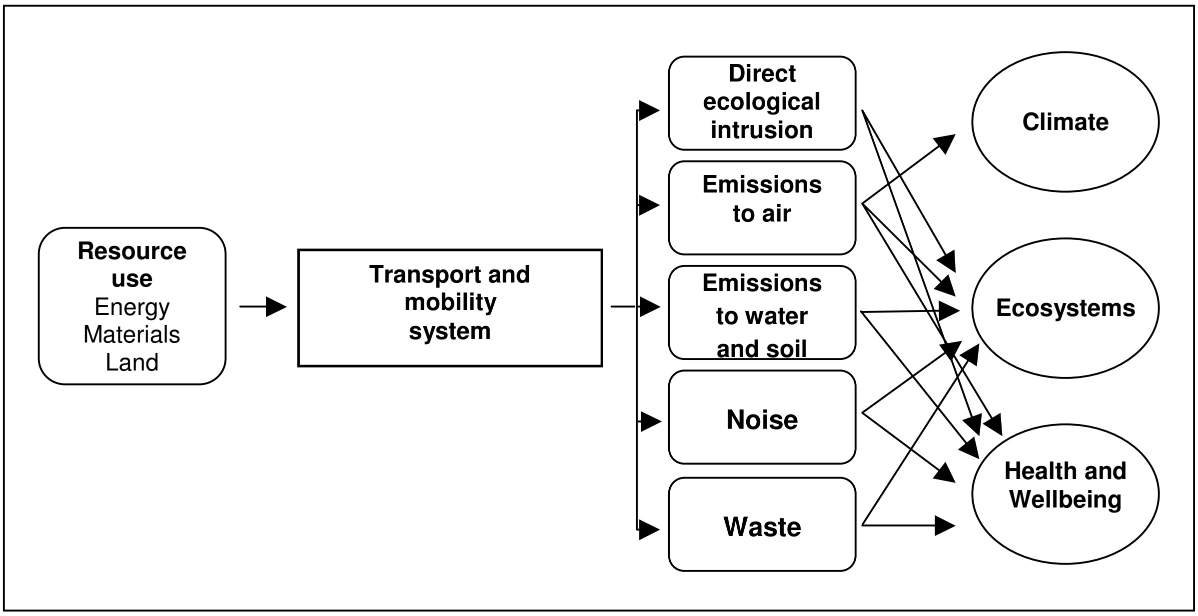


***Figure 2.7* – Input–output framework of the environmental outcomes of interest (adapted from Gudmundsson, 2002**

The selection of outcomes of interest was limited on the direct and immediate impacts (in other words the outputs) from the transport system. Indirect impacts (e.g. on health) that are results of the direct impacts (e.g. emissions to air) coming from the system are not included. The importance of the indirect impacts is taken into account in the selection of indicators and in the monetisation and quantification of the selected indicators.

An important concept that has been used in the selection of the indicators to represent the outcomes of interest is the life-cycle approach. Rather than looking at only the impacts of transport activity such as vehicle emissions and infrastructure land-take, we attempted to include impacts caused at all stages of the vehicle/vessel/aircraft life-cycle as well as infrastructure manufacture and production. A simple example of the contribution of transport to environmental problems is the life-cycle of vehicle production and use presented in the Figure 2.8.

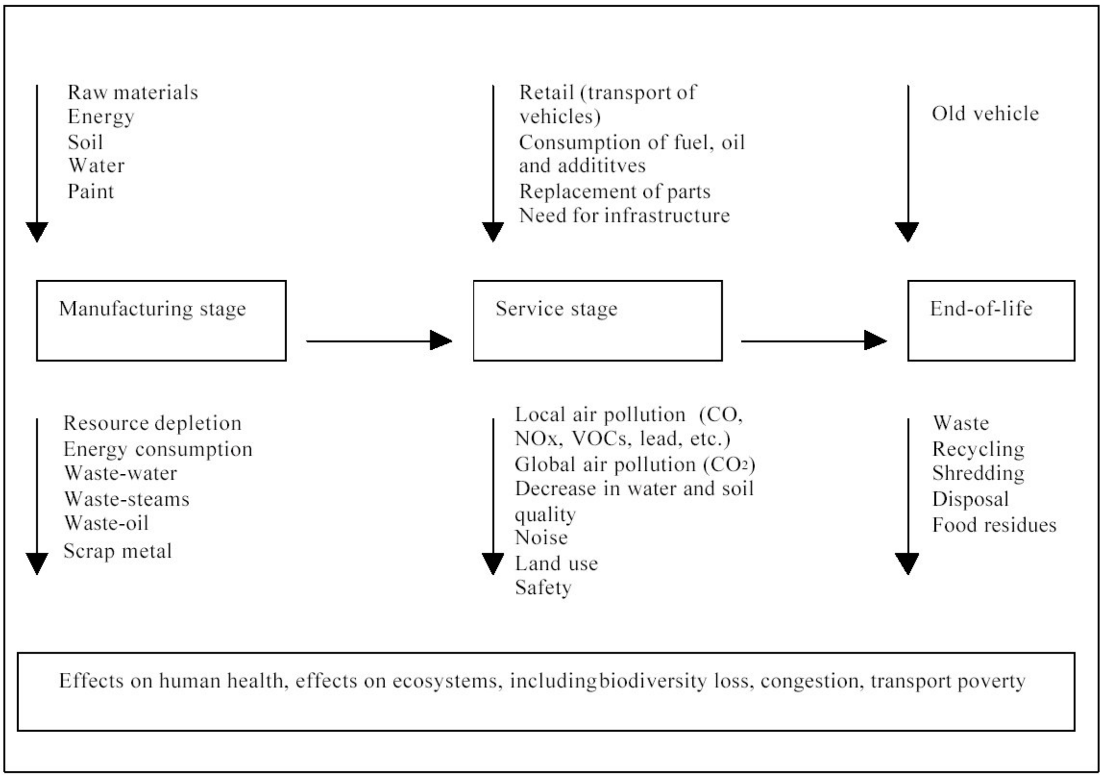


***Figure 2.8* – Life-cycle of vehicle production and use (UNEP 2001)**

Some may argue that looking at the whole life-cycle is not relevant since many of these issues belong to other policy sectors. It may seem so at first, but in most cases they can also be influenced through transport policy, even though these connections are not always so clear. Also, a more significant argument for applying the life-cycle approach is the fact that our aim was to identify the most important environmental impacts of transport, no matter to which policy domain they belong to. If these happen to be outside the traditional transport policy sector, this is also an important piece of information.

In developing indicators for monitoring environmental impacts of transport the USEPA identified the following stages of a transport system life-cycle:

- **Infrastructure construction** - Construction and development of transportation facilities, such as roadways, railways, airports, and navigation channels;
- **Vehicle manufacture** - Production of vehicles and parts (including motor vehicles, railcars and locomotives, aircraft, and ships and boats);
- **Travel** - Vehicle operations to transport people and goods;
- **Operations, maintenance and support** - Activities to support travel, such as application of deicing chemicals, as well as operation of facilities to support travel, such as gas stations, airport terminals, and marinas; and
- **Disposal** - Disposal or recycling of vehicles, parts, and facilities. (USEPA, 1999.)

However, introducing the life-cycle approach to the indicator selection entered into a complex field of interrelations, and in many cases finding suitable indicators for all aspects would have simply caused an endless list of indicators. Thus a coarse selection based on the present understanding of the relative importance of the impacts was necessary.

An overview of the selected indicators is in the Table 2.8. In the following section the environmental outcomes of interest and the selected indicators are discussed briefly. More detailed information on the indicators can be found in the indicator sheets in the Annex 4. The arrows in the table indicate the desired direction of development in the indicator values. In the case of some indicators the changes taking place may be ambiguous to interpret, due to the fact that within the indicator there may be counteracting changes. For example, in indicator EN42, the amount of pollutants released in transport accidents should of course be decreasing. However, it makes a difference what is the type of pollutant released. Thus, even when the overall amount may have decreased, the share of more harmful substances could have increased and therefore the net effect could be the same. Indicators, which therefore need a closer look on a more detailed data before the interpretation can be made, are marked with an asterisk (*).

Table 2.8 — Environmental outcomes of interest and related indicators

Outcomes of Interest	Name	Definition	Units and relation to the environmental aspect of sustainability	
EN1 RESOURCE USE	**EN11 Energy consumption**	A. Final energy consumption in transport by mode and by energy source	Million tonnes of oil equivalents	↓
		B. Share of final energy consumption in transport produced from renewable energy sources	Million tonnes of oil equivalents	↑
	EN12 Consumption of solid raw materials	A. Raw materials used in building transport infrastructure by type of material	Tonnes	↓*
		B. Raw materials used in vehicles manufacture by type of material	Tonnes	↓*
	EN13 Land take	A. Land take by transport infrastructure by mode	Km^2	↓
		B. Land take by transport infrastructure by mode percentage of country surfaces	Percentage of surface area	↓
EN2 DIRECT ECOLOGICAL INTRUSION	**EN21 Fragmentation of land**	Effective mesh size (m_{eff})	Km^2	↑
	EN22 Damage of underwater habitats	Amount of dredging at ports, waterways, etc. by type of dredged area	M^3	↓*
	EN23 Losses of nature areas	Losses of nature areas due to construction of transport infrastructure by mode, and as % of total nature area losses	Km^2 and percentage of total nature area losses	↓
	EN24 Proximity of transport infrastructure to designated nature areas	Designated nature areas in the proximity (unit has to be defined) of transport infrastructure in total and by mode	Km^2 and percentage of designated nature areas	↓
	EN25 Light emissions	Area of lighted transport infrastructure	Km^2	↓
	EN26 Collisions with wildlife	Annual number of collisions with animals by mode	Number of collisions per year	↓*
	EN27 Introduction of non-native species	Number of non-native species introduced by marine transport and in transport infrastructure construction	Number of species	↓*
EN3 EMISSIONS TO AIR	**EN31 Transport emissions of greenhouse gases**	Transport emissions of greenhouse gas by mode and by type of gas	Tonnes of CO_2 equivalent	↓
	EN32 Greenhouse gas emissions from manufacture and maintenance	Greenhouse gas emissions from vehicle and parts manufacture, and transport maintenance by mode and by gas	Tonnes of CO_2 equivalent	↓
	EN33 Transport emissions of air pollutants	Transport emissions of air pollutants by mode and by type of pollutant	Ktonnes	↓*
	EN34 Air pollutant emissions from manufacture and maintenance	Emissions of air pollutants from vehicle and parts manufacture, and transport maintenance by mode and by type of pollutant	Ktonnes	↓*

EN4 EMISSIONS TO SOIL AND WATER	**EN41 Hardening of surfaces**	Hardened surfaces in transport use by mode and as % of total land take by transport infrastructure	Km^2 and percentage of total land take	↓
	EN42 Polluting transport accidents	Amount of pollutants released in transport accidents by type of pollutant and by mode	Litres or tonnes	↓*
	EN43 Runoff pollution from transport infrastructure	Amount of pollutants released by run-offs by type of pollutant and by mode	To be defined	↓*
	EN44 Wastewater from manufacture and maintenance of transport infrastructure	Amount of wastewater produced from manufacture and maintenance of transport infrastructure not treated in wastewater treatment plants	M^3 or litres or tonnes	↓
	EN45 Discharges of oil at sea	Illegal discharges of oil by ships at sea	Number of observed oil slicks	↓
	EN46 Discharges of wastewater and waste at sea	A. Amount of wastewater discharged into sea from ships	Litres or tonnes	↓
		B. Amount of waste discharged into sea from ships	Tonnes or m^3	↓
EN5 NOISE	**EN51 Exposure to transport noise**	A. Amount of population exposed to traffic noise levels detrimental to health (>65 dBA) by mode	Number and percentage of population	↓
		B. Amount of population exposed to traffic noise levels affecting well-being (between 40 and 65 dBA) by mode	Number and percentage of population	↓
EN6 WASTE	**EN61 Generation of non-recycled waste**	Total amount of non-recycled waste generated by transport by mode and by type of waste	Tonnes	↓*

2.3.4. Social Impacts

2.3.4.1. Introduction and overview of social outcomes of interest and indicators

2.3.4.1.1 Underdeveloped social dimension and lacking knowledge about social aspects of sustainability

In almost every recent paper on sustainability and sustainable development there is a statement about the underdeveloped "poor-relation" social dimension and lacking knowledge about the social aspects of sustainability. As an example of such statements we quote from a research proposal of The York Centre for Applied Sustainability (YCAS) from the programme "Sustainable Toronto":

"Sustainable development and sustainability now form part of the common lexicon within the global environmental community, and both concepts are beginning to inform policy discourses at all levels from the international to the local. There is general agreement that sustainability involves more than environment and economy, but much debate about how best to conceptualise the additional component(s). Most theorists and practitioners agree that social equity is an important, integral and essential element of sustainability. The Brundtland Commission clearly established the primacy of social factors in defining sustainable development as requiring meeting human “needs” both in the present and in the future. Indeed, environment is not even explicitly mentioned in its often quoted definition. Yet, to date, many approaches to sustainability have emphasised the environment-economy nexus, sometimes exclusively. This is due, in part, to the complex challenge involved in identifying and integrating social factors into the concept of sustainable development."

What is true about the social sustainability discussion in general, is even more valid for social dimension of sustainability and sustainable transport and mobility. Also with regard to indicators and other methodological questions and aspects the social discussion started with a delay of several years and has not yet lead to broadly accepted and consolidated results. We hope that our work in SUMMA-project will be able to stimulate the discussion and reduce the knowledge gap about social indicators of sustainability and sustainable mobility.

2.3.4.1.2 Main existing approaches to the social dimension of sustainability and sustainable development

In this short chapter we can not provide a complete overview or state of the art of the knowledge on the social dimension of sustainability and sustainable development. Instead of it, we will briefly describe the most important theoretical and methodological approaches, which are also an important ground for our subsequent choices and recommendations.

2.3.4.1.2.1 The ISOE-approach stressing the need for adjustment and development of societal resources[17]

One of the most thorough and up to date analysis can be found in the work from the Institute for Socio-ecological Research ISOE in Frankfurt. Departing from the basic characteristics of social phenomena and processes as well as from the postulate of social justice, Empacher and Wehling identify four core elements of social sustainability:

- the provision of basic needs for all members of society,
- the maintenance and development of social resources,
- equal opportunities concerning access to resources and
- the participation within social decision processes

In partial contrast to other authors, Empacher and Wehling emphasise stronger the dynamic aspects of societal development and adjustments. The social sustainability does not mean the stability and maintenance of existing structures only, but rather the society must be able to react and adapt itself to changing external conditions and requirements. Due to the differences in its content the social dimension of sustainability requires also specific methods and indicators. Capital and flow concepts seem to be more appropriate here instead of the environment focused DPSIR-approach and subjective indicators as well as opinions of the actors and affected persons and groups must be taken into account.

2.3.4.1.2.2 The "social capital" concept and its relation to sustainable development

In recent years, the concept of “social capital” has attracted increased attention from economists, sociologists, and theorists in many other social sciences. According to the father of the concept R. Putnam, social capital refers to “features of social organisation such as networks, norms, and social trust that facilitate co-ordination and co-operation for mutual benefit”. It is embodied in such complex and often not easily observable phenomena as shared values, norms, formal and informal networks, stable and effective institutions, and social cohesion[18]. The latest definitions of social capital have been extended to incorporate aspects of governance and institutional effectiveness. Governmental social capital is the effectiveness of institutions (e.g. governance structures) in facilitating collective action. This is indicated by such features of society as the rule of law, political stability, and the effective protection of property and contract rights.

2.3.4.1.2.3 Conceptual Framework and Structure of the European System of Social Indicators

The conceptual framework of the European System of Social Indicators (EUSI) describes goal dimensions and political concerns of the societal development in Europe. The analysis of the scientific and political debate on societal goals lead to the identification of six relevant goal dimensions of societal development in Europe which are related to the concepts of quality of life, social cohesion and sustainability. The concept of quality of life incorporates goal dimensions "improvement of objective living conditions" and "enhancement of subjective well-being". The goal dimensions covered by the concept of social cohesion are "reduction of disparities, inequalities and social exclusion" and "strengthening social ties". (see also Berger-Schmitt, 2001)

[17] For details about ISOE work on social dimension of sustainability see http://www.isoe.de/ftp/kerpen.pdf and http://www.isoe.de/ftp/agsoznh.pps but both highly relevant and interesting documents are available in German only.

[18] The distinction between the concepts of social capital and social cohesion is not clear, both being related to overall social “connectedness”. Some authors use the term interchangeably, or prefer one to the other.

2.3.4.1.3 From sustainability in general to sustainable mobility and transport

The EXTRA-thematic paper 3/3 on "Social Aspects of Sustainable Mobility" covers following main topic areas:

- *social equity* of policy changes and the implications for public acceptability — depending e.g. on the effects on income distribution, regional development and employment;
- *accessibility* to transport services such as affordable public transport, and also access to destinations from different parts of the European Union;
- *effects* of the transport network on social cohesion;
- *care for marginal/disadvantaged/vulnerable groups* — e.g. ensuring physical access to transport services for people with mobility difficulties;
- *working conditions* for operatives, who may for instance be affected by policies towards safety, new technologies and deregulation of services.

Corresponding to these five topic areas are three policy issues "social equity" (with clusters "physical accessibility" and "pricing acceptance and equity"), "social cohesion" (with clusters "support for public transport" and "European cohesion") and "working conditions".

2.3.4.1.4 Overview of social outcomes of interest and indicators

In this section we will present an overview of selected outcomes of interest and indicators which will be used as input for subsequent SUMMA workpackages.

Our selection of seven outcomes of interest (accessibility and affordability, safety and security, fitness and health, liveability and amenity, equity, social cohesion and working conditions in transport sector) is based on general theoretical reflections on social aspects of sustainable development, as well as on specific analyses of aspects and areas, which are relevant for sustainable transport and mobility. It can also be linked to our definition of sustainable mobility, as it is presented earlier of this report.

The selection of indicators for each of the seven outcomes of interest was based on four following criteria:

- Best coverage of dimensions and aspects associated with the pertinent outcome of interest;
- Strong and direct relation between the indicator and transport system;
- Clear unequivocal relation between the indicator, sustainability and sustainable transport; and
- Availability of good (differentiated, reliable, …) data and easy quantification/monetisation.

Table 2.9 — Social outcomes of interest and related indicators

Outcomes of interest	Indicator name	Indicator definition	Units and relation to the social aspect of sustainability	
SO1 ACCESSIBILITY AND AFFORDABILITY (users)	**SO11 Access to basic services**	Average travel time for households to reach "basic" purposes	Minutes	↓
	SO12 Access to public transport	Percentage of households living within walking distance of 5 minutes from the next stop of public transport	Percentage of households	↑
	SO13 Car independence	Percentage of households without cars	Percentage of households	↑
	SO14 Affordability	Average percentage of household expenditures related to transport	Percentage of expenditures	↓
	SO15 Trip length	Percentage of short trips from all trips	Percentage of trips	↑

SO2 SAFETY AND SECURITY **(users, drivers, the affected)**	**SO21 Accident related fatalities and serious injuries**	SO21a Number of transport accident related fatalities and serious injuries per year and 1'000 inhabitants	Number of persons per year, per 1'000 inhabitants	↓
		SO21b (based on SO21a) Number of children below 18 years seriously hurt or killed per 1'000 children in the same age group	Number of children per year, per 1'000 children	↓
		SO21c (base SO21a): Number of adults from 18 to 65 years seriously hurt or killed per 1'000 persons in the same age group	Number of adults per year, per 1'000 adults	↓
		SO21d (base SO21a): Number of persons older than 65 years seriously hurt or killed per 1'000 persons in the same age group	Number of elderly per year, per 1'000 elderly	↓
	SO22 Vehicle thefts & other vehicle crimes	Recorded crimes against private vehicles per year and 1'000 inhabitants	Number of crimes per year, per 1'000 inhabitants	↓
	SO23 Security on public transport	Number of incidents (property offences + offences against passengers + offences against operatives) per year and 1'000 km	Number of incidents, per year, per 1'000 km	↓
SO3 FITNESS AND HEALTH (users)	**SO31 Walking and cycling as transport means for short distance trips**	Percentage of short trips/journeys done by walking or cycling	Percentage of trips/journeys	↑
SO4 LIVEABILITY AND AMENITY **(inhabitants, society, the affected)**	**SO41 Walkability, pedestrian friendliness**	Total length of separate walking paths and/or special pedestrian areas in % of the length of the whole transport net	Percentage of length of the whole transport network	↑
	SO42 Traffic calming	Total length of city streets with speed limits of maximum 30 km per hour in % of the length of the whole city street network	Percentage of length of the city street network	↑
	SO43 Children's journey to school	Percentage of children driven to school by car	Percentage of children	↓
	SO44 Open space availability and accessibility	Percentage of inhabitants/households living within maximally 15 minutes walking distance from urban green areas	Percentage of inhabitants/households	↑
SO5 EQUITY **(users and the affected)**	**SO51 Horizontal equity (fairness)**	Percentage of "self-financing" of transport costs by the users, differentiated by mode	Percentage of costs	↑
	SO52 Vertical equity (income)	SO52a Ratio between richest/poorest 20% (quintile) for transport related household expenditures (based on SO14)	Number	↓
		SO52b Ratio between richest/poorest 20% (quintile) households for access to basic services (based on SO11)	Number	↓
		SO52c Ratio between richest/poorest 20% (quintile) households for public transport reliance (based on SO13)	Number	?
	SO53 Vertical equity (mobility needs and ability)	SO53a Explicitly earmarked public transport expenditures for the disabled and elderly in % of total public transport expenditures	Percentage of expenditures	↑
		SO53b Percentage of easy accessible low-floor vehicles in % of the total urban transport fleet	Percentage of vehicles	↑
	SO54 Intergenerational equity	Important outcomes of interest, but no indicators can be suggested here		
	SO55 Interregional (spatial) equity			

SO6 SOCIAL COHESION **(inhabitants, society and the affected)**	**SO61 Public opinion profile on transport and transport policy issues**	Percentage of adults supporting radical pro- and anti-car positions in the transport policy discourse	Percentage of adults	↓
	SO62 Violation of traffic rules	Percentage of drivers violating traffic rules and regulations	Percentage of drivers	↓
	SO63 Long distance commuting	Percentage of commuters commuting daily over distances of more than 10 km	Percentage of commuters	↓
SO7 WORKING CONDITIONS IN TRANSPORT SECTOR **(employees, drivers, operatives)**	**SO71 Occupational accidents**	Number of recorded (notified) serious occupational accidents per year and 100'000 employees in the transport sector	Number of accidents	↓
	SO72 Precarious employment conditions	Percentage of employees in precarious employment conditions	Percentage of employees	↓
	SO73 Work absence due to work accidents and illness	Number of reported work absence days per year and 100'000 employees	Number of work absence days	↓

2.4. FAST SIMPLE MODEL

Continuing from the presentation of the policy assessment framework presented in § 2.2, it is clear that a model is required to represent the transport system. Ideally, the model to represent the transport system would be able to model all policy measures and provide the outcomes of interest with sufficient detail and accuracy. Additionally the model should cover the whole of Europe and be a useful and practical tool for policy makers to support their decision-making. In Deliverable D3 [SUMMA, 2004] a description of the transport system was given that should be modelled to comply with these demands. As the SUMMA project does not have the resources to build a new model for the ground up, it builds upon earlier work. The basis for the work in SUMMA is the result of a Fourth Framework project called EXPEDITE. The EXPEDITE model system calculates the impact of transport policies on transport demand for the whole of Europe. It does this so quickly that it allows the development of a policy assessment instrument that can be used by policy makers from behind their own desks.

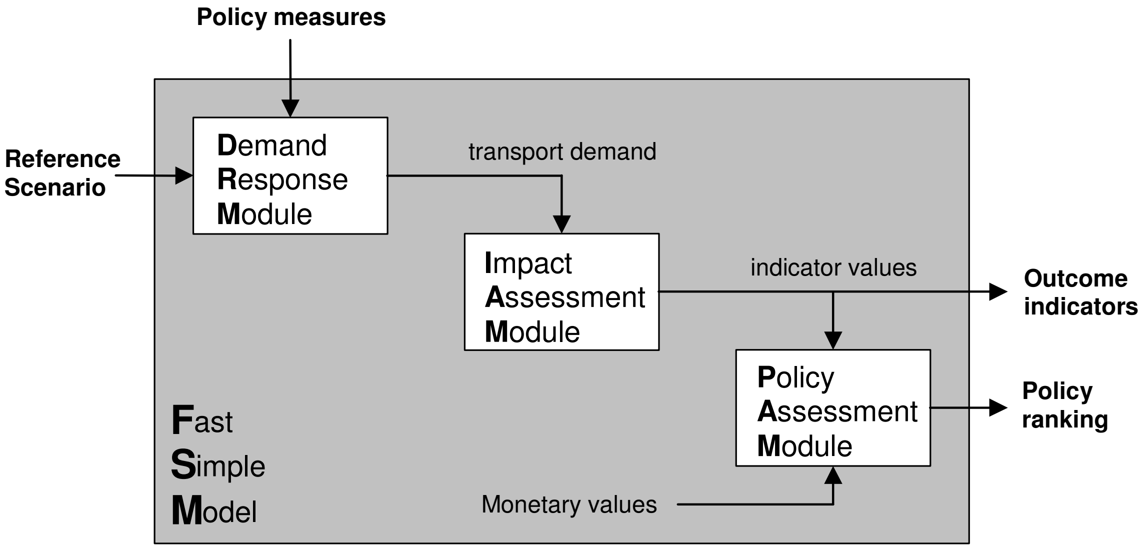


***Figure 2.9* – Structure of the Fast Simple Model**

With the EXPEDITE model system as basis, SUMMA has developed a new model for quantifying the impacts of transport policies. The model is called the SUMMA Fast Simple Model (FSM). The FSM is a user-friendly computer tool that enables the calculation of the impacts of various policy measures and policy packages. It integrates three submodules: (1) a Demand Response Module (DRM), which generates forecasts of demand for passenger and freight transport based on a Reference Scenario and influenced by policy changes, (2) an Impact Assessment Module (IAM), which estimates the environmental, economic, and social impacts of the transport demand, and (3) a Policy Assessment

Module (PAM), which produces an aggregate measure of the "sustainability" of the policies being assessed. The FSM is illustrated in Figure 2.9. As inputs, in addition to the Reference Scenario and the policy measures, the FSM also requires monetary values. The latter are used by the PAM to make trade-offs among the different outcomes from a policy (or policy package) in a consistent way.

The three modules will be discussed separately in the following sections. Following that, the Reference Scenario and the policy levers for the FSM will be discussed. More detailed descriptions of all FSM components can be found in appendixes A and B.

2.4.1. The Demand Response Module

The DRM calculates the demand for both passenger and freight transport. For passenger transport it calculates the number of trips made and the number of kilometres driven. The trips and kilometres are disaggregated by mode, by purpose, by population group, and by distance band. For each of the modes the shares of different vehicle types are calculated. For freight transport, the transport volumes are calculated in tonnes and ton-kilometres. The tonnes and ton-kilometres are disaggregated by mode, commodity, and distance band. For each of the modes the shares of different vehicle types are calculated.

The basis for the DRM is the model system EXPEDITE (De Jong et al., 2002). EXPEDITE calculates the transport demand at the NUTS2 level for the whole of Europe. It can provide the disaggregations mentioned above, but what it cannot do is calculate the shares for the different vehicle types. Because the latter is very important for calculating amongst others emissions (that depend strongly on the type of vehicle) a Vehicle Stock Model has been developed, to supplement EXPEDITE capabilities.

EXPEDITE is a type of model known as a meta-model. A meta-model is an simple aggregate model that approximates the behaviour of one that is more complex and disaggregate. Based on calculations with more detailed transport models for a (as much as possible) representative set of countries, a model is estimated that represents transport in the whole of Europe. EXPEDITE is not a network model and as such a meta-model will always be outperformed by a local, more detailed model, and a local model can additionally provide more detailed and fine-tuned policy analysis the EXPEDITE meta-model has been supplemented with a set of regional and city level models.

For details about EXPEDITE see the SUMMA Deliverable D5 and EXPEDITE.

The EXPEDITE meta-model was used as a basis for the implementation of the FSM in SUMMA. In the EXPEDITE model system, passenger and freight were modelled in two separate computer programmes. In the FSM passenger and freight transport have been integrated into a single computer tool. The EXPEDITE long distance passenger transport was limited to 160 km. The mode air was therefore omitted. In the FSM, distances above 160 km have now been included, so air passenger transport has been added. Although passenger and freight transport are integrated into one computer tool, there is no explicit link between them in the FSM. In other words, changes in passenger transport activities will not affect the freight transport outcomes of the model, and vice versa. In reality both passenger and freight transport are using the same infrastructure networks. Therefore, in reality, there are dependencies between freight and passenger transport (e.g. via road congestion). These dependencies are not taken into account in the FSM.

2.4.1.1. The Vehicle Stock Model

The EXPEDITE meta-model produces transport demand by mode, but not by vehicle type. Without vehicle types it is not possible to calculate environmental impacts of transport demand with a reasonable level of accuracy. As the environment is one of the three dimensions of sustainability within SUMMA it was decided to add a sub-model to the DRM to disaggregate the demands by mode to demands by vehicle type. This sub-model is called the Vehicle Stock Model (VSM).

The VSM calculates the share of different vehicle types in the total vehicle-kilometres for each mode in 1995 as well as in 2020. These shares allow disaggregating the transport activities by vehicle type instead of by mode.

The level of disaggregation differs between the modes, as also the level of disaggregation at which emission factors and other data are available differs between the modes. As shown in Table 2.10, the vehicle stock composition is very detailed for road transport, while there is no disaggregation for the maritime and air modes.

Table 2.10 — Vehicle stock composition

Road	Rail	IWW	Maritime	Air
Passenger cars (10)	Locomotives (4)	Tanker Vessel (7)	Ship (1)	Airplane (1)
Light Duty Trucks (2)	Rail cars (4)	Pusher Craft (7)		
Mopeds (1)	High Speed Train (1)	Dry Cargo Vessel (7)		
Motorcycles (4)				
Heavy Duty Trucks (4)				
Busses/Coaches (2)				

Between brackets the number of vehicle types.

The VSM in the SUMMA model is to a large extent derived from information in the more elaborate TREMOVE model. TREMOVE is a European policy assessment model to study the effects of different transport and environment policies on the emissions of the transport sector. The model estimates the transport demand, the modal shifts, the vehicle stock renewal, the emissions of air pollutants and the welfare level for different policies. The first version of TREMOVE has been developed as an analytical underpinning of the European Auto-Oil programme. Currently second version of TREMOVE is being developed in the context of the Clean Air for Europe Programme of Directorate-General Environment. More information on TREMOVE can be found on the website www.tremove.org.

First, the VSM disaggregates the number of vehicle-km form the DRM further into vehicle types (as small gasoline cars, medium gasoline cars etc.) using the actual vehicle stock in 1995. The main source for this is the TRENDS database.

For 2020 forecasting procedures are used. The disaggregation of total vehicle-km to individual vehicle types in 2020 is derived from a submodule, which forecasts the shares of different vehicle types in total vehicle-km in 2020. The choice model has variables such as purchase and usage costs of the vehicles. This vehicle choice model has been calibrated to give the same results as the second version of the TREMOVE model, which has more detail.

For cars and light duty trucks the submodule consists of vehicle choice modules, which also includes parameters as power, boot volume and income of the buyer to predict the purchase behaviour of consumers. Next to producing 2020 forecasts, these modules also enable simulating effects of policies that directly act on the vehicle fleets (such as fiscal and technological measures). Other forecasting approaches have been used for the other transport modes. A complete description can be found in Appendix A.

2.4.1.2. Regional and city level models

Within the consortium we have available for SUMMA two city models and two regional models for passenger transport. One of the regional models can also model freight transport. The models are the following:

- Hamburg (DE) — regional model (freight and passenger)
- Paris (FR) — city model
- Prague (CZ) — city model
- Randstad (NL) — regional model: three NUTS 2 zones in the centre of the Netherlands (North Holland, South Holland and Utrecht).

The regional and city models have two advantages over EXPEDITE: (1) they can provide more detailed information, e.g. data for calculating an outcome indicator that could not be calculated based on EXPEDITE outputs, and (2) they can assess a wider range of policies, e.g. infrastructure changes (because they are network models).

There are some important differences in the way the EXPEDITE meta-model and the regional and city level models are related to the FSM:

1. The EXPEDITE meta-model is an integral part of the FSM, which means that, after changing the inputs (policy levers), the EXPEDITE meta-model can be run to deliver new results.
2. The regional and city level models are not part of the FSM, which means that the FSM can only show results from of the regional and city level models for policies that have been pre-

run. Results for only for a limited number of policies and policy packages from the regional and city level models are available through the FSM.
3. Some policies can only be run in the regional and city level models, while other can only or also be run in the EXPEDITE meta-model.

The relevant information from the above mentioned regional and city level models have been integrated into the FSM. This is done on a policy-by-policy basis — the regional and city level models only provide relevant information if they have been run for a policy. When for a certain policy information is available from a regional or city level model it replaces the estimate from the EXPEDITE meta-model; When for a certain policy no information is available from a regional or city level model (the policy was not run) then the estimate for the subsequent NUTS2 zone is set to 0 (hence the estimate from the EXPEDITE meta-model is never used (for consistency reasons).

Consequently, there are three situations in relation to availability of calculated impacts of policy measures the regions and cities:
- There is a set of policies that was pre-run with the regional- and city-level model and that **can** also be run with the EXPEDITE meta-model (this is a very limited set)
- There is a set of policies that was pre-run with the regional- and city-level model and that **cannot** be run with the EXPEDITE meta-model (this is also a very limited set)
- There is a set of policies that can only be run with the EXPEDITE meta-model (this is a virtually unlimited set).

2.4.2. The Impact Assessment Module

The Impact Assessment Module calculates the values of the outcome indicators. The point of departure was the list of indicators published in Deliverable D3. Not all the D3-indicators could be specified and implemented in the IAM.

Most indicators implemented in the IAM are based on the results of the DRM (transport demand and vehicle stock composition). Some indicators do not depend on the demand; they have been defined based on external data. Table 2.11 shows the implemented indicators and whether or not they are based on DRM results.

Table 2.11 — outcome indicators

Code	Outcome indicator description	DRM-based
EC11	Intermodal Terminal facilities	Yes (H)
EC12	Accessibility of origins/ destinations	Yes (H)
EC13	Access to basic services	Yes (H)
EC21	Supplier operating costs	Yes
EC22	Transport- related expenditures of households	Yes
EC23A	Transport prices for passenger transport	No
EC23B	Transport prices for freight transport	Yes (H)
EC32	Utilisation rates	Yes
EC33	Energy consumption efficiency of transport sector	Yes
EC34	Energy efficiency	Yes
EC41	Infrastructure costs	No
EC43A	External transport costs (accidents)	Yes
EC43C	External transport costs (environmental costs)	Yes
EC44	Energy consumption	Yes
EC52	Public revenues from taxes and traffic system charging	Yes
EN11	Energy consumption	Yes
EN12	Consumption of solid raw materials	No
EN13	Land take	No
EN21	Fragmentation of land	No
EN23	Losses of nature areas	No
EN25	Light emissions	No
EN26	Collisions with wildlife	Yes
EN31	Transport emissions of greenhouse gases	Yes
EN33	Transport emissions of air pollutants	Yes
EN41	Hardening of surfaces	No

Code	Outcome indicator description	DRM-based
EN51	Exposure to transport noise	Yes
EN61	Generation of non-recycled waste	No
SO11	Access to basic services	Yes (R)
SO13	Car independence	No
SO14	Affordability	Yes
SO15	Trip length	Yes
SO21	Accident related fatalities and serious injuries	Yes
SO31	Walking and cycling as transport means for short distance trips	Yes
SO42	Traffic calming	Yes (P)
SO43	Children's journey to school	Yes
SO52B	Vertical equity (accessibility)	Yes
SO63	Long distance commuting	Yes

H=Hamburg, R=Randstad, P=Prague

2.4.3. The Policy Assessment Module

The Policy Assessment Module (PAM) produces an aggregate assessment of a policy measure (or policy package), which can be used to judge the relative attractiveness within the set of the policy measures (or policy packages) being evaluated. The aggregation lays in the fact that the sustainability indicators are combined into one policy evaluation function, for each of the modelled regions.

Policies have a variety of, sometimes, conflicting effects. It is rare that a single policy performs the best on all relevant criteria. Policymakers must make trade-offs among various criteria in choosing a policy. In making such choices, it is helpful for policymakers to have information about how a policy performs on individual criteria, as well as the aggregate performance of a policy. Thus, the PAM generates information about the monetary impact of individual policies or policy packages on individual criteria, as well an aggregate measure of the performance of the policy (in monetary terms).

The goal of the PAM is to translate the direct transport effects and the (monetised) sustainability indicators into useful policy terms. This required the construction of a welfare type of objective function that sums and weights effects of a very diverse nature e.g., time savings, changes in tax revenues, changes in accident rates, ecological impacts and social impacts. The policy evaluation function is based upon the TRENEN[19] and TREMOVE[20] experiences, as well as the UNITE[21] and MC-ICAM[22] work.

With such a function, sustainability has been operationalised through an objective function based on economic welfare theory. The sustainability objective function includes and weights direct effects and indirect effects of transport policies, as represented by indicators and their weights. It also expresses (all) effects in monetary terms to make them comparable.

The *structure of the welfare function* is important because it drives the selection of optimal policy parameters.

In a *realistic*, partial equilibrium[23] transport model, individual utility consists of 4 parts[24], see Table 2.12.

The *first term* in the welfare function can be seen as a generalised consumer surplus (area under the demand curve minus the consumers' expenses). There are three important issues with respect to this utility function formulation. First, it is expressed in terms of generalised costs rather than money prices. This allows to take into account time losses due to congestion and the reaction of consumers on variations in speed, waiting and walking time, and so on. Second, the utility formulation allows treating

[19] TRENEN reports: www.europa.eu.int/comm/transport/extra
[20] TREMOVE project, reports and data: www.tremove.org
[21] UNITE project, reports: www.its.leeds.ac.uk/projects/unite
[22] MC-ICAM project: www.mcicam.net
[23] The SUMMA Fast Simple Model is a partial equilibrium structure, because we do not deal explicitly with the labour market and do not model the feedback from freight transport prices into the prices of non-transport commodities.
[24] Bruno De Borger, Stef Proost, Reforming Transport pricing in the European Union – A Modelling approach, Edward Elgar, 2001

the different transport modes simultaneously. This is difficult with a traditional consumer surplus approach defined on each market when transport modes are substitutes, because the consumer surplus is not uniquely defined anymore in that case: it depends on the path of integration. Third, the income term takes into account the effect of changes in tax revenue. In other words it is assumed that, the change in tax income is ultimately redistributed to the consumers. The income term also takes into account the profits or losses of the suppliers of transport ("producer surplus"). Assume a transport provider decreases his price below the marginal cost. This benefits the consumer directly but the loss must be paid for by society, which implies ultimately an income decrease for the consumer.

Table 2.12 — The structure of the welfare function

Welfare is the sum of:	
Utility of households from private goods	Utility is a function of three elements: - Prices of non transport goods, which are taken as given; - Generalised costs of all alternative passenger transport options; the generalised price includes the resource costs and the time costs (incl. on board, waiting, walking time for mass transit); - Exogenous income + profits of the suppliers of transport + recycled tax revenue.
+ Utility of freight transport users	Represented by minus the total cost function of the production sector that is a function of three elements: - The level of production, specified exogenously; - The generalised cost of all freight transport options; these equal the money costs plus the time costs; - The prices of other production factors, which are taken as given.
+ Tax Revenue use correction	This correction is necessary to take into account the efficiency effects on the non-transport markets (e.g. labour) of the particular way in which tax revenues are assumed to be used.
- Environmental, accident and other external costs	Represents the product of environmental damage and the monetary valuation of the damage + the external accidents costs + other external costs.

The *second term* in the table above represents the cost level of firms. We assume that firms choose that mix of freight transport services that minimises their overall production costs for given production level. Assuming a constant production level, the benefit of any change in generalised freight transport prices equals the change in total production costs for the economy. This can be seen as a consumer surplus term for the users of freight transport. The level of production is taken as fixed here, because (a) there is only a small feedback effect from freight costs on production levels, and (b) the expected variation in the demand for non-transport consumption that can result from changes in transport prices will be small.

The *third* term in the welfare function is a correction term to take into account the secondary effects of changes in tax revenues. When there are no other distortions in the economy and when additional tax revenue is redistributed to the consumers in a lump sum form, this term drops out: the tax increase and the redistribution of the receipts are taken into account in the utility function. Other forms of revenue use lead to positive or possibly negative correction terms. The assumption taken in SUMMA is that changes in transport tax revenues are compensated by changes in the distortionary labour tax levels. This leads to positive correction terms for transport tax revenues.

The *fourth* term takes into account the environmental, accident and other externalities that have been expressed in monetary terms. The congestion externalities are integrated in the utility function formulation via the average time costs in the generalised prices. The other externalities also could be integrated into the utility function of the consumers but this would complicate the formulation.

The absolute levels of the PAM function in the base scenario or in policy scenarios are difficult to interpret. They give only a partial view upon total welfare, as the PAM only calculates the transportation aspects of the total welfare. What is of interest for SUMMA, are not the absolute levels in scenarios, but the differences between the PAM function values in the base scenario and the simulation scenarios. These differences represent measures for the overall sustainability impact of policy scenarios in monetary terms. This way, policies can be ranked according to their effects on overall sustainability.

Therefore, the sustainability impact of policies in the SUMMA model will be calculated as:

δ Sustainability = δ Consumer Surplus (δ CS) + δ Producer Surplus (δ PS) (current generation) + δ Government Transfers (δ GT) (current generation) - δ External Effects (δ EC) (current & future generation)

The components δ CS and δ PS represent the aggregate affects of term 1 (passenger transport) and term 2 (freight transport).

For comparability, all values need to be deflated to one reference year. SUMMA uses 2020. Negative values indicate a sustainability loss. Positive values a sustainability gain.

The changes in sustainability levels can be calculated by model region. It also includes external costs and the intra- and inter-generational equity aspects.

2.4.3.1. Implementation in the FSM

The above-described theoretical approach has been implemented in the SUMMA FSM. In the model, each term of the PAM function is calculated as a weighted function of indicator levels and/or other model outcomes. Most indicators calculated in the IAM could be included in the PAM. For four indicators this was not feasible, due to a lack of data.

However, despite the fact that the greater part of the indicators could be included, some limitations of the PAM modelling in the FSM should be reported. The policy evaluation function described above represents the optimal formulation of a welfare function in a (transport) partial equilibrium model. In SUMMA the PAM function that has been implemented in the FSM deviates from this optimal formulation with respect to a number of issues. This is mainly due to the following limitations of the FSM :

Quite some indicators have been included in the Consumer Surplus or Producers Surplus terms. The reason is that the CS and PS terms consist of all the effects that occur directly on the user and supplier of the transport system. However, the CS and PS terms are usually rather difficult to calculate. This is also the case in the FSM. The DRM does not provide enough information, therefore estimates haven been made (a Logsum for CS and the total transport expenses for PS).

The Expedite model has been taken as the main basis for the DRM. The Expedite model does not provide a measure for travel time from which time losses due to congestion can be derived (indicator EC 43B). This means that the effects of policies on the time component of generalised prices cannot be taken into account in the calculation of the utility of households nor the utility of freight transport users.

The absence of explicit congestion modelling also leads to the fact that passenger transport and freight transport are not linked in the DRM. This has implications on the modelling of policies with e.g. large congestion effects. A policy that would reduce the number of road freight km, has in reality an effect on congestion and thus on the number of car km. This effect is not included in the DRM, and therefore also not in the PAM results.

The FSM does not deliver information on the influence of policy measures on the total production volume in countries. Indeed, for none of the proposed indicators relating to production volumes (e.g. GDP) changes following from policy measures could eventually be quantified or modelled in the FSM. In a partial equilibrium model as the FSM it is acceptable to assume constant production volumes. Under that condition, the ‘utility of freight transport users’ term in the policy evaluation function can be estimated as the difference in total industry expenditures on freight transport and other inputs between the base scenario and the simulation. However, the FSM does not deliver information on substitution processes between freight transport and other industry inputs, such as stocks or local logistic infrastructure. Therefore industry expenditure changes relating to changes in the consumption of other production inputs cannot be taken into account in the SUMMA PAM function.

The FSM does not allow calculating profits of suppliers of transport and changes therein due to policies.

Four indicators have been abandoned in the PAM. All of them are environmental indicators with a major lack of data.

Some indicators would have been interesting to further refine the PAM results, but were not available in the IAM, as effects on GDP. Again, this is due to constraints in the DRM.

More detail on the Policy Evaluation Function as well as the calculation formulae used in the FSM can be found in Appendix B.

As show in the policy runs, the PAM is a useful indicator to assess sustainability correctly. However, the constraints mentioned above do have an impact on the ranking of the policies, as described in Paragraph 7.6. The most important effect on the results is the missing link between the passenger model and freight model in the DRM. Due to this, rebound effects could not be calculated. Another important effect on the results was caused by the external effects of congestion. From literature, we know that these are important, but this does not reflect in the results.

2.4.3.2. Monetisation of the indicators

For each of the monetary values required in the policy evaluation function values were provided as far as possible. According to the objectives of the policy assessment module monetary values are based on economic welfare theory. This implies that monetary valuation is based on individual preferences, which are usually expressed as willingness to pay (WTP) for something that improves individual welfare. The total value of an impact is the sum of the WTP of individuals, no special weight is given to any particular group.

The simplest case would be if market prices were available for the effects observed. This, however, is not the case for most of the outcome indicators. For this reason, monetary values have to be estimated using direct methods measuring the WTP by surveys (so called stated preference methods), or indirect methods analysing observed market data (so called revealed preferences methods). In cases where no WTP value can be estimated, either because no clear impact endpoint can be defined or quantified reliably, or the associated uncertainties appear too high (e.g. impacts of climate change), abatement costs for reaching a socially accepted goal may be used as a proxy for WTP values. Abatement costs are the costs associated to reaching a certain level (of emissions, of service) with minimal cost. This is valid under the assumption that people or the society as a whole are prepared to spend a certain amount on the abatement of e.g. CO_2 emissions (e.g. to reach the Kyoto targets). For a more detailed description of underlying principles and methods of monetary valuation see chapter 9 of Deliverable 3.

Table 2.13 gives an overview of the monetary values required in the policy evaluation function and the availability of values. Indicators EC43A and EC43C can be used directly, as the information given is identical (valuation of injuries slightly differs as SO21 defines the number of accidents with injuries and not the number of injuries; however this is considered in the monetary valuation and therefore the result is the same).

Table 2.13 — Monetary values required in the policy evaluation function

Parameters in policy evaluation function	Unit	Description	Availability
p_m	€ / pkm € / tkm	Price per mode for passenger and freight transport	Calculated as EC23
TR	€	Total tax revenues and subsidies from the transport sector	Tax revenues calculated as EC52B; Subsidies provided separately (see Annex B)
$maec_{fatality}$	€ / fatality	Monetary average external cost of fatality	See EC43A
$maec_{injury}$	€ / injury	Monetary average external cost of injury	See EC43A; however not number of injuries is used, but number of accidents with injuries; the monet. factor is defined correspondingly.
$maec_{increasedlandtake}$	€ / km^2	Monetary average external cost of increased land take	See EC43C
$maec_{decreasedmeshsize}$	€ / km^2	Monetary average external cost of decreased mesh size	No appropriate studies available on the monetary cost of decreased mesh size.
$maec_{decreasedlighting}$	€ / km^2	Monetary average external cost of decreased lighting	No appropriate studies available on the monetary cost of decreased lighting
$maec_s$	€ / animal	Monetary average external cost per killed animal of species s	60 € / animal; estimate based on the expenditures for pets.
$maec_p$	€ / tonne	Monetary average external pollution cost for emission of substance p	See EC43C
$maec_{noise65}$	€ / person	Monetary average external cost of noise due to amenity losses >65 dBA	See EC43C
$maec_{noise40}$	€ / person	Monetary average external cost of noise due to amenity losses >40 dBA	55 dB(A) is generally considered as threshold, below which no amenity losses occur.
$maec_f$	€ / Mtoe	Monetary average external cost due to fuel production (not fuel combustion) per unit fuel consumption	3.6 E+7 € / Mtoe Calculated as costs due to fuel production emissions of airborne pollutants based on Lewis (1997), European Commission (2003) and cost factors $maec_p$
$maec_{decreasedslowtrips}$	€ / person	Monetary average external health cost of decreased number of cycle and walk trips	No appropriate studies available
$maec_{decreasedslowstreets}$	€ / %	Monetary average external cost of decreased number of slow streets (< 30 km/h)	No value for change in relative share available
$maec_{verticalequitye}$	€ / %	Monetary average external cost of increased ratio (expenditures)	No value for change in relative share available
$maec_{verticalequityt}$	€ / %	Monetary average external cost of increased ratio (travel time)	No value for change in relative share available

2.4.3.2.1 Issues in the context of monetary valuation

2.4.3.2.1.1 Discounting of future values

A critical element, not only within monetary valuation but all approaches of decision-making, is how to compare impacts occurring today with impacts occurring in the future. Usually, the impacts are discounted to a common base year: a cost or benefit of X Euro appearing T years from now has a present value of $X / (1+r)^T$. Assuming a non-negative discount rate r this implies that a cost or benefit occurring in the future is given a lower value today. Clearly the higher r and T are, the lower the discounted value.

The practice of discounting arises because individuals attach less weight to a benefit or cost in the future than they do to a benefit or cost now. Impatience, or 'time preference', is one reason why the present is preferred to the future. The second reason is that, since capital is productive, a Euro worth of resources now will generate more than a Euro worth of goods and services in the future. Hence an entrepreneur would be willing to pay more than one Euro in the future to acquire a Euro worth of these resources now. This argument for discounting is referred to as the 'marginal productivity of capital' argument; the use of the word marginal indicates that it is the productivity of additional units of capital that is relevant.

Individual time preference describes the preference for present consumption over future consumption. It is a key concept underlying the theory of intertemporal choice. The strength of this preference is measured by the *rate of time preference* (or synonymously *discount rate*). However, there is substantial dispute on the appropriate discount rate to be used. In particular for long-term effects not an individual rate of time preference should be applied, but a "social rate of time preference". The latter should represent the view of the whole society instead of that of the individual and is particularly relevant for decisions taking effect in the future.

For long term impacts (or investments) extending to more than one generation, there are some arguments, that lower values should be used:

- the individual time preference is influenced by the limited individual life time, so the interests of future generations may not be fully reflected in the current discount rates;
- the average long-term economic growth is lower than the growth observed in the last decades in Europe.

Furthermore, it can be argued, that an increase of income in the future might lead to a shift in the relative utility of goods in the sense, that a better environment or health gains in importance relative to market goods. This could be implicitly included by decreasing the discount rate used for environmental and health damage. However, it is better to treat this argument separately by explicitly introducing increases in the monetary values of future environmental impacts.

Based on the vast literature on discount rates, in the ExternE project a discount rate of 3% for the best estimates was used, with 0% and 1% recommended for sensitivity analysis (see Hunt and Markandya, 2001).

2.4.3.2.1.2 Benefit transfer

It can be expected that monetary values will not be available for all outcomes of interest in all countries and contexts. Under certain conditions values may be derived from studies in other countries or similar contexts. This so called benefit transfer is 'an application of monetary values from a particular valuation study to an alternative or secondary policy decision setting, often in another geographic area than the one where the original study was performed' (Navrud, 1994). There are three main biases inherent in transferring benefits to other areas:

a) original data sets vary from those in the place of application, and the problems inherent in non-market valuation methods are magnified if transferring to another area;
b) monetary estimates are often stated in units other than the impacts. For example, in the case of damage by acidic deposition to freshwater fisheries, dose response functions may estimate mortality (reduced fish populations) while benefit estimates are based on behavioural changes (reduced angling days). The linkage between these two units must be established to enable damage estimation;
c) studies most often estimate benefits in average, non-marginal terms and do not use methods designed to be transferable in terms of site, region and population characteristics.

Transferability depends on being able to use a large body of data from different studies and estimating the systematic factors that would result in variations in the estimates. In most cases the range of studies available are few. More can be done to carry out meta-analysis, but it will take time. The best practice in the meantime is to use estimates from sources as close to the one in which they are being applied and adjust them for differences in underlying variables where that is possible. Often the most important obstacle to systematic benefit transfer, however, is a lack of documentation in the existing valuation studies.

2.4.3.2.1.3 WTP and equity

One objection often voiced in the use of WTP is that it is 'income constrained'. Since you cannot pay what you do not have, a poorer person's WTP is less than that of a richer person, other things being equal. This occurs most forcefully in connection with the valuation of mortality effects where the WTP to avoid an increase in the risk of death is measured. In general one would expect the 'value' for a poor person to be less than that of a rich person. But this is no more or less objectionable than saying that a rich person can and does spend more on health protection than a poor person; or that individuals of higher social status and wealth live longer on average than persons of lower status; or that better neighbourhoods will spend more on environmental protection than poorer neighbourhoods. The basic inequalities in society result in different values being put on health, the environment, etc. by different people. One may object to these inequalities, and make a strong case to change them, but as long as they are there, one has to accept the consequences. One could argue, for example, that increased expenditure on high technology medicine in Europe is unethical, even though the citizens of that region have a WTP that justifies such expenditures, because the same expenditure on preventative medicine in a poor developing country would save more lives. However, society does not accept such an argument, taking the view that most decisions about allocation of resources are predicated on the existing inequality of income and wealth, both between and within societies.

2.4.3.3. Monetisation approaches used for different Outcome Indicators

The process of identifying approaches for assigning monetary values to the outcome indicators follows two steps. In the first step the values affected are identified; for instance in the case of air pollution it is not the emission of SO_2 per se that has an effect on the utility of people, but the impacts on health, ecosystems etc. caused. So in the case of this example, the impairment of human health is one of the values affected. In the second step approaches for monetary valuation are identified.

Many outcome indicators are defined as percentage values. For calculating monetary values they usually have to be transferred into absolute figures (for example instead of "percentage of trips done by walking or cycling" one could say "number of trips per day, per week or per month). Often it is possible to derive the absolute number, but this needs additional data (in our example the total number of trips done by walking or cycling has to be known).

In theory, almost every indicator could be valued with the stated preference approach. However, appropriate studies, respectively values are often not available, therefore – wherever possible –costs or prices will be used. The valuation approaches suggested describe the ideal case in which appropriate monetary values are available. However, only for some indicators this ideal approach will be feasible, while for many a second best solution will have to be used and for some monetary valuation will be impossible at the moment.

As the main objective of monetary valuation of outcome indicators is the aggregation of values, an important issue is to clearly identify potential overlaps to avoid double counting. Such overlaps may occur both between outcome indicators (e.g. *EC13 Access to basic services* and *EC14 Commuting time*) and the monetary valuation approaches (e.g. *EC43 External transport costs* overlaps with SO21, EC13, EC14 and others). Such overlaps are indicated in the description of the approaches for the indicators given below.

A general issue is whether the approach for monetary valuation appropriately captures the value measured by an indicator. This is important when aggregating the different values, because it determines the weight of an indicator in the whole set of indicators. However, this is not only a problem of monetary valuation, but of any kind of aggregation of values.

The following sections give an overview of the affected values identified for each outcome indicator and the valuation approach suggested in form of a table for each outcome of interest.

2.4.4. Impact Assessment Module

The IAM contains a number of outcome indicators that are not based on the transport demand and will thus not be influenced by policies affecting the transport demand. Their values would not be changed by policies. Rather than removing these outcome indicators from the FSM all-together (since their value would not change for different policies), a few policy levers have been defined that will directly affect the outcome indicators in the IAM. An example of such a policy lever is “add train infrastructure”. The FSM does not explicitly model train infrastructure, so demand will not be affected, but indicators such as land take by infrastructure (EN13) will now be affected directly.

Another change to the original concept is caused by the fact that SUMMA is evaluating White Paper policies with respect the sustainability goal and not their operational goal. The White Paper also has the overall sustainability goal, but the White Paper has operationalised this by a number of operational goals for which it defined its policies. The White Paper includes goals such as mode shift, which describes changes inside the transport system. The SUMMA outcome indicators will allow the assessment of policies towards the overall sustainability goal, but not towards the operational goals. To assess the White Paper policies also on their operational goals we added a group of system indicators (e.g. mode shift, average length of car trips, number of car trips).

2.4.5. From Policy Measures to Policy Levers

Most policy measures cannot be implemented in the models directly. The models have a set of policy levers that have a direct influence on the model and the policy measures need to be translated in terms of these levers. Most levers from the FSM will be an input to the DRM (some for freight some for passenger). Two levers will be an input to the IAM, and one of these will be an input to both the DRM and the IAM.

Many of the levers refer to changes in time or cost. Although the DRM is not a network model, the models on which it was based were, and thus changes in time and cost will lead to changes in transport demand (tours made, kilometres driven). However, instead of the very specific changes possible in network models (such as adding or improving a road, or changing the maximum speed on a road) the changes in the DRM are generalised changes in cost and time as compared to the reference situation (e.g the travel times in the network have improved by x%, or the cost of car transport have been reduced by y%).

Table 2.14 — Levers used by models

Policy description	Lever	Used by:
Car Passenger		
Hybrid fixed car cost	% change	DRM passenger
Hybrid variable car cost	% change	DRM passenger
Other fixed car cost	% change	DRM passenger
Other variable car cost	% change	DRM passenger
Car Time	% change	DRM passenger
Add car-infrastructure	% change	DRM & IAM
PM filter	on / off	IAM
Train Passenger		
Train Cost	% change	DRM passenger
Train IVT (In Vehicle Time)	% change	DRM passenger
Train Wait time	% change	DRM passenger
Train Access time	% change	DRM passenger
Add infrastructure	% change	IAM
BTM Passenger		
BTM cost	% change	DRM passenger
BTM IVT	% change	DRM passenger
BTM Wait time	% change	DRM passenger
BTM Access time	% change	DRM passenger
Freight Lorry		
Lorry cost	% change	DRM freight
Lorry time	% change	DRM freight
Lorry handling/storage cost	% change	DRM freight
Lorry frequency	% change	DRM freight
Freight Train		
Rail/combined cost	% change	DRM freight
Rail/combined time	% change	DRM freight
Rail/combined handling/storage cost	% change	DRM freight
Rail/combined frequency	% change	DRM freight
Freight Inland WaterWays		
Inland Waterway cost	% change	DRM freight
Inland Waterway time	% change	DRM freight
Freight Sea		
Sea cost	% change	DRM freight
Sea time	% change	DRM freight
Sea handling/storage cost	% change	DRM freight
Sea frequency	% change	DRM freight

2.4.6. The Reference Scenario

In performing the policy analysis, we are using the reference scenario from the EXPEDITE project [De Jong, et al., 2002], which is based on the SCENES Reference Scenario for 2020 [SCENES Consortium, 2001]. In SCENES, the scenarios for 2020 consist of two elements. The first is called the 'External scenario', to emphasise that it includes autonomous changes, not policy changes. The second component is a 'Transport scenario'. The part of the EXPEDITE Reference Scenario that is based on the SCENES External scenario includes for 2020:

- Population will grow in most EU15 countries, but will decline in some (e.g. Italy, Germany); net migration is included in these forecasts. For the New Member States, population will decline somewhat, except in Poland and the Slovak Republic; by the year 2020, the total EU15 population will have grown by almost 4% compared to 1995.

- The proportion of persons 65 years and older will increase.
- Total employment will increase in most EU15 countries, but will decline in some (e.g. Greece); the same applies to the New Member States.
- Car ownership rates per 1000 persons will increase in all countries, especially in Eastern Europe; for the EU15 by about 25% in total, for some New Member States the motorisation rate will almost double between 1995 and 2020.
- For most EU15 countries the gross domestic product (GDP) will in the period 1995-2020 grow by between 2 and 3 % per year; in the New Member States the growth rates are 4-5.5%.
- The transport networks will be expanded according to planned national and international infrastructure developments (especially the European Commission's 'TEN Implementation Report'). In the runs with the EXPEDITE meta-models (which are not network models), we use the assumption that in the Reference Scenario in the EU15 the travel times will stay the same. Where travel demands grow over time, at some links the new demand may exceed the old capacity. Here our assumption implies that capacity will be expanded to keep the network performance at the 1995 level. For the New Member States we assume that the network performance of the road and rail networks will become better between 1995 and 2020, moving towards West-European standards.

EXPEDITE combined the SCENES External scenario (modified for motorisation in the EU15) with the SCENES Constant Cost scenarios for passengers and freight to produce its Reference Scenario for 2020. This implies that in the Reference Scenario the cost for all modes remains fixed in real terms at the 1995 levels, except for Eastern Europe, where the car becomes cheaper and public transport more expensive. In the following, this scenario is called the 'SUMMA Reference Scenario' or, more simply, the Reference Scenario.

2.5. POLICY ASSESSMENT

2.5.1. Defining the policy goals

A *goal* is a generalized, non-quantitative policy objective (e.g., "reduce air pollution" or "ensure traffic safety"). Policy actions are intended to help meet the goals. In SUMMA, the policymakers' overarching goal is to facilitate sustainable transport and mobility. In order to identify outcomes of interest, however, this high-level goal had to be operationalised by relating it to more concrete goals. In Deliverable 2 [2003], we identified three pillars of sustainable development – economic, environmental, and social. Each of these pillars has its own subgoals. For example, economic subgoals include improving economic development and efficiency; environmental goals include improving biodiversity and reducing air pollution; social goals include reducing poverty and improving intergenerational equity. In Deliverable 3 [2004] we related these subgoals to outcome indicators. The subset of these outcome indicators that were implemented in the FSM is presented in § Table 2.11.

The White Paper is targeted on its own set of goals, some of which match sustainability subgoals (e.g., reduce air pollution) and some of which do not (e.g., make transport users pay the full costs of their activities). In order to be able to assess the performance of a White Paper policy relative to its desired effects, we had to first identify the desired effects. As already mentioned, some of the desired effects are already captured in the sustainability outcome indicators. For those that are not, we had to define additional outcome indicators with which to assess the policies. For example, one of the most important goals of the White Paper policies is to shift transport off the roads and onto other modes, thereby bringing the modes more into balance. Of course, shifting transport off the roads will help to achieve some of the sustainability goals, such as reducing pollutant emissions. But, mode shift is an intermediate goal (toward the higher-level goals of reducing air pollution or reducing energy consumption), not an end in itself. In order to assess the effects of some of the White Paper policies, we need to identify these intermediate goals and specify outcome indicators to estimate the extent to which the policies might help to achieve the White Paper goals and subgoals.

The White Paper policies are divided into several categories. We used these categories as the starting point for identifying the goals and subgoals. The overarching goal of the European Transport Policy as described in the White Paper is to achieve “a modern transport system which is sustainable from an economic and social as well as an environmental viewpoint” (EC, 2001, p.10). In order to achieve this goal, four major ‘policy guidelines’ are listed (EC; 2001; p.4-5):

5. Shifting the balance between modes of transport
6. Eliminating bottlenecks
7. Placing users at the heart of transport policy
8. Managing the globalisation of transport

Within most of these guidelines, the White Paper described policy goals. The set of goals and subgoals that we derived from the White Paper are:

1	**Shifting the balance between modes of transport**	
	1.1	*Improving quality in the road sector*
	1.2	*Revitalising the railways*
	1.3	*Controlling the growth in air transport*
	1.4	*Adapting the maritime and inland waterway transport system*
	1.5	*Linking up the modes of transport*
2	**Eliminating bottlenecks**	
3	**Placing users at the heart of transport policy**	
	3.1	*Unsafe roads*
	3.2	*The facts behind the costs to the user*
4	**Managing the globalisation of transport**	
5	**Rationalising urban transport**[25]	
6	**Achieving a sustainable transport system**	

Out of these goals and subgoals, we identified eight policy goals for which we are able to evaluate policies using the FSM the goals are:

1	**Improving quality in the road sector**
2	**Revitalising the railways**
3	**Adapting the maritime and inland waterway transport system**
4	**Linking up the modes of transport**
5	**The facts behind the costs to the user**
6	**Managing the effects of transport globalisation**
7	**Rationalising urban transport**
8	**Achieving a sustainable transport system**

A goal hierarchy can be constructed for some of the goals, as is illustrated in Figure 2.10 for the goal “Improve Road Sector”. There are six subgoals under this goal:

- Pay full costs
- Improve road safety
- Improve accessibility
- Reduce air pollution
- Reduce road congestion
- Increase energy efficiency

One of the subgoals under the goal of improving the road sector is “reduce air pollution”. This goal can be achieved in three different ways: (1) by reducing the number of car trips, (2) by reducing the length of each car trip, or (3) by leaving the car trips unchanged, but reducing the pollutant emissions from each trip. These three would be subgoals under the goal of reducing air pollution. They are not yet policies; they are policy goals. Similarly, the subgoal of reducing car trips can be achieved in at least two ways: (1) the trip could be eliminated entirely (e.g., by telecommuting) or (2) the trip could be switched to a less-polluting mode (e.g., a slow mode or public transport). Finally, reducing the length of a car trip could be achieved by (1) switching part of the trip to a less-polluting mode (i.e., making the trip intermodal) or (2) shortening the distance to be travelled (e.g., by going to a closer shop). The policies in the White Paper can be related to these and other goals. Similarly, we can identify outcome

[25] In the White Paper, this is a goal within Policy Guideline 3 (Placing users at the heart of transport policy). But, since we are doing separate policy analyses at the European and urban levels, we decided to make this a separate goal category.

indicators for measuring the degree to which these policies are able to achieve each of these goals and subgoals (these are shown on the bottom row of the goal hierarchy – e.g., EN33ACarNOx, which refers to the amount of NOx emitted by cars).

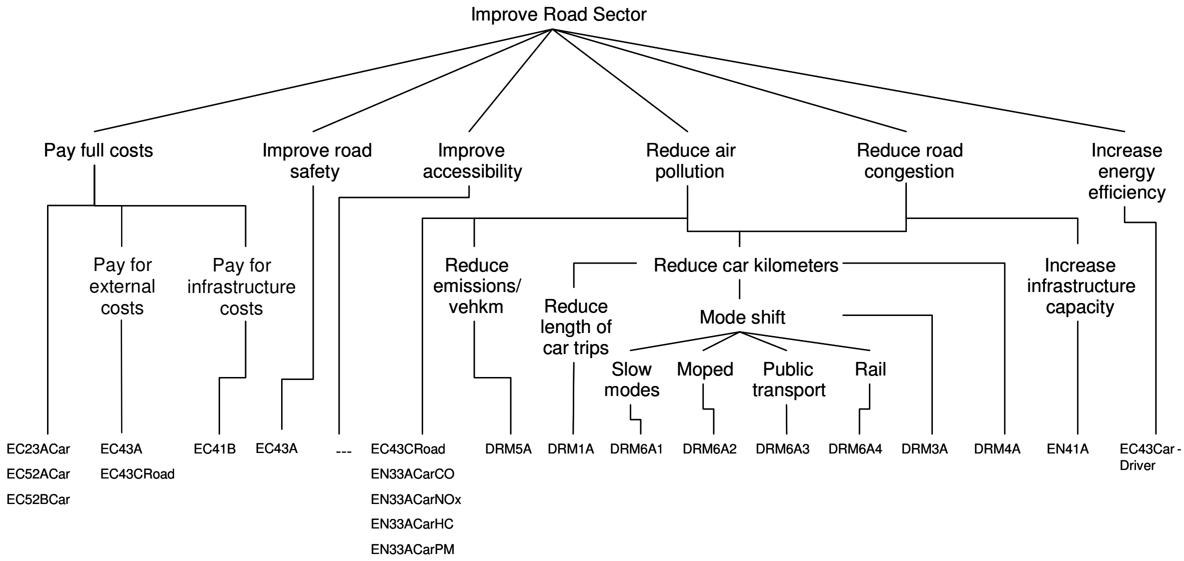


Figure 2.10 – Goal tree for the goal "Improve Road Sector"

The goal tree related to the non-road land modes is less complicated than that related to the road sector. In the case of both the railways and the water modes (maritime and inland waterways), the overarching goal is to make these modes more attractive and competitive in order to improve the balance among the modes. The policies in the White Paper focus on achieving these overarching goals, and the outcome indicators for these goals are directly related to the amount to which the use of the roads is reduced and the use of the non-road modes is increased.

In the case of air transport, the overarching White Paper goal is controlling its growth. There are four subgoals: (1) tackling saturation of the skies, (2) rethinking airport capacity and use, (3) striking a balance between growth and the environment, and (4) maintaining safety. The White Paper includes several policies for achieving these goals. However, the FSM does not have policy levers outcome indicators that will enable us to assess the performance of any of these policies relative to the White Paper goals, so we will not present any further elaboration of the hierarchy of air transport goals.

In most cases, the goals presented above apply to both passenger and freight transport. However, the hierarchy has to be modified slightly in each case. For example, the goal tree for freight transport does not include goals related to public transport or slow modes. And the goal tree for passenger transport does not include goals related to maritime or inland waterway transport.

In our policy analysis, we will perform separate analyses for transport at the European and national levels (which we will call 'non-urban') and at the urban/regional level (which we will call 'urban'). Similar goal trees apply to these two geographical levels. The main differences in the analysis are that different policies will be used to help achieve the goals (e.g., parking policies will be used at the urban level), and some outcome indicators at the non-urban level are not relevant or not calculated at the urban level (e.g., public revenues from taxes and traffic system charging).

The division of goals and policies between passenger and freight transport and between urban and non-urban areas, led us to perform separate policy analyses for four different domains:

- Passenger non-urban
- Passenger urban
- Freight non-urban
- Freight urban

The goal hierarchies for each of these are given in the subsections in which the corresponding policy analysis is described.

An analysis of the White Paper goals and policies led us to define 27 additional outcome indicators to be produced by the DRM. The translation of the White Paper goals into FSM outcome indicators is described in § 2.3.

2.5.2. Defining the policy measures

2.5.2.1. Introduction

In the White Paper [EC, 2001], a large number of policy measures are proposed. But there are only vague statements about what the policies actually are and how they would be implemented in the system. Therefore, to quantify the impacts of the policies using the FSM, we had to decide which of the policies could be run through the FSM models and how to represent each of them in the models (i.e., what changes to make to the system in order to represent the policy). In order to do this, we carried out the following steps:

1. The policies proposed in the White Paper and policies from other sources were listed and categorised.
2. We determined which of the policies could be run using which of the models.
3. The policies that could be run using the models had to be translated into model inputs.
4. The individual policy measures were run through the models.
5. The individual policy measures were combined into policy packages that were able to help achieve the goals of the White Paper and the goal of sustainable transport and mobility.

In this chapter, we cover Steps 1-3 of this process. The process was somewhat different for the White Paper policies and other policies (e.g. policies designed specifically for urban areas). So, we divide the Step 1 into two sections – the policies of the White Paper, and other policies.

Not all policy measures that are proposed in the White Paper can be run in every model used in SUMMA, because not all models have the same capability to make all policies operational. E.g. policies that relate to freight transport could only be run by the Hamburg or the EXPEDITE meta-model because only these have a freight submodel. Therefore, a screening on the feasibility of the listed and categorised White Paper policies for every used model has been necessary.

Finally, we had to translate the policy measures into changes to the transport system that could be represented in the various models of the FSM. These changes are defined in terms of 'lever values', which are input parameters to the models.

2.5.2.2. The Policies of the White Paper

The White Paper policy goals were described in § 2.5.1. The actions designed to achieve those goals are listed in Annex I of the White Paper (the 'Action Programme'). There are 101 policies. These formed the starting point for the policies to be evaluated in SUMMA. They are listed in Table 2.15.

Not all of these policies have been able to be assessed using the FSM or its modules. We, therefore, had to identify the subset of these policies that would be examined.

Table 2.15 — White Paper Action programme

1 Shift the balance between modes of transport	
1.1 Improving quality in the road sector	
1.1.1	Harmonise inspections and penalties
1.1.2	Increase the number of checks that Member States are required to carry out on compliance with driving times and drivers' rest periods
1.1.3	Keep the road transport profession attractive by promoting the necessary skills and ensuring satisfactory working conditions
1.1.4	Harmonise the minimum clauses in contracts governing transport activity in order to allow tariffs to be revised should costs increase (e.g., a fuel price rise)
1.2 Revitalising the railways	
1.2.1	Gradually open up the railway market in Europe by
1.2.2	Step up rail safety by proposing a directive and setting up a Community structure for railway interoperability and safety
1.2.3	Create rail freight freeways
1.2.4	Get rail industries to reduce adverse environmental impacts (through dialogue)
1.3 Controlling the growth in air transport	
1.3.1	Introduction of a "Single Sky" by
1.3.2	Airport policies:
1.3.3	New slot allocation system
1.3.4	Replacement for current open skies agreements
1.3.5	Air transport taxation policies (kerosene tax and differential en route air navigation charges)
1.4 Adapting the maritime and inland waterway transport system transport.	
1.4.1	Developing infrastructure for "Motorways of the Seas"
1.4.2	New regulatory framework for maritime and inland waterway transport
1.4.3	New regulatory framework for safety controls for cruise ship passengers
1.4.4	Modifications in maritime safety rules
1.4.5	Reflag ships to Community registers
1.4.6	Improve inland waterway transport by:
1.4.7	Development of a European maritime traffic management system
1.5 Linking up the modes of transport	
1.5.1	Building and promoting multi-modal transport networks and terminals, for freight and passenger transport.
1.5.2	Marco Polo programme (to promote alternative solutions to road transport)
1.5.3	Develop the profession of freight integrator
1.5.4	Standardise transport units and freight loading techniques
2 Eliminating bottlenecks	
2.1	Revise the trans-European network guidelines to encourage corridors with priority for freight, a rapid passenger network, traffic management plans for major roads, and additional projects (29 specific projects listed in this subcategory)
2.2	Change the funding rules for the trans-European network
2.3	Revise the trans-European network to integrate the networks of the Accession countries, introduce the concept of 'motorways of the seas', develop airport capacities, and improve territorial cohesion
2.4	Establish a Community framework to channel revenue from charges on competing routes towards the building of new infrastructure
2.5	Harmonise safety standards for road and rail tunnels belonging to the trans-European network

3 Placing users at the heart of transport policy		
3.1 Unsafe roads		
	3.1.1	Reduce by half the number of people killed on European roads by 2010
	3.1.2	Harmonise rules governing checks and penalties concerning speeding in international commercial transport on the trans-European road network
	3.1.3	Harmonise rules governing checks and penalties concerning drink driving in international commercial transport on the trans-European road network
	3.1.4	Harmonise sign- posting of hazardous locations on trans-European routes
	3.1.5	Obligation for seat belts in new manufactured coaches
	3.1.6	Encourage responsible driving through training and education schemes (particularly for young drivers)
	3.1.7	Combat drink-driving and solve problems of use of drugs and medicines
	3.1.8	Encourage independent technical investigations
3.2 The facts behind the costs to the user		
	3.2.1	Guarantee the interoperability of means of payment on the trans-European road network
	3.2.2	Establish an infrastructure charging system
	3.2.3	Propose uniform taxation for commercial road transport fuel
3.3 Right and obligations of users		
	3.3.1	Increase air passengers' rights concerning denied boarding due to overbooking, delays, and flight cancellations
	3.3.2	Introduce regulations concerning requirements relating to air transport contracts
	3.3.3	Extend the Community measures protecting passengers' rights to include other modes of transport in particular railway, maritime transport, public transport service concerning:
	3.3.4	Adjust procedures for notifying State aid
	3.3.5	Clarify the general principles that should govern services of general economic interest in the field of transport
4 Managing the effects of transport globalisation		
	4.1	*Mobilise private sector finance to link the Accession countries to the trans-European network in particular railway sector*
	4.2	*Ensure adequate public funding of infrastructure in the Accession countries*
	4.3	*Develop the administrative capacities of the Accession countries by training inspectors and administrative staff responsible for enforcing transport legislation*
	4.4	*Become full members in the main international transport organisations*
	4.5	*Develop an EU satellite navigation system (Galileo)*

2.5.2.3. Urban Policies (To be run in Regional/City Models)

The White Paper policies are designed for controlling the transport development in the whole of Europe. In order to reach the White Paper objectives at the local and regional levels, additional policies for the local and regional levels that are in line with the European Transport Policy have to been added to the White Paper policies and then evaluated using local and regional models. To distinguish between the two sets of policies, we call the NUTS-2 regions 'urban regions' and larger regions 'non-urban regions'. We performed the policy analysis separately for these two types of regions. The analysis for the urban regions was performed using the detailed regional models (Randstad, Paris, Hamburg, and Prague).

The basic source we used for these additional policies were the transport investment plans and policies of the cities for which we already had transport model systems. But we also added information about other local and regional transport policies[26]. From this information, policies were chosen that are

[26] From the literature or from areas where the SUMMA partners had or have other research projects

implemented or under consideration in urban areas in Europe and which are in line with the objectives of the White Paper. The initial list of local and regional policies is given in Table 2.16 .

Table 2.16 — Initial list of Regional and City Policies

POLICY		EXPLANATION
5.1	Impose a speed limit of 30 km/h on intra-urban streets, except main radial roads	To make cities more attractive and to reduce noise and accidents in urban areas
5.2	Reduce parking facilities in the city centre	To shift trips to public transport
5.3	Restrict the use of big trucks in the city centre	To make cities more safe and attractive and to move the heavy trucks to main road
5.4	Introduce low-priced tickets for employees to use all public transport means in an urban region ('job tickets')	To shift commuting trips to public transport
5.5	Increase the frequency of scheduled services	To make the public transport system more attractive
5.6	Sponsor car-sharing	To make more efficient use of the transport means in urban areas
5.7	Concentrate new settlements (housing, commercial, employment zones) near existing public transport infrastructure	To support the use of existing public transport systems
5.8	Promote residential functions in commercial areas	To reduce the need for car travel
5.9	Place constraints on settlements in suburban areas	To reduce travel distances and the need for car travel
5.10	Promote city logistic centres in the surrounding of populated areas	To reduce and bundle heavy truck transport
5.11	Introduce road-pricing for trucks and cars in city centres	To reduce congestion and encourage the use of public transport
5.12	Increase parking fees	To shift trips to public transport
5.13-5.15	Extend inland waterways, rail-trucks and transit streets	To encourage the use of environmentally-friendly modes and to shift transit traffic from urban streets to main roads
5.16-5.18	Extend cycling and walking paths and places for Park and Bike / Bike and Ride	To encourage the use of non-motorised transport means
5.19	Extend the use of city logistic centres	To improve goods delivery and reduce congestion in urban areas
5.2	Increase service frequency for non-road freight transport	To shift freight transport to non-road modes
5.21	Allow bigger trucks for long-haul transport	To make road transport more efficient
5.22	Add road infrastructure	To increase the amount of road infrastructure in order to reduce congestion
5.23	Implement cordon pricing	To reduce congestion and encourage the use of public transport
5.24	Implement congestion pricing	To reduce congestion and encourage the use of public transport

2.5.2.4. Other Policies

In addition to the White paper goals and the urban goals, also a general sustainability goal can be defined, which is wider than the goals described in the White paper. Several Member States have embraced sustainability / sustainable transport as one of their main policy aims and have come up with a variety of (transport) policies that are either under discussion or being applied as means to achieve sustainability. To be able to compare these state of the art policies / ideas to achieve sustainability with the White paper goals, a selection of (best) practices in sustainable transport policies is added to the total list of policies that will be assessed through the models. Table 2.17 gives an overview of the policies that were added to the long list of policies in this respect.

Table 2.17 — Other policies

Policy option		Policy category
6.1.1P	Subsidise energy efficient car purchase (for passenger transport)	Increasing sustainability
6.1.2P	Subsidise energy efficient car technologies (for passenger transport)	Increasing sustainability
6.2F	Increase / make uniform time windows (for freight transport)	Rationalising urban transport (cat 5)
6.3F	Subsidise environmentally friendly transport modes (for freight transport)	Increasing sustainability
6.4P	Make PM filter mandatory (for passenger transport)	Increasing sustainability
6.5P	Change fixed price of car ownership (for passenger transport)	Increasing sustainability
6.6F	Subsidise rail transport (for freight transport)	Increasing sustainability
6.7F	Increase service frequency for non-road modes (for freight transport)	Linking up the modes of transport (cat 1.5)

Since these policies are neither mentioned of the White Paper nor have a regional focus, a new policy category ("Increasing sustainability") was introduced to encompass these policies. However two of these policies (6.2F and 6.7F) better fitted other, existing, policies categories and were reallocated to these as can be seen from the last column of Table 2.17.

2.5.2.5. Identification of Single Policies (to be run in the FSM)

2.5.2.5.1 Non-Urban policies

As described before, the final assessment of policies for the European and national level is based on the results of the SUMMA Fast Simple Model (FSM) that includes the modules DRM, IAM, and PAM (for descriptions of these modules see § 2.4). The calculations in the DRM are based on the results of the Vehicle Stock Model (VSM), regional/city transport models, and the EXPEDITE meta-model, as the core element for the calculation of policy impacts on a European and national level.

Not all policy measures that are proposed in the White Paper can be run in the FSM. There are several reasons for this. For example, only the Hamburg model and the EXPEDITE meta-model have a freight sub-model. Therefore freight transport policies can only be assessed for the EXPEDITE transport zones and for the Hamburg region. Impacts of pricing policies can only be analysed if the underlying model allows the specification of pricing policies. Only if a transport model uses a network for the calculation of the characteristics of the modes and the network loading infrastructure measures can be analysed. Also, some policies are not specified in a way that they can be transformed into model inputs (e.g., "Keep the road transport profession attractive by promoting the necessary skills and ensuring satisfactory working conditions").

Therefore, we first had to filter out those policy measures from the White Paper whose impacts could not be estimated with the FSM. All individual single policies based on the White Paper action programme and the described national, regional and urban transport planning programmes that were able to be run at the European and national level were run. The reduced table of policies that we assessed with the FSM is shown in Table 2.18 (A complete listing that includes an indication of the models in which each policy has been evaluated is provided in Appendix E1).

2.5.2.5.2 Urban policies

As described above, a limited number of policy runs from all possible runs had to be selected. There were five criteria that we used in order to select the policies to be run in the regional/city models:

- In a first step, those policies were selected that could be implemented in the various regional/city models. (Table 2.16).
- Chose policies from different policies areas (areas such as administrative / regulatory, pricing, infrastructure).
- Policies should exhibit wide variations in the values of the policy levers - a high variance in the values of the levers, and therefore in the results of the policies, enables a recalibration of the FSM with higher ranges.
- Focus on the selection of policies that are not available by the Expedite meta-model Since regional and city models are in general much more detailed and network based, they will be used to model the effect of policies that are not available in the Expedite meta-model in the FSM.

- A limited number of policies should be selected that are available by the Expedite meta-model. The results of the these policy runs will serve as pre-selection factor for the creating of policy packages for the FSM

These criteria were used to select the policies for the runs with the regional and city models. For example “extend the use of city logistic centres” (5.19) as an infrastructure policy, “introduce road-pricing for trucks and cars in city centres” (5.11) as a pricing policy measure and “the single sky” (1.3.1) as an administrative / regulatory have been amongst others selected for the Hamburg model. The selected policies are listed in Table 2.34 and Table 2.41.
It has to be stressed that the selection of policies for recalibration means no limitation for the use of the FSM. This procedure only helps to make the FSM sensitive to policies on regional and urban level and opens therefore a variety of policy specifications.

The selection of feasible single policies and policy packages for the European and national level can be found in Appendix E1 and E3.

2.5.2.6. Translating the policies into inputs that can be used by the FSM

2.5.2.6.1 Translation of Policies into Model Inputs

The translation of policies into lever values as input for the transport models and the FSM is an important step, because this is the link between an abstract policy and the quantification of its impacts on various outcome indicators.

Next to complexity of implementing single policies, implementing policy packages adds an additional dimension to this. We will start with a discussion of preparing the single policies, followed by the policy packages.

2.5.2.6.1.1 Preparing single policies

The translation was done in the following steps:

1. Determination of the available policy levers for all of the models in the FSM.
2. Determination of how the policies can be implemented using the policy-levers.
3. Setting values for the policy levers to assess the policies using the models.

The result of the determination of policy levers and their segmentation that is available for all of the models in the FSM is given in Appendix E4. The application of the available policy levers to assess the policies has been done by using percentage increases from the reference case.

To determine how the policies can be implemented using the policy-levers and from a policy lever point of view, the policies can be divided into three categories:

1. Policies that change the characteristics of the transport infrastructure – building new links, additional tracks, improving nodes of the network, and so on. Also parking restrictions, establishing new freight transport centres, speed reductions (or increases) on specific links, elimination of bottlenecks, etc. are included in this category. If network models are used, the model levers are the new specific mode characteristics, which are the revised networks and the resulting traffic assignments on these networks. The most important system variables affected by infrastructure policies are driving time, transport costs, waiting time for the next connection in the public transport system etc. These changes can be specified easily in the models. If no cost variable is specified in the model, well-known value-of-time quantities can be used. The EXPEDITE model, as the core of the DRM model, is a zone-based model, i.e. it does not represent the system in terms of networks. But the model output is segmented into different distance classes. This requires that we estimate the policy’s effect on the mode characteristics, which we then translate into changes in the average characteristics of the distance bands, like e.g. the effect of 10% more road infrastructure facility.
2. Policies that directly change the user prices or costs of transportation, such as fuel prices, taxes, parking fees, ticket prices for public transport, costs of car maintenance, etc. The translation of changes in user prices into changes in lever values is possible in the same way as described above. If no price variable is specified in the models, value-of–time

quantifications are used. If policies have an impact on cost – that means the price the operator or supplier of transport service has to pay – additional assumptions have to be made. In SUMMA we are making the assumption that there is enough competition in the transport market that any increase or decrease of transport prices will be paid (or saved) in the end by the user.

3. Policies that improve the quality of the transport system (or specific means), focus on safety, or result in a better organisation of transport operations have been quantified approximately.

For the most part of these policies, the quantification and translation into lever values was taken from existing studies and research projects familiar to the partners, such as studies on transport investment planning for Hamburg (Freie und Hansestadt Hamburg, 1995), North Rhine Westphalia (Kessel + Partner et.al., ongoing research) and the policies definition within the EXPEDITE project (EC, 2001). The quantification of the policies was based on expert interviews and ex-post analysis.

Assumptions for policy lever values based on discussions and agreements within the project group that probably and validly reflect the policy impacts where made for policies for which quantifications from existing studies were not available.

Table 2.18 provides an overview and justification of the determined policy levers and their values. The provided degree of reliance for the lever values - i.e. the assessment of the quality of the used lever values - are declared in the following way:

- * **Low degree of reliance**, if the lever values are only based on internal discussions within the project group.
- ** **Middle degree of reliance**, if the lever values are operationalised in the same way as in related projects and planning concepts or based on output of sub-models.
- *** **High degree of reliance**, if the lever values are based on and proven by results of corres-ponding research studies.

Altogether it was possible to quantify the levers for all selected policy measures, so that the impacts of these policies can be estimated with the regional/city models and the FSM.

Table 2.18 — Policies and their policy lever values, justification and reliance

Policy No.	Policy	Lever value/ implementation	Justification of policy levers	Reliance in the lever values
Improving quality in the road sector				
1.1.1P	Harmonise inspections and penalties (for passenger transport)	Car time increase of 5%	Referring to discussions and proposals within the project group. Given the enormous difference in enforcement practices of inspections and penalties in the Member States lever values are considered to be plausible.	*
1.1.1F	Harmonise inspections and penalties (for freight transport)	Lorry cost increase of 5%		*
1.1.2F	Increase the number of checks that Member States are required to carry out on compliance with driving times and drivers' rest periods (for freight transport)	Lorry time increase of 5%	Referring to discussions and proposals within the project group. Given the fact that intensification of checks on the road shows that violation is frequent, affecting 50 % of overall driving time and rest periods27 the value assumption is considered to be plausible.	**
5.21F	Allow bigger trucks for long-haul transport (for freight transport)	Lorry cost decrease of 5%	Referring to discussions and proposals within the project group. (based on research results by the Heriot-Watt University in Edinburgh, http://www.sml.hw.ac.uk/logistics)	***

27 European Commission: Road transport-Europe on the move, Brussels. 2004.

Policy No.	Policy	Lever value/ implementation	Justification of policy levers	Reliance in the lever values
Revitalising the railways				
1.2.1.1F	Open up the national freight markets to cabotage (for freight transport)	Rail cost decrease of 5%	Referring to discussions and proposals within the project group.	*
1.2.1.2P	Ensure a high level of safety for the railway network (for passenger transport)	Train time decrease of 2%	Referring to discussions and proposals within the project group.	*
1.2.1.2F	Ensure a high level of safety for the railway network (for freight transport)	Rail time decrease of 2%		*
1.2.1.3P	Update the interoperability directives for all components of the network (for passenger transport)	Train time decrease of 2%	Referring to discussions and proposals within the project group.(based on study results from NERA economic consulting28)	***
1.2.1.3F	Update the interoperability directives for all components of the network (for freight transport)	Rail time decrease of 4%		***
1.2.1.4P	Open up international passenger transport	Train time decrease of 1%	"Integration-Scenario for forecast 2015" of the German Federal Transport network planning	***
Adapting the maritime and inland waterway transport system				
1.4.6F	Improve inland waterway transport (for freight transport)	IWW cost decrease of 2%, IWW time decrease of 5%	Referring to discussions and proposals within the project group.	*
1.4.7F	Develop a European maritime traffic management system (for freight transport)	Sea cost and Sea time decrease of 5%	Referring to operationalisation of Scenario C of Hamburg Transport Planning Concept 2010	***
Linking up the modes of transport				
1.5.1P	Build and promote multi-modal transport networks and terminals (for passenger transport)	Train waiting and access time decrease of 5%; BTM waiting and access time decrease of 5%	Changes in atractivity of zones, and input indicator matrices. Changes in transport supply number of connections transfer times etc. Referring to discussions and proposals within the project group. (based on EC- project results of INFREDAT 1999)	**
1.5.1F	Build and promote multi-modal transport networks and terminals (for freight transport)	Lorry, sea and rail handling cost decrease of 5%		**
1.5.4F	Standardise transport units and freight loading techniques (for freight transport)	Rail time and handling cost decrease of 5%	Decrease of waiting and handling penalties, decrease of handling costs average velocity performance, decrease of costs, Transhipment costs for transport units –5%, waiting and handling penalties for transhipment –5% (except maritime transport). Referring to operationalisation of Scenario of the "integrated transport planning Concept for 2015 of North Rhine-Westphalia"	**
6.7F	Increase service frequency for non-road modes (for freight transport)	Rail and sea frequency increase of 5%	Referring to discussions and proposals within the project group.	*
Eliminating bottlenecks				
2.1P	Revise the trans-European network and guidelines (for passenger transport)	Modification of network	Only if the model area is touched by one or more of the network improvements, this is modelled by modifying the characteristics of the infrastructure	**
2.1.22P	Railway line Athina. Sofia-Budapest-Wien-Praha-Nürnberg/Dresden (for passenger transport)	Modification of network		**
5.22P	Add road infrastructure (for passenger transport)	Add 5% road infrastructure	Estimates of the effects on passenger travel times of a 4.3% increase in road infrastructure in the Netherlands were made using the LMS model. The results were scaled to represent the effects of a 5% increase.	**

28 NERA: Assessment of the 3rd railway package. Brussels. 2004.

Policy No.	Policy	Lever value/ implementation	Justification of policy levers	Reliance in the lever values
Unsafe Roads				
3.1.2F	Harmonise rules governing checks and penalties concerning speeding in international commercial transport on the trans-European road network (for freight transport)	Lorry cost increase of 1%	Referring to discussions and proposals within the project group.	*
The facts behind the costs to the user				
3.2.1P	Guarantee the interoperability of means of payment on the trans-European road network (for passenger transport)	Car time decrease of 2%	Referring to discussions and proposals within the project group.	*
3.2.2P	Establish an infrastructure charging system (for passenger transport)	Hybrid cars variable cost increase of 16% and other cars variable cost increase of 13%	15 cents per km road charging on main routes for HGV >12t. General road pricing on highways and motorways for all motorized PT vehicles - 10 Cents per km. LC: Referring to "Integration-Scenario for forecast 2015" of the German Federal Transport network planning (share of cost component and trips on charging routes); CC: Referring to operationalisation of Scenario C of Hamburg 2010Transport Planning Concept 2010 (share of cost component and trips on charging routes)	**
3.2.2F	Establish an infrastructure charging system (for freight transport)	Lorry cost increase of 18%		***
5.11P	Implement road pricing (for passenger transport)	Car cost increase of 13% on inner city roads	Referring to operationalisation of Scenario C of Hamburg 2010 Transport Planning Concept 2010	***
5.11F	Implement road pricing (for freight transport)	Lorry cost increase of 3% on inner city roads		***
3.2.3P	Establish uniform taxation for commercial road transport fuel (for passenger transport)	Hybrid cars variable cost increase of 9% and other car s variable cost increase of 12%	Referring to internal cost model structure (share of cost component)	**
3.2.3F	Establish uniform taxation for commercial road transport fuel (for freight transport)	Lorry cost increase of 18%		**
Managing the effects of transport globalisation				
4.1P	Mobilise private sector finance to link the Accession countries to the trans-European railway network (for passenger transport)	Train time decrease of 5%	Referring to discussions and proposals within the project group (based on assumptions by "PricewaterhouseCoopers - European transport finance team"[29])	***
4.5P	Develop an EU satellite navigation system (Galileo) (for passenger transport)	Car time decrease of 3%	Monitoring and management of traffic fludity will be significantly facilitated and travel time will be cut by 10% due to studies by the EC. After internal discussions we consider this as too optimistic. So the conservative value of 3% has been chosen for sensitivity consideration (http://europa.eu.int/comm/dgs/energy_transport/galileo)	**
4.5F	Develop an EU satellite navigation system (Galileo) (for freight transport)	Lorry time decrease of 3%		**
Rationalising urban transport				
5.1PF	Reduce speed limits in urban areas (for passenger and freight transport)	Speed limits on inner city roads	Referring to operationalisation of Scenario C of Hamburg Transport Planning Concept 2010	***
5.2P	Implement parking space management (for passenger transport)	Increasing car time of 15min in inner city area	Referring to operationalisation of Scenario C of Hamburg Transport Planning Concept 2010	***
5.3F	Reduce freight through traffic in urban areas	Lorry time increase of 10% in inner city area	Referring to operationalisation of Scenario C of Hamburg Transport Planning Concept 2010	***

29 http://www.pwcglobal.com/uk/eng/about/svcs/pfp/The%20trans-European%20transport%20network%20Report.pdf

Policy No.	Policy	Lever value/ implementation	Justification of policy levers	Reliance in the lever values
5.4P	Introduce low-price tickets for employees to use on public transport in cities ('job ticket' for passenger transport)	Train and BTM cost decrease of 20% for purpose work	Referring to operationalisation of Scenario C of Hamburg Transport Planning Concept 2010	***
5.5P	Improve the performance and service quality of public transport (for passenger transport)	Train and BTM access time decrease of 2%	Referring to operationalisation of Scenario of the "integrated transport planning Concept for 2015 of North Rhine-Westphalia"	***
5.6P	Increase car -sharing (for passenger transport)	Modification of MODAL SPLIT	Referring to output of Scenario C of Hamburg Transport Planning Concept 2010	***
5.10F	Promote city logistic centres (systems) in the surrounding of populated areas (last mile logistics) (for freight transport)	Increasing load factor for HGV of 15%	Referring to results of studies in North Rhine-Westphalia "Modellvorhaben Stadtlogistik NRW 1995-2000"	***
5.12P	Increase parking fees (for passenger transport)	Hybrid cars variable cost increase of 1% and other car variable cost increase of 1%	Referring to operationalisation of Scenario C of Hamburg 2010Transport Planning Concept 2010	***
5.25P	Implement congestion pricing (for passenger transport)	Increasing car cost of 9 Euroct on roads (highways) with intesity/capacity >0,8	In the Randstad model roads / highways with intesity/capacity of over 0,8 are assigned an increase in car cost by 9 Eurocents.	**
6.2F	Increase / make uniform time windows (for freight transport)	Lorry cost and frequency decrease of 5%	Referring to discussions and proposals within the project group.	*
Increasing sustainability				
6.1.1P	Subsidise energy efficient car purchase (for passenger transport)	Hybrid fixed car cost decrease of 5%	Assumption is saving of vehicle taxes for two years. Lever value refers to internal cost model structure (share of cost component)	**
6.1.2P	Subsidise energy efficient car technologies (for passenger transport)	Hybrid fixed car cost decrease of 5%	Due to subsidies, there will be a 10% decrease in passenger car purchase costs. Lever value refers to internal cost model structure (share of cost component)	**
6.3F	Subsidise environmentally friendly transport modes (for freight transport)	IWW, rail and sea cost decrease of 60%	Referring to discussions and proposals within the project group.	*
6.4P	Make PM filter mandatory (for passenger transport)	PM obligation	The policy lever is a switch that is either on or off. By choosing the value 'on', it is assumed that all passenger cars in 2020 are equipped with a PM filter. A PM filter reduces PM emissions by 90%.	**
6.5P	Change fixed price of car ownership (for passenger transport)	Hybrid cars and other cars fixed cost increase of 10%	Referring to discussions and proposals within the project group.	*
6.6F	Subsidise rail transport (for freight transport)	Rail cost decrease of 60%	Referring to discussions and proposals within the project group.	*

2.5.2.7. Creating the policy packages

Preparing policy packages from single policies is not as easy as simply combining them into one package. This would only be possible if it is established that the single policies are independent. To establish independency all single policies and all combinations of them should be evaluated. This obviously is a labour intensive task. Because all policies are implemented with the same set of policy levers the situation is somewhat less complicated. Two situations relating the policy levers can occur when combining single policies:

1. The single policies all use different policy levers. In this case the policies can simply be combined into a package with the combine set of policy levers. The single policies might be dependent on each other, but this dependence is taken care of by the model (dependence between the policy levers).
2. The single policies (partly) use the same policy levers. In this case it is yet to be decided whether the policies are dependent or independent. Expert knowledge is required in this case. If the single policies that are combined have independent impacts or if the same levers have different direction of impact and components (e.g. different cost components- variable and

fixed components), the single policy levers can be combined in an additive way. However, if different single policies that are combined to policy packages have the same levers with equal directions of impact and components, the combination of the single policies will lead to a new and separate lever value. Again the definition of the separate lever value was taken from existing studies and research projects that based on expert interviews and ex-post analysis.

2.5.2.8. Filling in the score cards

2.5.2.8.1 The Policy Analysis Process

Operationally, the process we have followed in the policy analysis phase of SUMMA is illustrated in Figure 2.11, which shows how the four dimensions of the policy analysis process -- goals, policies, levers, and indicators – relate to each other. The figure is divided into four quadrants. Each quadrant represents a relationship between two of the dimensions. In Quadrant I, the relationship between goals and policies is established: the policies (e.g., from the White Paper) are linked to the goals (both those from the White Paper and the overarching goal of sustainable transport and mobility). To be able to assess the effectiveness of the policies in achieving the goals they were designed to achieve, the policies are translated into inputs to the FSM – the policy levers. This is conveyed through the relationship between policies and levers represented by Quadrant II. The levers convey to the model the expected first order impacts of the policies on the transport system. Quadrant III represents the FSM. In this quadrant, the values of the policy levers for each of the policies are used as input to the FSM, which translates the policy lever values into outcome indicator values. By doing so, the FSM simulates the effects of the policies on the transport system. The indicator values that flow from the FSM are then used to assess the effectiveness of a policy in achieving its goal(s). This is what takes place in Quadrant IV.

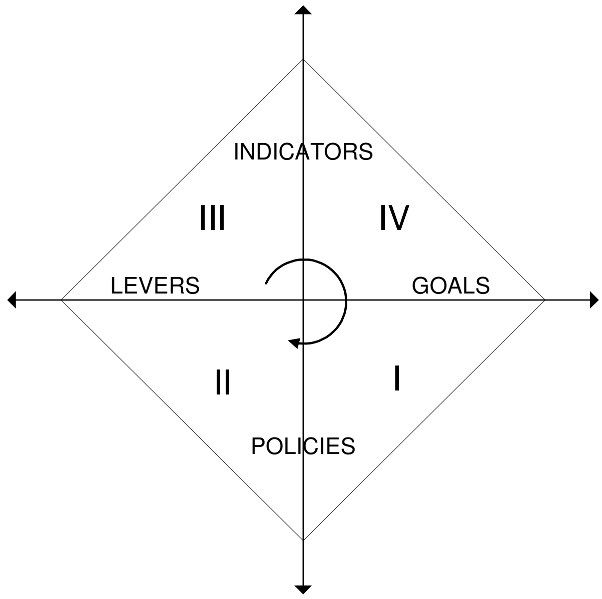


Figure 2.11 — Dimensions of the SUMMA policy analysis process

The process suggested in Figure 2.11 by which goals are translated into policies, policies into levers, levers into indicators, and policies are assessed on the basis of the indicator outcomes, is carried out for four different policy domains, based on two types of transport (passenger and freight) and two types of geographic areas (urban and non-urban). The resulting four policy domains are:

- Passenger non-urban
- Passenger urban
- Freight non-urban
- Freight urban

The analysis for urban regions made use of results for the NUTS-2 zones for which we had detailed models (Randstad, Paris, Hamburg, and Prague). The passenger urban policy analysis is based on results from all four of these models; the freight urban policy analysis is based on results from only the

Hamburg model. Each of the four policy domains has separate goals, policies, levers, and indicators, although there are many overlaps. So, we performed a separate analysis for each of the domains.

Figure 2.12 presents an overview of the SUMMA policy analysis framework.

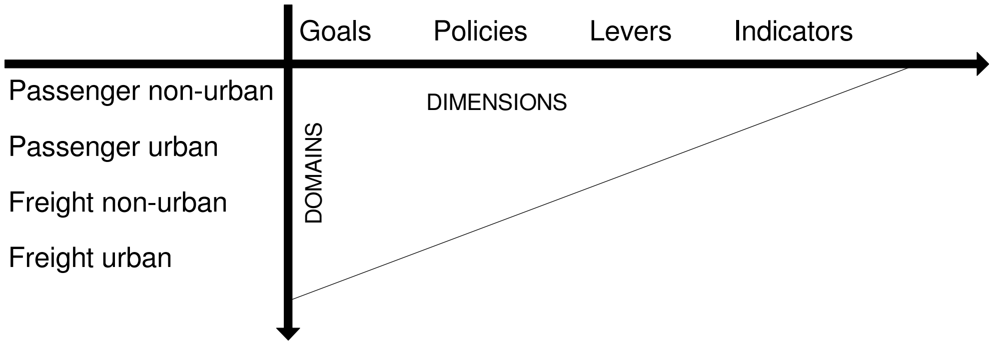


Figure 2.12 — Dimensions of the SUMMA policy analysis process

The policy analysis for all domains was carried out using two primary tools: the SUMMA Fast Simple Model (FSM) and the DynaRank Decision-Support System (Hillestad and Davis, 1998). DynaRank is an Excel program that generates 'scorecard' displays of the FSM outputs. In these scorecards, the individual policy options appear as rows and the outcome indicators (or their aggregations along the goal hierarchy) appear as columns. An individual box in the scorecard, therefore, contains the value produced by the FSM for the corresponding outcome indicator and policy. The values shown are percentage changes in the outcome indicators between the Reference Case and the policy run. So, a value of 100 means that the policy led to no change is the corresponding outcome indicator; a value of 115 means that we estimate that the policy would lead to a 15% increase in that outcome indicator; and a value of 95 means that we estimate that the policy would lead to a 5% decrease in that outcome indicator.

DynaRank will also colour the boxes in the scorecard in order to show the relative attractiveness of the various policies for each of the outcome indicators; i.e., colours are applied to the boxes in a column to indicate whether a policy has a large positive effect (dark green, indicating an increase of at least 11.25%), a small positive effect (light green, indicating an increase of 3.75% to 11.25%), practically no effect (yellow, indicating a change ranging from -3.75% to +3.75%), a small negative effect (orange, indicating a decrease ranging from -3.75% to -11.25%), or a large negative effect (red, indicating a decrease of more than -11.25%). This display permits a quick overview of how all policy options in a policy domain compare across the outcomes of interest. For example, if all of the outcomes for a policy are coloured yellow, the policy is estimated to have little or no effect. If there are only yellows and greens, the policy should be considered promising (worthy of more careful examination). The existence of both reds and greens in a row indicates that the policy will require the policymaker to make some important trade-offs when considering possible implementation of the policy. Of course, our choice of the break-points between colours is arbitrary. We are not claiming that a difference between, say, 3.5% and 4.0% is meaningful. DynaRank allows the colours to be assigned according to the user's preferences. Policymakers should pay attention to the underlying percentage changes and decide for themselves whether an increase or decrease of x% is significant or not.

Since the exact specifications of many of the policies are policymaker choices and the values of some of the policy levers are based on uncertain assumptions, we performed sensitivity analyses for all of the policies and policy packages. These analyses showed how the results would change if the lever values that were influenced by a policy were changed. For this purpose all of the single policies and policy packages were run with two alternative sets of lever values. The lever values of these alternative (sensitivity) runs meet two conditions:

1. They cover a wide spectrum to enable identifying non-linear effects from changing lever values on the (intermediate) goals;
2. They are within the bandwidth in which the elasticities incorporated in the models are valid.

In both § 2.6.1 (on single policies) and § 2.6.2.3 (on policy packages) descriptions of the sensitivity analyses performed for these policies are included.

2.6. RESULTS

2.6.1. Analysis of Single Policies: Non-Urban

In this section and the following one (§ 2.6.2), we present the analysis of single policies for each of the four domains. This section treats non-urban policies (both passenger and freight). The next section treats urban policies (both passenger and freight). We used the same analytic approach to the analysis of single policies for each of the four domains. So, we use the same structure in presenting each of the analyses. We first describe the goals and policies for the domain that were used in the analysis. We then present the analysis and the conclusions of the single policy analysis for the domain.

The FSM permits us to perform the non-urban analysis for three types of geographical areas:

- Countries (the FSM produces results for 25 European countries – the EU25 except for Cyprus and Malta, plus Norway and Switzerland);
- Regions (the FSM produces results for two European regions: Western Europe (the EU15 plus Norway and Switzerland) and Eastern Europe (the last Accession countries, except for Cyprus and Malta));
- Europe (the FSM produces results aggregated over all 25 European countries).

The country, region, and European results are derived from aggregating the results of the underlying NUTS2 zones. Zones that were modeled by means of a regional model (Hamburg, Ile de France, Randstad, and Prague) were left out of these aggregations. The results for countries (and higher levels as indicated in Figure 2.13) that encompass any of these zones are derived from the remaining NUTS 2 zones.

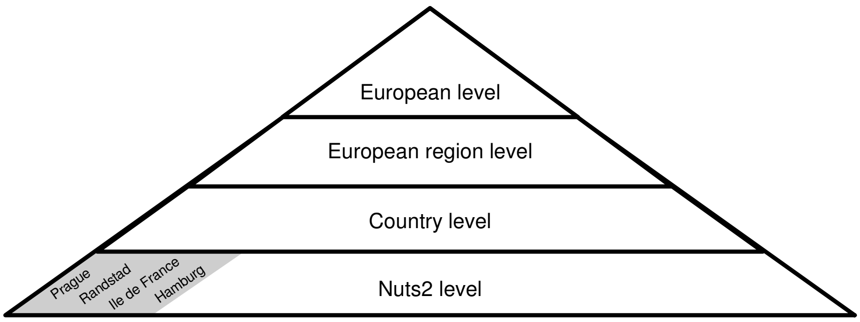


Figure 2.13 — Geographical aggregations

Although results for each of these levels are made available through the FSM, most of the non-urban analysis is performed at the European level. However, we highlight cases where results at the regional and country level are significantly different from what we found at the European level. We also perform sensitivity analyses on the results.

2.6.1.1. Passenger Non-Urban

Goals

From the EC's goals and subgoals described earlier, only a subset are relevant and available from the FSM results for assessing non-urban passenger policies. Figure 2.14 gives an overview of the goals and subgoals that are strived for in non-urban passenger transport.

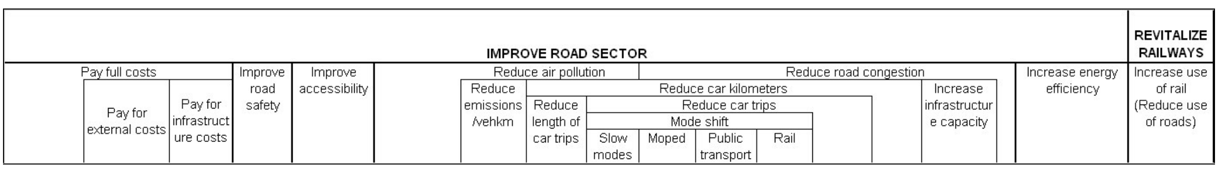


Figure 2.14 — Passenger non-urban goals

As shown in Figure 2.14, there are two high-level goals for this domain: (1) improve the road sector, and (2) revitalize the railways. The second-level goal for the goal of revitalizing the railways (essentially, the mechanism for achieving this goal) is to increase the use of rail for passenger transport (in order to provide a better balance between rail transport and road transport). There are six second-level goals for the goal of improving the road sector:

- Pay full costs (with two third-level goals: pay for external costs and pay for infrastructure costs);
- Improve road safety;
- Improve accessibility;
- Reduce air pollution (with two third-level goals: reduce emissions/vehkm and reduce car kilometres);
- Reduce road congestion (with two third-level goals: increase infrastructure capacity and reduce car kilometres);
- Increase energy efficiency.

As shown in the above list, three of the second-level goals have third-level goals. In addition, one of these third-level goals (reduce car kilometres) has lower-level goals. There are many ways in which a reduction in car kilometres can be accomplished. These are reflected in the large variety of subgoals. One way is to leave the number of car trips the same, but to reduce their average length. Another way is to reduce the number of trips made by car. This can be done by eliminating some trips entirely (e.g., by telecommuting to work or school) or by using a different mode (a slow mode, a moped, or public transport). This hierarchy of goals results in two fourth-level goals (reduce length of car trips and reduce car trips), two fifth-level goals (eliminate trips and shift from the car mode), and three sixth-level goals (shift to slow mode, shift to moped, and shift to public transport).

Policies

Table 2.19 gives an overview of the 17 passenger policies that were identified for passenger transport in non-urban areas.

Table 2.19 — Passenger non-urban policies

Passenger policies	
1.1.1P	Harmonise inspections and penalties (for passenger transport)
1.2.1.2P	Ensure a high level of safety for the railway network (for passenger transport)
1.2.1.3P	Update the interoperability directives for all components of the network (for passenger transport)
1.5.1P	Build and promote multi-modal transport networks and terminals (for passenger transport)
3.2.1P	Guarantee the interoperability of means of payment on the trans-European road network (for passenger transport)
3.2.2P	Establish an infrastructure charging system (for passenger transport)
3.2.3P	Establish uniform taxation for commercial road transport fuel (for passenger transport)
4.1P	Mobilise private sector finance to link the Accession countries to the trans-European railway network (for passenger transport)
4.5P	Develop an EU satellite navigation system (Galileo) (for passenger transport)
5.4P	Introduce low-price tickets for employees to use on public transport in cities ('job ticket' for passenger transport)
5.5P	Improve the performance and service quality of public transport (for passenger transport)
5.12P	Increase parking fees (for passenger transport)
5.22P	Add road infrastructure (for passenger transport)
6.1.1P	Subsidise energy efficient car purchase (for passenger transport)
6.1.2P	Subsidise energy efficient car technologies (for passenger transport)
6.4P	Make PM filter mandatory (for passenger transport)
6.5P	Change fixed price of car ownership (for passenger transport)

Analysis of policies at the European level

The scorecard for non-urban passenger policies at the European level for the second-level goals is shown in Table 2.20. The rows of the scorecard are the 17 policy options listed in Table 2.19. The columns show the aggregated outcome indicators for the six second-level goals. The value shown in the scorecard for each of the goals is the average over the lower-level indicators. For example, the column showing the value for the outcome ‘Improve road safety’ is an average of the values for the outcome indicators ‘External accident costs’ (EC43A), Number of persons killed in road accidents per pkm’ (SO21A), and ‘Number of road accidents with injured people per pkm’ (SO21B) (whose values can be found on lower-level scorecards).

Table 2.20 — Results from passenger non-urban policy runs

	IMPROVE ROAD SECTOR					REVITALIZE RAILWAYS
	Reduce road congestion	*Reduce air pollution*	*Pay full costs*	*Improve road safety*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*
1.1.1P	102	102	99	103	101	104
1.2.1.2P	101	101	100	101	100	103
1.2.1.3P	101	101	100	101	100	103
1.5.1P	101	101	100	102	101	110
5.22P	98	94	103	91	102	100
3.2.1P	100	100	100	100	100	99
3.2.2P	102	103	167	105	100	103
3.2.3P	102	103	102	104	99	102
4.1P	101	101	100	101	100	107
4.5P	100	100	100	100	99	98
5.4P	101	101	99	102	101	118
5.5P	101	101	100	102	100	102
5.12P	100	100	105	100	100	100
6.1.1P	100	101	100	100	99	100
6.1.2P	100	101	100	100	99	100
6.4P	100	152	104	100	100	100
6.5P	101	102	99	103	99	104

We first examined the scorecard to find the best policies (and runner-up policies) for each of the second-level goals. These results are summarised in Table 2.21. For example, the best policy for reducing air pollution is Policy 6.4P ('Make PM filter mandatory'). All of the policies for improving road safety provide either small or no improvements, as did the policies for increasing energy efficiency.

Table 2.21 — Best and runner-up passenger non-urban policies

Second-Level Goal	Best Policy	Runner-up Policies
Reduce road congestion		3.2.2P 3.2.3P
Reduce air pollution	6.4P	3.2.2P 3.2.3P
Pay full costs	3.2.2P	5.1.2P
Improve road safety		3.2.2P 3.2.3P
Increase energy efficiency		5.2.2P
Revitalise railways	5.4P	1.5.1P

The most interesting results were produced for the goals 'Reduce road congestion', 'Reduce air pollution', and 'Revitalise railways'. For the road congestion goal, it might have been expected that the policy 'Add road infrastructure' (5.22P) would be very effective. In fact, it has very little effect on congestion, since it leads to an increased number of trips by car, and an increase in passenger kilometres. (If you build new roads, people will use them.) In fact, adding road infrastructure will cause people to travel over larger distances, which benefits both car and train at a cost of slow modes and BTM. The increase in train is compensated by the increase in attractiveness of road. As a result, adding road infrastructure will appear to draw people away from BTM and slow modes to car without influencing the number of trips by train. A much better way of reducing congestion is to charge for using the infrastructure, as is done in policies 3.2.2P and 3.2.3P. These policies lead to a decrease in passenger kilometres, which leads to a decrease in congestion. The mode shift towards rail under these policies is rather limited, indicating a mode shift to other modes such as BTM and slow modes.

For the air pollution goal, the policy 'Make PM filter mandatory' (6.4P) is extremely effective as it reduces particle matter, which is one of the four pollutants that comprise air pollution, by 87%[30] compared to the reference case while it has no negative effects with respect to other goals.

For the goal of revitalising the railways, the policy ' Introduce low-price tickets for employees to use on public transport in cities' (5.4P) is most effective, and the policy 'Build and promote multi-modal transport networks and terminals' (1.5.1P) and 'Mobilise private sector finance to link the Accession countries to the trans-European railway network' (4.1P) are also quite good. These policies not only achieve improving the rail sector but do so without hampering the other goals.

Comparing the results of policies that increase charges for car transport (3.2.2P and 3.2.3P) with policies that improve the rail sector (such as 1.5.1P, 5.4P, and 4.1P) illustrates that reductions in car transport are not directly translated into increases in rail transport. This will happen only within the long distance classes in which there is no possibility to switch to slow modes, mopeds, and BTM, which happens in the short distance classes. We, therefore, conclude that policies that aim to bring about a mode shift transferring tours from car to rail will be most effective for long distance trips.

Insights from analysis of policies at other geographical levels
An examination of the individual scorecards for the countries and the regions ('EU15' and 'Rest of Europe') for the high-level goals revealed some similarities and differences for the various policies. There were only very small regional differences. (I.e., the separate results for the 'EU15' and the 'Rest of Europe' were about the same, and practically identical to the results for Europe as a whole.) However, some countries appeared to be highly sensitive to a few of the policy changes (i.e., the outcome indicators increase or decrease significantly), while other countries show much smaller changes for the same policies. We believe, however, that any significant differences are due to data differences among the countries. In particular, data for calculating outcome indicators are sometimes wrong or missing for some countries, in which cases the FSM produces incorrect estimates of a policy's effects on the outcome indicators. For example, the high-level scorecards showed that Policy 3.2.2P ('Establish an infrastructure charging system') would have a very large positive effect on the goal of improving the road sector in Denmark, and practically no effect on this goal in Finland.

In most cases there are only small differences in the values of the outcome indicators across the countries. For most policies, the policy has no significant effect on the outcome indicators across all of the countries (e.g., Policy 1.2.1.2P ('Ensure a high level of safety for the railway network')). There are, however, some policies for which the outcomes for all countries are very positive. This is particularly true for Policy 1.5.1P ('Build and promote multi-modal transport networks and terminals'), and Policy 5.4P ('Introduce low-price tickets for employees to use on public transport in cities'), both of which have strong positive improvements with respect to the goal of revitalising the railroads in all of the countries. Similarly, Policy 6.4P ('Make PM filter mandatory') has strong positive improvements with respect to the goal of improving the road sector in all of the countries.

Sensitivity analysis
Translating policies into model inputs by means of identifying lever values was performed on the basis of results from the literature. It might be that, in practice, lever values are different from what was found in the literature or that not all aspects of a policy could be or were incorporated within the set of levers available for the models. In addition, for some policies the lever values to use are quite clear, but the appropriate value depends on choices made by the policymakers. For instance in (road) charging policies, the percentage change in car cost, which is a lever for the models, depends on what is chosen as the amount of the charge. Although a range within which these charges will typically lie can be taken from literature, there is no 'correct' value for a lever in such a case.

We, therefore, were interested in gaining an understanding of the influence of a specific lever or set of levers that define a policy on the model results instead of getting a point estimate of the effect of the lever for one specific value. To do this, we performed a sensitivity analysis. In this analysis, we made two additional runs for each policy in addition to the actual policy run. The results from the additional two runs were then used to determine the relationship between the model's outcomes and the lever value. In performing this sensitivity analysis, it is not necessary to examine the effects on all outcome indicators. The indicators used should be representative of the outcome behaviour. Because of the way the values of the indicators are aggregated, if high-level goals were to be used for the sensitivity analysis, we would run the risk that one or two indicators would dominate the outcomes. Ideally a

[30] This number can be derived from the lower level scorecards.

weighted average, such as the PAM value, would be used to perform this assessment; but the PAM, in its current form, does not take into account a large number of important indicators. We decided that it would be best to use an indicator that provides insight into the modal split. The indicator ‘Road transport kilometres car’ (DRM 4A) is used to assess multiple goals in the scorecards. In addition, there are several indicators that assess mode shift that make use of DRM4A. Although the indicator does not actively assess shifts to other modes, it does contain information on these shifts, since each modal shift will be reflected in DRM4A.

For passenger non-urban, three runs per policy were made to support the sensitivity analysis:

- Normal ⇒ run of the policy using its standard predefined lever values.
- Low ⇒ run of the policy using lever values at half of their standard values.
- High ⇒ run of the policy using lever values at twice their standard values.

Since the FSM only accepts integer values for the levers, the lever values had to be rounded for some of the sensitivity runs. This was taken into account in assessing the relationship between lever values and model outcomes.

The FSM applies the values of the levers that are given prior to a policy run by the user or through a predefined policy, as a percentage change of certain internal model variables (which are directly related to the lever). When doubling or halving lever values, the percentage change defined within a policy is doubled or halved. To enable a comparison of sensitivities of different policies comprising of different levers and lever values, the increases of both lever values and transport outcomes (DRM4A) are translated into percentage changes from the Low sensitivity run. As a result of this transformation, a line can be plotted (see Figure 2.15) indicating the percentage increase of transport outcomes (y-axis in Figure 2.15) as a function of the percentage increase of the lever values (x-axis in Figure 2.15), which basically comes down to deriving a transport outcomes elasticity of lever values.

Figure 2.15 depicts the analyses described above and gives the sensitivity results for passenger non-urban policies. The slopes of each of the lines in this figure illustrate the effect of changes in the values of the lever(s) within a specific policy on the transport outcomes: the steeper the slope, the larger the effect on transport outcomes (i.e. the larger the elasticity).

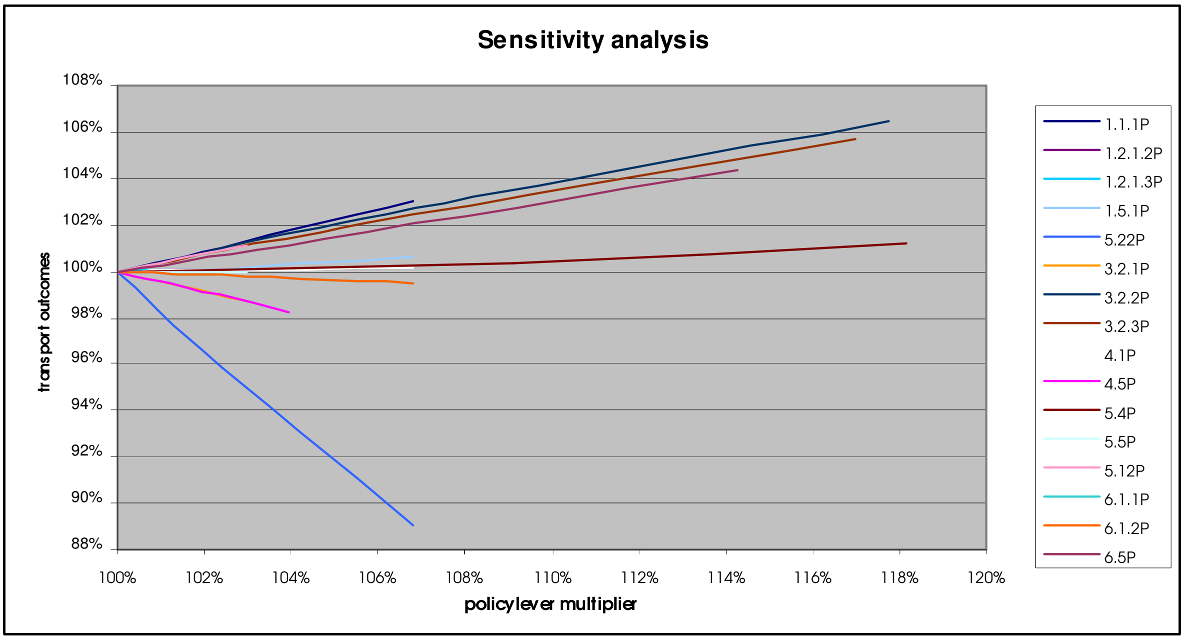


Figure 2.15 — Passenger non-urban sensitivity analysis

As can be seen from this graph, the transport outcomes respond (nearly) linearly to changes in the values of the policy levers that define a policy. However, the transport outcomes respond much stronger to changes of some policies, and thus to specific levers, than to others. Lines that are below the 100% gridline indicate that these policies will have adverse effects on the transport outcomes (from a sustainability perspective). Increasing the lever values of these policies will, as can be seen from the graph, only make things worse. This is especially true for policy 5.22P, which causes the transport outcomes to degrade at a rate that is greater than the percentage increase in the lever value (i.e. the elasticity is lower than –1).

Lines that remain close to 100% indicate that the policy levers used within these policies (1.2.1.2P, 1.2.1.3P, 1.5.1P, 4.1P, 5.4P, 5.5P, 6.1.1P, and 6.1.2P) only have marginal effects on transport outcomes, virtually irrespective of the value applied for the lever(s) that constitute the policy. The bulk of these policies have in common that they impose changes through train and/or BTM levers. Of these levers, train and BTM cost (policy 5.4P) appear to have some effect, while train and BTM time-related levers (TT, BT, TA, BA) do not seem to have a significant impact. TW and BW were not assessed in isolation, although the policy measures that encompass these levers do not appear to be affecting transport outcomes in any significant way.

Levers that do appear to have a significant effect on the transport outcomes are car and infrastructure related. It appears that transport outcomes are most sensitive to changes in infrastructure (see policy 5.22P). In addition, but to a much lesser extent as can be seen from the slopes in the figure, car time (1.1.1P, 3.2.1P, 4.5P) and car cost (3.2.2P, 3.2.3P, 5.12P) also have a significant impact.

2.6.1.2. Freight Non-Urban

Goals

Of the EC's goals described earlier, three are relevant and available from the FSM results for assessing non-urban freight policies. Figure 2.16 gives an overview of these goals and the subgoals that are strived for in non-urban freight transport.

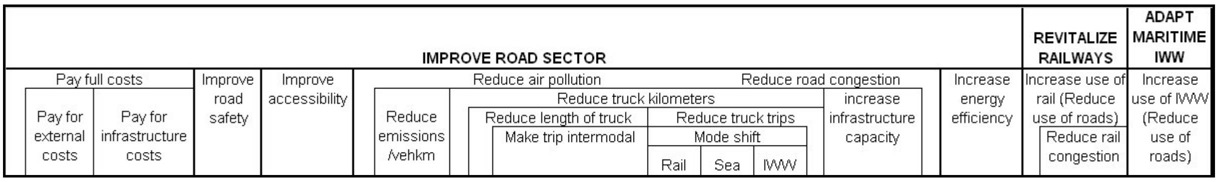


Figure 2.16 — Freight non-urban goals

As shown in Figure 2.16, there are three high-level goals for this domain: (1) improve the road sector, (2) revitalize the railways, and (3) adapt the maritime and inland waterway transport system. The second-level goal for the goal for the goal of revitalizing the railways (essentially, the mechanism for achieving this goal) is to increase the use of rail for passenger transport, and the second-level goal for the goal of adapting the maritime and inland waterway transport system is to increase the use of maritime and inland waterway transport. The objective behind the last two second-level goals is to provide a better balance among rail, maritime, inland waterway, and road transport.

Just as for passenger transport, there are six second-level goals for the goal of improving the road sector for freight transport:

- Pay full costs (with two third-level goals: pay for external costs and pay for infrastructure costs)
- Improve road safety
- Improve accessibility
- Reduce air pollution (with two third-level goals: reduce emissions/vehkm and reduce truck kilometres)
- Reduce road congestion (with two third-level goals: increase infrastructure capacity and reduce truck kilometres)
- Increase energy efficiency

As shown in the above list, three of the second-level goals have third-level goals. In addition, one of these third-level goals (reduce truck kilometres) has lower-level goals. There are many ways that a reduction in truck kilometres can be accomplished. These are reflected in the large variety of subgoals. One way is to leave the number of truck trips the same, but to reduce their average length. Another way is to reduce the number of trips made by truck. This can be done by eliminating some trips entirely (e.g., by using bigger trucks or filling the trucks fuller) or by using a different mode (rail, sea, or inland waterway). This hierarchy of goals results in two fourth-level goals (reduce length of truck trips and reduce truck trips), three fifth-level goals (make the trip intermodal, eliminate trips, and shift from the road mode), and three sixth-level goals (shift the trip to rail, sea, or inland waterway).

Policies
For the non-urban areas, we identified 18 freight policies as can be seen from Table 2.22.

Table 2.22 — Freight non-urban policies

Freight policies	
1.1.1F	Harmonise inspections and penalties (for freight transport)
1.1.2F	Increase the number of checks that Member States are required to carry out on compliance with driving times and drivers' rest periods (for freight transport)
5.21F	Allow bigger trucks for long-haul transport (for freight transport)
1.2.1.1F	Open up the national freight markets to cabotage (for freight transport)
1.2.1.2F	Ensure a high level of safety for the railway network (for freight transport)
1.2.1.3F	Update the interoperability directives for all components of the network (for freight transport)
1.4.6F	Improve inland waterway transport (for freight transport)
1.4.7F	Develop a European maritime traffic management system (for freight transport)
1.5.1F	Build and promote multi-modal transport networks and terminals (for freight transport)
1.5.4F	Standardise transport units and freight loading techniques (for freight transport)
6.7F	Increase service frequency for non-road modes (for freight transport)
3.1.2F	Harmonise rules governing checks and penalties concerning speeding in international commercial transport on the trans-European road network (for freight transport)
3.2.2F	Establish an infrastructure charging system (for freight transport)
3.2.3F	Establish uniform taxation for commercial road transport fuel (for freight transport)
4.5F	Develop an EU satellite navigation system (Galileo) (for freight transport)
6.2F	Increase / make uniform time windows (for freight transport)
6.3F	Subsidise environmentally friendly transport modes (for freight transport)
6.6F	Subsidise rail transport (for freight transport)

Analysis of policies at the European level
The scorecard for non-urban freight policies at the European level for the second-level goals is shown in Table 2.23. The rows of the scorecard are the 18 policy options listed in Table 2.22. The columns show the aggregated outcome indicators for the six second-level goals. The value shown in the scorecard for each of the goals is the average over the lower-level indicators. For example, the column showing the value for the outcome 'Reduce road congestion' is an average of the values for the third-level goals 'Reduce lorry kilometres' and 'Increase infrastructure capacity' (whose values can be found on lower-level scorecards).

We first examined the scorecard to find the best and runner-up policies for each of the second-level goals (all of these policies were then considered as promising when policy packages were being formed). These results are summarised in Table 2.24. For example, Policy 6.3F ('Subsidise environmentally friendly transport modes') is a slightly better policy for reducing air pollution and for reducing road congestion than is Policy 6.6F ('Subsidise rail transport'), while Policy 6.6F is a slightly better policy for increasing the use of railways. The comparison of the results for these two policies is actually quite interesting. The subsidisation of both rail and inland waterway transport shifts quite a bit of freight away from road transport. However, even though inland waterway transport is subsidised, the subsidisation of rail transport ends up shifting freight from inland waterways to rail. When both modes are subsidised, IWW transport is reduced by 15%; when only rail is subsidised, IWW transport is reduced by 26%. In the former case, road transport is reduced by 26%; in the latter case, road transport is reduced by about 19%[31].

The policy 'Allow bigger trucks for long-haul transport' (5.21F) also produced interesting results. It might be expected that using bigger trucks would reduce the number of truck trips, thereby reducing air pollution and reducing road congestion. The results show, however, that truck kilometres actually increased. This happens because some transport is shifted from rail and inland waterways to road hurting the goals revitalise railways and adapt maritime IWW. As a result, air pollution and road congestion actually increase somewhat. This policy is one of three in the category "Improving quality in the road sector. The other two policies (1.1.1F – 'Harmonise inspections and penalties', and 1.1.2F

[31] These percentages can be derived from the lower level scorecards.

– 'Increase the number of checks that Member States are required to carry out on compliance with driving times and drivers' rest periods') exhibit much better performance. These two policies result in some extra costs (1.1.1F) and extra travel time (1.1.2F) for road transport, which have the effect of shifting some goods from the roads to the railways and inlands waterways. As a result, these two policies exhibit better results relative to the goals of revitalising the railways and adapting the maritime and inland waterway transport system than do any of the policies from the White Paper that are directly targeted on these goals.

Table 2.23 — Results from freight non-urban policy runs

	IMPROVE ROAD SECTOR				REVITALIZE RAILWAYS	ADAPT MARITIME IWW
	Pay full costs	*Reduce air pollution*	*Reduce road congestion*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*	*Increase use of IWW (Reduce use of roads)*
1.1.1F	102	101	101	100	107	102
1.1.2F	99	101	101	100	108	102
5.21F	101	99	99	100	93	98
1.2.1.1F	100	100	100	100	103	99
1.2.1.2F	100	100	100	100	103	99
1.2.1.3F	100	101	100	100	106	99
1.4.6F	100	100	100	100	100	101
1.4.7F	100	100	100	100	99	100
1.5.1F	98	102	102	100	109	101
1.5.4F	98	102	102	100	118	98
6.7F	100	100	100	100	101	100
3.1.2F	100	100	100	100	101	100
3.2.2F	153	105	105	100	126	109
3.2.3F	107	105	105	100	126	109
4.5F	101	99	99	100	95	99
6.2F	101	99	99	100	93	98
6.3F	90	115	113	100	179	85
6.6F	93	111	110	100	200	74

Table 2.24 — Best and runner-up freight non-urban policies

Second-Level Goal	Best Policy	Runner-up Policies
Pay full costs	3.2.2F	3.2.3F
Reduce air pollution	6.3F 6.6F	3.2.2F 3.2.3F
Reduce road congestion	6.3F 6.6F	3.2.2F 3.2.3F
Increase energy efficiency		
Increase use of railways	6.6F 6.3F	3.2.2F 3.2.3F 1.5.4F 1.5.1F 1.1.2F 1.1.1F 1.2.1.3F
Increase use of inland waterways	3.2.2F 3.2.3F	

Policies that tend to benefit rail or IWW (1.5.1F, 1.5.4F, 1.2.1.3F) potentially are able to generate a substantial percentage increase in the use of these modes. However, the substantial percentage increases for these modes often translate into only small modal shifts, due to the limited volumes of these modes; they also tend to draw volume from other, environmentally friendly, non-road modes. This renders these policy options less interesting from a sustainability perspective.

Policies that benefit the efficiency of road transport, such as policies 4.5F and 6.2F, can, from a sustainability perspective, obviously not be implemented without mitigating measures, such as pricing. The mitigating measures would be required to counter the mode shift towards road modes that would be generated by improving the level of service of lorry transport under these policies.

The importance of using increases in truck transport costs as a policy instrument to achieve sustainability goals is dramatically illustrated by the results for Policies 3.2.2F ('Establish an infrastructure charging system') and 3.2.3F ('Establish uniform taxation for commercial road transport fuel'). Both of these policies increase lorry costs by 18% (3.2.2F uses charges, 3.2.3F uses taxes). So, both contribute to the goal of having road freight transport pay its full costs. But, more important, both policies make significant contributions to reducing air pollution and reducing road congestion (by reducing truck kilometres) and to both the railways and adapting the maritime and inland waterway transport system (by shifting freight to these modes).

Comparing the results from charging (policies 3.2.2F and 3.2.3F) with subsidising (6.3F and 6.6F) clearly illustrates the advantages of charging over subsidising. Subsidising does not meet the goal of having the user pay full cost, but more importantly, it also brings about unintended mode shifts. While subsidising promotes a single mode, which consequently will draw away mode share from all competing modes, charging on the other hand allows to the policymaker to target one specific mode to the benefit of all other modes. This obviously is a better tool for achieving both the White Paper goals and the overall goal of achieving sustainability. Only in cases in which there was a single alternative to road transport (e.g., rail transport, but no inland waterway transport) would charging and subsidising produce about the same mode shift, although some differences would still occur stemming from the demand response to changing transport prices.

None of the freight policies make much of a contribution to the goal of increasing energy efficiency.

Insights from analysis of policies at other geographical levels

An examination of the individual scorecards for the countries and the regions ('EU15' and 'Rest of Europe') for the high-level goals revealed some similarities and differences for the various policies. As was the case for passenger transport, there were only very small regional differences. (I.e., the separate results for the 'EU15' and the 'Rest of Europe' were about the same, and practically identical to the results for Europe as a whole.) However, some countries appeared to be more sensitive to a few of the policy changes (i.e., the outcome indicators increase or decrease significantly) than other countries. It is possible that these differences are due to data differences among the countries. In particular, data for calculating outcome indicators are sometimes wrong or missing for some countries, in which cases the FSM produces incorrect estimates of a policy's effects on the outcome indicators. For example, the high-level scorecards showed that Policy 3.2.2F ('Establish an infrastructure charging system') would have a very large positive effect on the goal of improving the road sector in Poland, a smaller (but still substantial) effect in Estonia, and practically no effect in Finland.

In most cases there are only small differences in the values of the outcome indicators across the countries. For most policies, the policy has no significant effect on the outcome indicators across all of the countries (e.g., Policy 6.7F ('Increase service frequency for non-road modes')). There are, however, some policies for which the outcomes for all countries are very positive. This is particularly true for Policy 1.5.1F ('Build and promote multi-modal transport networks and terminals') and 1.5.4F ('Standardise transport units and freight loading techniques'), both of which have strong positive improvements with respect to the goal of revitalising the railroads in all of the countries. Similarly, Policy 3.2.3F ('Establish uniform taxation for commercial road transport fuel') has strong positive improvements with respect to all three of the high-level goals in all of the countries.

Sensitivity analysis

The method used to determine the sensitivity of freight non-urban policies for changes in lever values is the same as for passenger non-urban. Similar to non-urban passenger policies, an outcome indicator that provides insight into (changes in) the modal split is required to assess the sensitivity of non-urban freight policies to changes in lever values. The indicator Road transport kilometres lorry (DRM 4B) is used to assess multiple goals in the scorecards. In addition, there are several indicators that assess mode shift that make use of DRM4B. Although the indicator does not actively assess shifts to other modes, it does contain information on these shifts, since each modal shift will be reflected in DRM4B.

Since some non-urban freight policies have relatively high lever values, and because elasticities in freight models are only valid within a certain range, both of the sensitivity runs for a policy use lower lever values than were used in the normal policy run. In total, three runs per policy were made to support the sensitivity analysis for non-urban freight policies:

- Normal ⇒ run of the policy using its standard predefined lever values.
- Medium ⇒ run of the policy using lever values at 1/2 of their standard values.
- Low ⇒ run of the policy using lever values at 1/3 of their standard values.

Since the FSM only accepts integer values for the levers and the sensitivity lever values are derived from the normal runs by dividing its lever values, rounding lever values for the sensitivity analysis is common practice in the sensitivity analysis for non-urban freight policies. In assessing the outcomes the actual factor applied in deriving the lever values for the sensitivity runs was taken into account.

Similar to passenger non-urban also for freight non-urban a comparison of sensitivities of different policies comprising of different levers and lever values is enabled by translating lever value changes and transport outcomes (DRM4B) into percentage changes from the Low sensitivity run. As a result of this transformation a line can be plotted indicated the percentage increase of transport outcomes as a function of the percentage increase of the lever values, which basically comes down to deriving a transport outcomes elasticity of lever values.

Figure 2.17 depicts the sensitivity results for freight non-urban policies. The slope of each of the lines in this figure illustrate the effect of changes in the values of the lever(s) within a specific policy on the transport outcomes: the steeper the slope, the larger the effect on transport outcomes (i.e. the larger the elasticity).

As can be seen from this graph, the transport outcomes respond (nearly) linearly to changes in the values of the policy levers that define a policy. However, the transport outcomes respond much stronger to changes of some policies, and thus to specific levers, than to others. Lines that are below the 100% gridline indicate that these policies will have adverse effects on the transport outcomes (from a sustainability perspective). Increasing the lever values of these policies will, as can be seen from the graph, only make things worse. It was already noted above that improving the level of service for road modes hurts sustainability. This is reiterated in Figure 2.17 for policies 5.21F, 4.5F, and 6.2F.

Lines that remain close to the 100% gridline indicate that the policy levers used within these policies (1.4.6F, 6.7F, and 1.4.7F) only have marginal effects on transport outcomes, virtually irrespective of the value applied for the lever(s) that constitute the policy. Although from the analysis it appears that RF, WC, WT, SC, and ST do not have a significant impact on transport outcomes, these levers are generally applied in policies that comprise of various levers clouding the influence of the individual levers. For this reason identifying the effect of individual levers on transport outcomes is not straightforward.

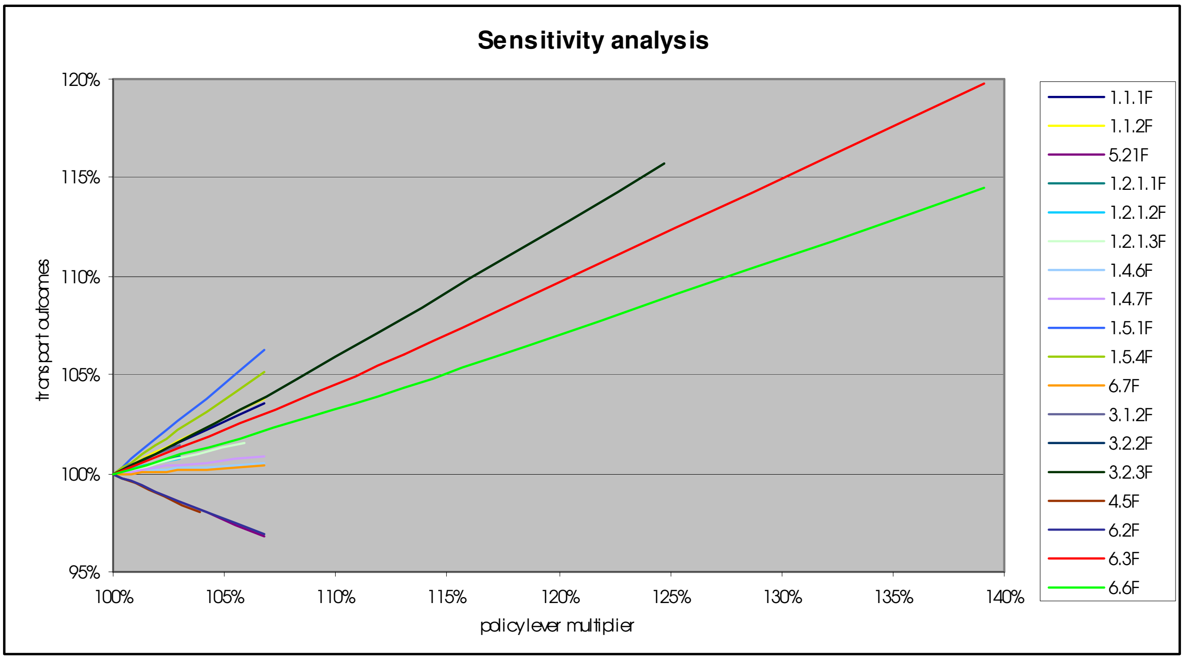


Figure 2.17 — Freight non-urban sensitivity analysis

Rail cost and rail time (included in policies 1.2.1.1F, 1.2.1.2F, 1.2.1.3F, and 6.6F) do appear to have a significant impact on the transport outcomes although their effect is still half that of lorry cost (policies 1.1.1F, 5.21F, 3.1.2F, 3.2.2F, and 3.2.3F) and lorry time (1.1.2F, and 4.5F) impacts.

Policies that do surprisingly well are 1.5.1F and 1.5.4F. As these policies affect the handling times of a variety of modes, it is difficult to state which of these levers (LH, RH, or SH) brings about the most significant effect. However, given the fact that 1.5.4F include RH and RT, and RT is known not to have a large effect on transport outcomes (as can be seen from policies 1.2.1.2F and 1.2.1.3F), conclude that RH is playing an important role in affecting transport outcomes under 1.5.1F.

A closer look at the relationship between policy lever multipliers and transport outcomes reveals that some non-linearities do exist. These are however most apparent in policies 1.4.6F, 3.2.2F, 3.2.3F, 6.3F, and 6.6F, which, since all but 1.4.6F have relatively high lever values, strengthens our belief that non-linear behaviour will generally be the result of the limited validity of the model's elasticities rather than pointing out interesting freight transport system responses.

2.6.2. Analysis of Single Policies: Urban

2.6.2.1. Passenger Urban

Our analysis of policies and their effects on urban areas were carried out for the areas for which runs were able to be made with the city and regional models. For passenger transport, we performed our analysis for four geographical areas: Hamburg, Randstad, Paris, and Prague. Within these areas the goals and the indicators to assess these are the same. Due to the level of detail in some of the regional models that provide input to the FSM, the FSM can run some additional policies for urban areas.

Goals
From the EC's goals described earlier, three are relevant and available for assessing non-urban freight policies. Figure 2.18 gives an overview of the goals and the subgoals that are strived for in urban passenger transport.

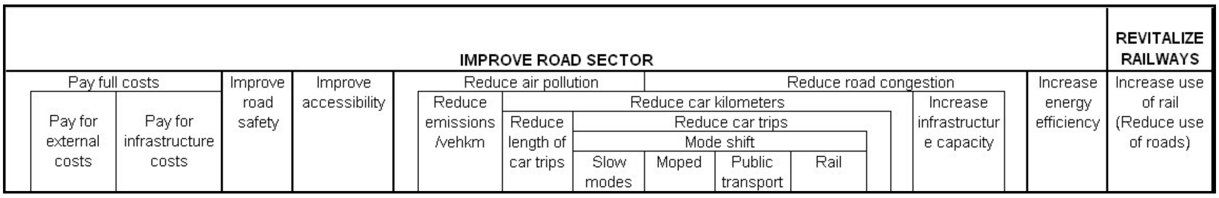


Figure 2.18 — Passenger urban goals

As shown in Figure 2.18, the goal hierarchy for the passenger urban domain is identical to the goal hierarchy for the passenger non-urban domain. There are two high-level goals for this domain: (1) improve the road sector, and (2) revitalize the railways. The second-level goal for the goal for the goal of revitalizing the railways is to increase the use of rail for passenger transport. There are six second-level goals for the goal of improving the road sector:

- Pay full costs (with two third-level goals: pay for external costs and pay for infrastructure costs)
- Improve road safety
- Improve accessibility
- Reduce air pollution (with two third-level goals: reduce emissions/vehkm and reduce car kilometres)
- Reduce road congestion (with two third-level goals: increase infrastructure capacity and reduce car kilometres)
- Increase energy efficiency

As shown in the above list, three of the second-level goals have third-level goals. In addition, one of these third-level goals (reduce car kilometres) has lower-level goals. There are many ways that a reduction in car kilometres can be accomplished. These are reflected in the large variety of subgoals. One way is to leave the number of car trips the same, but to reduce their average length. Another way is to reduce the number of trips made by car. This can be done by eliminating some trips entirely (e.g., by telecommuting to work or school) or by using a different mode (a slow mode, a moped, or public transport). This hierarchy of goals results in two fourth-level goals (reduce length of car trips and reduce car trips), two fifth-level goals (eliminate trips and shift from the car mode), and three sixth-level goals (shift to slow mode, shift to moped, and shift to public transport).

Policies
For the 4 urban regions identified above a total of 21 individual policies were composed and run. Not all of these individual policies, however, were run for each urban area. The table below shows which policies and policy packages were run for which areas.

Table 2.25 — Passenger urban policy runs

ban passenger policies and policy packages		Randstad	Paris	Prague	Hamburg
1.1P	Harmonise inspections and penalties	x	x	x	
2.1.2P	Ensure a high level of safety for the railway network	x	x	x	x
2.1.3P	Update the interoperability directives for all components of the network	x	x	x	x
2.1.4P	Open up international passenger transport			x	x
5.1P	Build and promote multi-modal transport networks and terminals	x	x	x	
1P	Revise the trans-European network and guidelines			x	
1.22P	Railway line Athina. Sofia-Budapest-Wien-Praha-Nürnberg/Dresden			x	
2.1P	Guarantee the interoperability of means of payment on the trans-European road network	x	x		
2.2P	Establish an infrastructure charging system (for passenger transport)				x
2.3P	Establish uniform taxation for commercial road transport fuel	x	x		
1P	Mobilise private sector finance to link the Accession countries to the trans-European railway network	x			
5P	Develop an EU satellite navigation system (Galileo)	x	x	x	
1PF	Reduce speed limits in urban areas	x		x	x
2P	Implement parking space management	x	x	x	x
4P	Introduce low-price tickets for employees to use on public transport in cities ('job ticket')	x			x
5P	Improve the performance and service quality of public transport	x	x	x	x
5P	Increase car -sharing				x
11P	Implement road pricing				x
12P	Increase parking fees	x	x		x
22P	Add road infrastructure	x			
25P	Implement congestion pricing	x			

Analysis of policies at the urban level

In general, in reaching the goals defined earlier in this document, achieving a modal shift away from road transport is one of the main intermediate goals. Reducing car kilometres is likely to reduce air pollution, increase road safety, reduce road congestion, and revitalise the railways. This is also one of the main reasons for using car kilometres later on in this document as an indicator to assess the sensitivity of the policies for changing lever values.

Passenger Hamburg

Table 2.25 shows that 11 urban passenger policies were run for the Hamburg region. The results of these policy runs for each of the goals depicted in Figure 2.18 can be found in the scorecard presented in Table 2.26.

Table 2.26 — Results from passenger urban policy runs for Hamburg

	IMPROVE ROAD SECTOR						REVITALIZE RAILWAYS
	Pay full costs	*Improve road safety*	*Improve accessibility*	*Reduce air pollution*	*Reduce road congestion*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*
1.2.1.2P	100	100	100	100	100	100	100
1.2.1.3P	100	100	100	100	100	100	100
1.2.1.4P	100	100	100	100	100	100	100
3.2.2P	1148	101	103	102	103	99	100
5.11P	99	102	100	101	101	99	100
5.1PF	100	100	101	100	101	100	100
5.2P	100	101	92	100	96	100	100
5.4P	100	100	100	100	100	101	100
5.5P	100	100	100	100	100	100	100
5.6P	100	100	100	100	100	100	100
5.12P	153	104	102	102	102	99	100

The results presented in Table 2.26 provide a clear example of the positive impacts of charging and pricing policies. The top three policies that bring about a mode shift away from car all encompass a form of pricing. In the model, all forms of pricing are brought about by increasing car cost, which causes the modal shift. The policies run for Hamburg affect were implemented in only a small portion of the city (in the city centre), so it is difficult to determine how effective they actually would be. (The effects are diluted by averaging them with no effects in the surburban region outside the city center.) Thus, the effects from all policies are small, so it is difficult to determine which form of pricing would be most efficient in achieving mode shifts.

Policies that improve the quality of modes that provide an alternative to car such as rail and BTM (e.g. policies 5.4P, 1.2.1.2P, 1.2.1.3P, 1.2.1.4P, and 5.5P), do not appear particularly successful for the Hamburg region in achieving mode shifts. No policies that affect in-car time were run for the Hamburg region.

Table 2.27 — Ranking of single policies and policy packages for Hamburg urban passenger transport

Policy	
Best performing single policies	
3.2.2P	Establish an infrastructure charging system (for passenger transport)
5.12P	Increase parking fees (for passenger transport)
5.11P	Implement road pricing (for passenger transport)
Worst performing single policies	
5.1PF	Reduce speed limits in urban areas (for passenger and freight transport)

Passenger Randstad

Table 2.25 shows that for the Randstad region 15 urban passenger policies were run. The results of these policy runs, against the goals depicted in Figure 2.18, can be found in Table 2.28.

Table 2.28 — Results from passenger urban policy runs for the Randstad

	IMPROVE ROAD SECTOR						REVITALIZE RAILWAYS
	Pay full costs	*Improve road safety*	*Improve accessibility*	*Reduce air pollution*	*Reduce road congestion*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*
1.1.1P	99	102	99	101	100	100	101
1.2.1.2P	100	100	100	100	100	100	101
1.2.1.3P	100	100	100	100	100	100	101
1.5.1P	100	100	100	100	100	100	104
5.22P	100	99	101	99	100	100	99
3.2.1P	100	99	101	99	100	100	100
3.2.3P	103	108	101	105	103	99	105
4.1P	100	100	100	100	100	100	102
4.5P	101	99	101	99	100	100	99
5.1PF	100	100	98	100	99	100	101
5.2P	100	100	100	100	100	100	100
5.4P	100	100	100	100	100	100	104
5.5P	100	100	100	100	100	100	101
5.12P	153	100	100	100	100	100	100
5.25P	98	106	100	104	102	98	102

For the Randstad, pricing/charging appears to be the most efficient way to achieve a mode shift away from road. This mode shift can be obtained both by pricing infrastructure (5.25P – 'Implement congestion pricing') and by increasing fuel taxes (3.2.3P – 'Establish uniform taxation for commercial road transport fuel'). For the Randstad, no policies were run that affect fixed car cost. Another policy that brings about a mode shift away from car is 'Harmonise inspections and penalties' (1.1.1P). For the Randstad model this policy was implemented by reduced the speed on the network by 5%. The results indicate that a mode shift is more apparent from increasing car cost compared to increasing car time or reducing the network speed; i.e. mode choice is more sensitive to cost than to time.

Although the bulk of the policies do not result in any significant mode shifts, some policies (such as 1.5.1P and 5.4P) do contribute to the goal of revitalising the railways. Within these two policies, which have fairly similar impacts, rail draws tours and kms away from the other modes, especially from the slow modes. In addition, since rail has a smaller mode share compared to road, a mode shift (in kilometres) from car to rail will result in a smaller percentage reduction for car compared to the increase for rail. For these reasons these policies are not particularly interesting, since they tend to increase total distance travelled and air pollution.

A similar effect is brought about by the policies 5.22P, 3.2.1P and 4.5P. These policies improve the level of service in the road sector and thus lead to an increased use of cars, resulting in more car kilometres. From a sustainability perspective, these policies appear to be inappropriate.

Table 2.29 — Ranking of single policies and policy packages for Randstad urban passenger transport

Policy	
Best performing single policies	
3.2.3P	Establish uniform taxation for commercial road transport fuel (for passenger transport)
5.25P	Implement congestion pricing (for passenger transport)
1.1.1P	Harmonise inspections and penalties (for passenger transport)
Worst performing single policies	
4.5P	Develop an EU satellite navigation system (Galileo) (for passenger transport)
5.22P	Add road infrastructure (for passenger transport)
3.2.1P	Guarantee the interoperability of means of payment on the trans-European road network (for passenger transport)

Passenger Ile de France (Paris)

The Ile de France region comprises of wider Paris. Table 2.25 shows that for the Ile de France region 10 urban passenger policies were run. The results of these policy runs, against the goals depicted in Figure 2.18, can be found in Table 2.30.

Table 2.30 — Results from passenger urban policy runs for Ile de France

	IMPROVE ROAD SECTOR						REVITALIZE RAILWAYS
	Pay full costs	*Improve road safety*	*Improve accessibility*	*Reduce air pollution*	*Reduce road congestion*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*
1.1.1P	98	107	98	104	101	101	105
1.2.1.2P	100	100	100	100	100	100	101
1.2.1.3P	100	100	100	100	100	100	100
1.5.1P	100	101	100	101	100	100	105
3.2.1P	101	97	101	98	99	100	98
3.2.3P	104	106	101	104	103	98	105
4.5P	102	96	101	98	99	99	97
5.2P	98	107	92	104	99	102	115
5.5P	100	100	100	100	100	100	101
5.12P	102	100	100	100	100	100	100

From the policy runs, and particularly from the low level scorecards, it can be seen that time is an important variable in achieving mode shifts for this region. Both policies 1.1.1P and 5.2P increase in-car time and thus result in a significant reduction of car kilometres in favour of all competing modes.

Similar to the Randstad also for Ile the France increasing the cost of road transport is an effective way of achieving a mode shift away from car.

Table 2.31 — Ranking of single policies and policy packages for Ile de France urban passenger transport

c	
Best performing single policies	
5.2P	Implement parking space management (for passenger transport)
1.1.1P	Harmonise inspections and penalties (for passenger transport)
3.2.3P	Establish uniform taxation for commercial road transport fuel (for passenger transport)
Worst performing single policies	
4.5P	Develop an EU satellite navigation system (Galileo) (for passenger transport)
3.2.1P	Guarantee the interoperability of means of payment on the trans-European road network (for passenger transport)

As Table 2.30 shows, from the Ile the France region results it becomes apparent that policies improving road transport, such as 4.5P and 3.2.1P, will reduce sustainability and will lead to modal shift towards road transport instead of away from it.

Passenger Prague

Table 2.25 shows that for the Prague region 11 urban passenger policies were run. The results of these policy runs, against the goals depicted in Figure 2.18, can be found in Table 2.32.

Table 2.32 — Results from passenger urban policy runs for Prague

	IMPROVE ROAD SECTOR						REVITALIZE RAILWAYS
	Pay full costs	*Improve road safety*	*Improve accessibility*	*Reduce air pollution*	*Reduce road congestion*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*
1.1.1P	100	101	96	100	98	100	103
1.2.1.2P	100	100	100	100	100	100	102
1.2.1.3P	100	100	100	100	100	100	102
1.2.1.4P	100	100	100	100	100	100	100
1.5.1P	100	101	100	100	100	100	103
2.1P	100	100	100	100	100	100	100
2.1.22P	100	100	100	100	100	100	100
4.5P	100	99	103	100	101	100	99
5.1PF	98	105	81	102	92	101	118
5.2P	99	102	94	101	98	100	107
5.5P	100	100	100	100	100	100	101

The most likely top performers for achieving a mode shift away from car transport (Policies 5.25P and 3.2.3P) were not run for Prague. The alternative option of reducing the level of service for car transport by increasing in-car time was run for Prague and appears to be somewhat successful. Policy 1.1.1P brings about a mode shift from car (and car passenger) to all other modes, especially in terms of tours, but also in terms of kilometres. This mode shift results in a reduction of air pollutants, mainly in CO and PM (although there is a small increase in HC due to the shift to BTM and train). It however hurts accessibility, which also translates into an increase in road congestion.

Table 2.33 — Ranking of single policies and policy packages for Prague urban passenger transport

Policy	
Best performing single policies	
5.1PF	Reduce speed limits in urban areas (for passenger and freight transport)
5.2P	Implement parking space management (for passenger transport)
1.1.1P	Harmonise inspections and penalties (for passenger transport)
Worst performing single policies	
4.5P	Develop an EU satellite navigation system (Galileo) (for passenger transport)
Best performing policy packages	

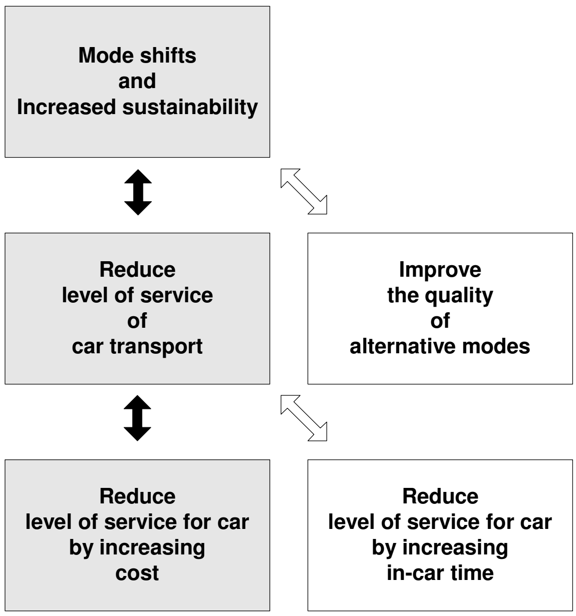
As can be seen from Table 2.32 and Table 2.33, the best options for achieving mode shift are 5.1PF and 5.2P. These policies, however, both achieve this mode shift by measures that decrease accessibility, which raises the question whether the combined effects of these measures should be considered positive.

Instead of lowering the level of service for road transport, as is done under policies 5.1PF and 5.2P, the level of service for rail and BTM can be improved in order to shift transport to these modes. Policy 1.5.1P ('Build an promote multi-modal transport networks and terminals') brings about a mode shift from car and slow modes to rail and btm, which has a small positive effect on air pollutant emissions (slightly negative for NOx and HC, but positive for CO and PM).

Again, as can also be seen from other regions, making road transport more efficient (as in policy 4.5P) has a negative effect on sustainability, since it creates a mode shift towards car at the expense of all other modes.

Overall conclusions from urban passenger runs
From the four urban regions and the policies run for each of these regions the following conclusions can be drawn:

- Mode shifts and increased sustainability can be achieved by reducing the level of service of car and / or improving the quality of modes that provide an alternative to car transport.
- Policies that aim to bring about a mode shift by reducing the level of service of car transport are generally more effective in achieving this mode shift than policies that aim to do so by improving the quality of alternative modes.
- In general it appears that policies that reduce the level of service for car by increasing cost are more efficient in achieving a mode shift away from car than policies that increase in-car time. However, for the Ile de France region the opposite holds; mode shift in this region is more sensitive to time than to cost.



2.6.2.2. Freight Urban

For urban freight transport, the analysis of policies and their effects on urban areas were carried out for the only area for which city and regional models were available -- Hamburg. Due to the greater level of detail in this regional model than exists in the EXPEDITE meta-model, the FSM was able to run some additional policies for the Hamburg region.

Goals
From the EC's goals described earlier only one is relevant (since only lorries are considered a viable means of freight transport in urban areas) and available for assessing urban freight policies -- improve the road sector. Figure 2.19 gives an overview of the goals and subgoals for this goal that are strived for in urban freight transport.

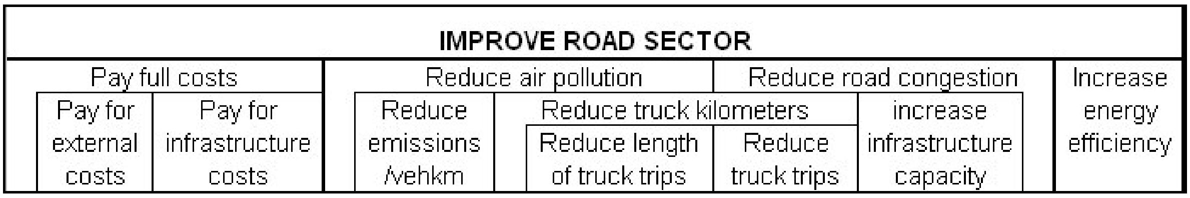


Figure 2.19 — Freight urban goals

As shown in Figure 2.19, there is only one high-level goal for this domain, -- improve the road sector (since intra-urban freight does not have the choice of rail, maritime, or inland waterway. Just as for non-urban freight transport, there are four second-level goals for the goal of improving the road sector for freight transport:

- Pay full costs (with two third-level goals: pay for external costs and pay for infrastructure costs)
- Reduce air pollution (with two third-level goals: reduce emissions/vehkm and reduce truck kilometres)
- Reduce road congestion (with two third-level goals: increase infrastructure capacity and reduce truck kilometres)
- Increase energy efficiency

As shown in the above list, three of the second-level goals have third-level goals. In addition, one of these third-level goals (reduce truck kilometres) has fourth-level goals. In the case of urban freight transport, mode shift is not possible. So, the only ways to reduce truck kilometres are to leave the number of truck trips the same, but to reduce their average length or to eliminate some trips entirely. This hierarchy of goals results in two fourth-level goals (reduce length of truck trips and reduce truck trips).

Policies
For the urban areas, 9 freight policies were identified (see Table 2.34)

Table 2.34 — Freight urban policy runs

Freight urban policies	
5.21F	Allow bigger trucks for long-haul transport (for freight transport)
1.2.1.1F	Open up the national freight markets to cabotage (for freight transport)
1.2.1.2F	Ensure a high level of safety for the railway network (for freight transport)
1.5.4F	Standardise transport units and freight loading techniques (for freight transport)
3.2.2F	Establish an infrastructure charging system (for freight transport)
5.11F	Implement road pricing (for freight transport)
5.1PF	Reduce speed limits in urban areas (for passenger and freight transport)
5.3F	Reduce freight through traffic in urban areas
5.10F	Promote city logistic centres (systems) in the surrounding of populated areas (last mile logistics) (for freight transport)

Analysis of policies at the European level
The scorecard for urban freight policies at the European level for the third-level goals is shown in Table 2.35. The rows of the scorecard are the nine policy options listed in Table 2.34. The columns show the aggregated outcome indicators for the four second-level goals and the indicators which aggregate up to these second level goals. The values for the individual outcome indicators can be found in lower-level scorecards.

Table 2.35 — Results from urban freight policy runs for Hamburg

	IMPROVE ROAD SECTOR								
	Pay full costs			*Reduce air pollution*				*Reduce road congestion*	*Increase energy efficiency*
	EC23B Lorry	*EC52A Lorry*	*EC52B Lorry*	*EC43C Road*	*EN33B Lorry*	*Reduce emissions /vehkm*	*Reduce Lorry kilometres*	*Reduce Lorry kilometres*	*EC34B Lorry*
5.21F	100	103	103	99	97	100	97	97	100
1.2.1.1F	100	99	99	100	101	100	101	101	100
1.2.1.2F	100	100	100	100	100	100	100	100	100
1.5.4F	100	99	99	100	101	100	101	101	100
3.2.2F	100	504	92	103	109	100	109	109	100
5.11F	100	98	98	101	102	100	102	102	100
5.1PF	100	100	100	100	100	100	100	100	100
5.3F	100	99	99	100	101	100	101	101	100
5.10F	100	103	103	99	97	100	97	97	100

We first examined the scorecard to find the best policies (and runner-up policies) for each of the second-level goals. The only urban freight policy that appears to have a significant positive impact is 3.2.2F – Establish a road infrastructure charging system. Since lorry transport is the only mode within urban areas for freight transport (i.e., no transport by rail or inland waterways), mode shift strategies do not make sense. Through charging (as in 3.2.2F), however, the number of lorry kilometres can be brought down. The reduction in kilometres mainly stems from a reduction in length per trip, although the number of trips is also reduced to some extent. From a sustainability perspective, according to the goals specified in previous chapters, this policy option does not have any drawbacks. In addition the policy is likely to be a net financial contributor, as the cost of implementation could remain below the income from the funds generated by the charges, depending on the charge and its associated cost of implementation. In general it is attractive for helping to reach three of the second-level goals ('Pay full costs', Reduce air pollution', and 'Reduce road congestion').

None of the individual policies make much of a contribution to the other three goals. Policies 'Allow bigger trucks for long-haul transport' (5.21F) and 'Promote city logistic centres (systems) in the surrounding of populated areas (last mile logistics)' (5.10F) even produce an increase in lorry kilometres and are thus not sensible from a sustainability perspective.

Table 2.36 — Ranking of single policies and policy packages for Hamburg urban freight transport

Policy	
Best performing single policies	
3.2.2F	Establish an infrastructure charging system (for freight transport)
Worst performing single policies	
5.21F	Allow bigger trucks for long-haul transport (for freight transport)
5.10F	Promote city logistic centres (systems) in the surrounding of populated areas (last mile logistics) (for freight transport)

Although the other urban freight policies do not have a significant impact on transport or sustainability, some of them actually have small negative effects. The policies 'Allow bigger trucks for long-haul transport' (5.21F) and 'Promote city logistic centres (systems) in the surrounding of populated areas (last mile logistics)' (5.10F) adversely affect road congestion and air pollution.

2.6.2.3. Analysis of Policy Packages: Non-Urban

2.6.2.3.1 Non-Urban Passenger

We created two types of policy packages for passenger transport at the European and national level. The first type focuses on trying to achieve individual goals. We looked at the columns of the scorecards that pertained to a single goal and assembled two or more policies that seemed to be helpful in contributing to achieving that goal (these policies are shown in the rows of Table 2.21). These policy packages are called 'single goal packages'. The lever values for these policies were combined following the criteria explained earlier. If two policies used the same lever, their values were added together after establishing that their contribution was independent (in none of the cases the policies were considered dependent). We then ran the policy combination in the FSM. There were five single goal packages, which are identified in the top portion of Table 2.37.

For the second type of policy package, we looked across the goals, and identified policies that might work together to achieve multiple goals. These policy packages are called 'multiple goal packages'. The lever values for these policies were combined; if two policies used the same lever, their values were added together. We then ran the policy combination in the FSM. There were two multiple goal packages, which are identified in the bottom portion of Table 2.37.

Table 2.37 — Passenger Policy Packages

SINGLE GOAL PACKAGES	
Identifier	*Policies*
PPP1 (Reduce congestion)	5.22P + 3.2.2P + 3.2.3P
PPP2 (Reduce air pollution)	6.4P+ 3.2.2P+ 3.2.3P
PPP3 (Pay full costs)	3.2.2P+ 5.12P
PPP4 (Improve road safety)	3.2.2P+ 3.2.3P
PPP5 (Revitalise the railways)	1.5.1P+ 4.1P

MULTIPLE GOAL PACKAGES	
Identifier	*Policies*
PPP6	5.22P+ 6.4P+ 3.2.2P+ 1.5.1P
PPP7	5.22P+ 6.4P+ 3.2.2P+ 1.5.1P+ 4.1P

The results for the second-level policy goals from running these policy packages in the FSM are shown in Table 2.38.

Table 2.38 — Results from passenger non-urban policy packages

	IMPROVE ROAD SECTOR					**REVITALIZE RAILWAYS**
	Reduce road congestion	*Reduce air pollution*	*Pay full costs*	*Improve road safety*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*
PPP1	98	100	184	100	101	105
PPP2	104	106	94	109	99	105
PPP3	104	162	181	109	99	105
PPP4	104	106	177	109	99	105
PPP5	101	101	99	102	101	118
PPP6	96	147	184	96	103	112
PPP7	96	147	183	96	103	120

The results show that, as desired, the combined policies generally improve the overall performance of the passenger transport system, both for the individual goals and over all the goals, compared to the performance of the individual policies. For example, the policy package focused on the goal of revitalising the railways (PPP5) strengthens the performance of the individual policies. (Basically, the effects are the sum of the effects from the individual policies.) The multiple goal policy packages balance the negatives of one policy with the positives from another.

2.6.2.3.2 Non-Urban Freight

In the case of freight transport policies at the European and national levels, we used a different approach to identifying policy packages. Our examination of single policies showed that most of the promising policies contributed to achieving several goals at the same time. For example (as can be seen in the scorecard shown in Table 2.23), the two policies 3.2.2F (Establish an infrastructure charging system) and 3.2.3F (Establish uniform taxation for commercial road transport fuel) make positive contributions to all of the goals of freight transport policy except the goal of increasing energy efficiency (Examining the rows of Table 2.24 shows this). We, therefore, made the combination of these two policies the basis of most of the freight policy packages. We then added additional policies one at a time, to form increasingly large (multiple goal) packages. In this way, we ended up with the six policy packages shown in Table 2.39. The lever values for these policies were combined following the criteria explained earlier. If two policies used the same lever, their values were added together after establishing that their contribution was independent (in none of the cases the policies were considered dependent). We then ran each of the six policy combinations in the FSM.

Table 2.39 — Freight Policy Packages

Identifier	Policies
FPP1	3.2.2F + 3.2.3F
FPP2	3.2.2F + 3.2.3F + 1.5.4F
FPP3	3.2.2F + 3.2.3F + 1.5.4F + 6.6F
FPP4	3.2.2F + 3.2.3F + 1.5.4F + 6.6F + 1.1.2F
FPP5	3.2.2F + 3.2.3F + 1.5.4F + 6.6F + 1.1.2F + 1.1.1F
FPP6	1.5.4F - 6.3F

The results for the second-level policy goals from running these policy packages in the FSM are shown in Table 2.40.

Table 2.40 — Results from freight non-urban policy packages

	IMPROVE ROAD SECTOR				REVITALIZE RAILWAYS	ADAPT MARITIME IWW
	Pay full costs	*Reduce air pollution*	*Reduce road congestion*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*	*Increase use of IWW (Reduce use of roads)*
FPP1	154	112	110	100	151	118
FPP2	150	114	113	100	177	114
FPP3	136	126	124	100	320	74
FPP4	134	128	126	100	338	73
FPP5	138	130	128	100	350	74
FPP6	91	113	112	100	231	71

2.6.3. Analysis of Policy Packages: Urban

2.6.3.1. Urban Passenger

Because of the way the FSM was designed, we had to define urban policies and urban policy packages and run them in the regional and city models prior to using the FSM to run other single policies and policy packages. So, potentially interesting policy packages had to be identified before the assessments of the individual policies were made. Once the individual policies to be run in the regional and city models were chosen, policy packages had to be identified. We have used a combination of two approaches to identify passenger policy packages to be run for urban areas.

1. Wide coverage approach
   Policymakers want to know if policy packages have the same general impacts in any area. Therefore the objective of this approach is that there should be the possibility to compare the effects of policy packages on sustainability in different areas and under different circumstances. That means as far as possible policy packages for the different regional and city models should be defined and merged in a way that as many of the same policy packages as feasible can be run in the different regional/city models.

Table 2.16 of from the White Paper (§ 2.5.2.3) presented an initial list of urban policies that was compiled from the White Paper and other sources. We incorporated the results from four regional/city models in the FSM. Not all of the models could run all of the policies listed in Table 2.16 . The policies that could be run in one or more of the city/regional models are shown in Table 2.41:

2. Goal-oriented approach
   This is an ex-ante approach to creating policy packages that is similar in spirit to the ex-post approach to the development of single goal policy packages. In this case, single policies were merged in (before running them individually) in order to strengthen each other in achieving a specified goal or goals and to see the combined impacts. For example, all of the White Paper measures in Category 1.2 (Revitalise the railways) that were sensible for urban areas are were clustered in one a single policy package in order to see their combined effects, and all

White Paper measures in Category 1.3 (control the growth in air transport) are clustered in one package to see their combined effect.

Similarly, we have combined selected single policies for cities and regions in a way that they are oriented toward a goal or the effectiveness of different policy combinations for the same goal can be analysed.

Table 2.41 shows the passenger policy packages that were created and the regional/city models in which they were run (labelled with x) and the justification. For each of the packages, there is reasoning behind it that justifies the combination. For example, the combination of Policy 5.2 (reduce parking facilities) and Policy 5.4 (introduce low-priced tickets for employees) in UPP8 is to reduce car use and increase public transport use in cities by restricting parking and reducing the cost of public transport. The combination of Policy 5.1 (impose a speed limit) and Policy 5.5 (increase the frequency of scheduled services) in UPP15 is an alternative way to reduce car use and increase public transport use in cities. Overall, the policy packages have been selected and combined in ways that the most important and most discussed urban policies are tested and the relative effectiveness of various combinations of policies are estimated.

Table 2.41 — Urban Passenger Policy Packages

Policy codes		Regional / city model			
		Randstad	Paris	Prague	Hamburg
UPP1	Urban Policy Package 1: 1.2.1.2P - 1.2.1.3P - 1.2.1.4P			x	x
UPP2	Urban Policy Package 2: 5.1P - 5.25P	x			
UPP3	Urban Policy Package 3: 5.2P - 5.2.2P	x	x		
UPP4	Urban Policy Package 4: 5.1P - 5.2P	x		x	x
UPP5	Urban Policy Package 5: 1.2.1.2P - 1.2.1.3P - 1.2.1.4P - 2.1.22P			x	
UPP6	Urban Policy Package 6: 1.2.1.2P - 1.2.1.4P			x	x
UPP8	Urban Policy Package 8: 5.2P - 5.4P	x			x
UPP9	Urban Policy Package 9: 5.2P - 5.5P	x	x	x	x
UPP10	Urban Policy Package 10: 5.2P - 5.4P - 5.5P	x			x
UPP11	Urban Policy Package 11: 5.2P - 5.2.2P - 5.4P - 5.5P	x			
UPP12	Urban Policy Package 12: 5.1P - 5.2P - 5.5P	x		x	x
UPP13	Urban Policy Package 13: 5.1P - 5.2P - 5.2.2P - 5.4P - 5.5P	x			
UPP14	Urban Policy Package 14: 5.25P - 3.2.3P	x			
UPP15	Urban Policy Package 15: 5.1P - 5.5P	x		x	x
UPP17	Urban Policy Package 17: 3.2.1P - 3.2.3P		x		

Hamburg

The results for the policy packages run in the Hamburg model are presented in Table 2.42.

Table 2.42 — Results from passenger urban policy packages for Hamburg

	IMPROVE ROAD SECTOR						REVITALIZE RAILWAYS
	Pay full costs	Improve road safety	Improve accessibility	Reduce air pollution	Reduce road congestion	Increase energy efficiency	Increase use of rail (Reduce use of roads)
UPP1	100	100	100	100	100	100	100
UPP4	100	100	93	100	96	101	100
UPP6	100	100	100	100	100	100	100
UPP8	100	101	92	100	96	101	100
UPP9	99	102	93	101	97	100	100
UPP10	99	102	93	101	97	101	100
UPP12	100	101	94	100	97	101	100
UPP15	100	101	102	100	101	101	100

Best performing policy packages

Randstad

The results for the policy packages run in the Randstad model are presented in Table 2.43. In general there is no synergistic effect of policy packages. Within a policy package, effects are more or less additive, meaning that the individual effects of policies comprising a package are added together. This means that policy packages that contain policies that were among the top performers in the single policies are likely to perform well in the policy packages. For the Randstad, this means that packages UPP2 and UPP14 do well. Their good performance stems from the effects of Policies 5.25P and 3.2.3P, which were described above. The other packages do not have any significant positive effects, but in general also do not have any negative effects.

Table 2.43 — Results from passenger urban policy packages for the Randstad

	IMPROVE ROAD SECTOR						REVITALIZE RAILWAYS
	Pay full costs	*Improve road safety*	*Improve accessibility*	*Reduce air pollution*	*Reduce road congestion*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*
UPP2	98	107	98	104	101	98	102
UPP3	100	100	100	100	100	100	100
UPP4	100	100	98	100	99	100	101
UPP8	100	100	100	100	100	100	105
UPP9	100	100	100	100	100	100	101
UPP10	100	100	100	100	100	100	106
UPP11	100	100	100	100	100	100	106
UPP12	100	100	98	100	99	100	102
UPP13	100	100	98	100	99	100	106
UPP14	95	115	101	108	105	97	107
UPP15	100	100	98	100	99	100	101

For the Randstad some of the individual policies that scored best are combined into policy packages, which as a result also score high. UPP14 clearly combines the benefits of congestion pricing on top of increase in fuel price. UPP2 only includes one of these elements and therefore comes second best. Typically all the other policy packages have only little impact on the number of car kilometres. UPP3 actually even has a negative impact and increases car kilometres.

Best performing policy packages

UPP14	Urban Policy Package 14: 5.25P - 3.2.3P
UPP2	Urban Policy Package 2: 5.1P - 5.25P

Worst performing single policies

UPP3	Urban Policy Package 3: 5.2P - 5.2.2P

Ile de France (Paris)

The results for the policy packages run in the Paris model are presented in Table 2.44. Policy packages that encompass single policies that are among the best performers automatically are among the best performing policy packages. An interesting observation from the policy packages is that UPP17, which is composed of one of the best performers (3.2.3P) and the poorest performer (3.2.1P) (in terms of achieving modal shift away from car), does have a net positive effect. It could be argued that through UPP17 some of the user benefits that flow from 3.2.1P but that do not contribute to sustainability as it is defined in this project, for instance convenience of payment for users, are implemented in this package while improving sustainability. This would suggest that 3.2.1P could well be implemented as long as it is supported by road charging policies.

Table 2.44 — Results from passenger urban policy packages for Ile de France

	IMPROVE ROAD SECTOR						REVITALIZE RAILWAYS
	Pay full costs	*Improve road safety*	*Improve accessibility*	*Reduce air pollution*	*Reduce road congestion*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*
UPP3	97	107	92	104	99	102	115
UPP9	97	107	92	104	99	102	117
UPP17	99	104	102	102	102	98	103

Since only three packages were run for Ile de France, these are automatically the best performing packages. Typically these three policy packages each contain one of the best performing individual policies together with an individual policy that has either no or a negative effect. As a consequence the policy packages do not outperform the individual policies, as there is no synergy between the components of the packages. Since 3.2.1P is one of the individual policies comprising UPP17 and has a negative effect on car kilometres, UPP17 is lagging compared to UPP9 and UPP3.

Best performing policy packages	
UPP9	Urban Policy Package 9: 5.2P - 5.5P
UPP3	Urban Policy Package 3: 5.2P - 5.2.2P
UPP17	Urban Policy Package 17: 3.2.1P - 3.2.3P

Prague

Table 2.45 — Results from passenger urban policy packages for Prague

	IMPROVE ROAD SECTOR						REVITALIZE RAILWAYS
	Pay full costs	*Improve road safety*	*Improve accessibility*	*Reduce air pollution*	*Reduce road congestion*	*Increase energy efficiency*	*Increase use of rail (Reduce use of roads)*
UPP1	100	100	100	100	100	100	104
UPP4	97	108	77	104	91	100	125
UPP5	100	100	100	100	100	100	104
UPP6	100	100	100	100	100	100	102
UPP9	99	103	94	101	98	100	108
UPP12	97	108	77	104	91	100	126
UPP15	98	105	81	103	92	101	119

In terms of car kilometres driven, policy packages UPP12, UPP4, UPP15, and, to a lesser extent, UPP9 all do well. However, as can be seen from Table 2.45, these policy packages are achieving their goal by reducing accessibility. This drawback is the result from including individual policy 5.1PF in packages UPP12, UPP4 and UPP15, in which speeds in urban areas are limited to 30 kilometres per hour. As could be seen in the individual policies' section, policy 4.5P mitigates the problem of accessibility, although this policy was not run in combination with the packages containing 5.1PF.

Best performing policy packages	
UPP12	Urban Policy Package 12: 5.1P - 5.2P - 5.5P
UPP4	Urban Policy Package 4: 5.1P - 5.2P
UPP15	Urban Policy Package 15: 5.1P - 5.5P
UPP9	Urban Policy Package 9: 5.2P - 5.5P

2.6.4. Urban Freight

Table 2.46 shows the freight policy packages that were created to be run in the Hamburg model.

Table 2.46 — Results from freight urban policy packages for Hamburg

	IMPROVE ROAD SECTOR								
	Pay full costs			*Reduce air pollution*				*Reduce road congestion*	*Increase energy efficiency*
	EC23B Lorry	*EC52A Lorry*	*EC52B Lorry*	*EC43C Road*	*EN33B Lorry*	*Reduce emissions /vehkm*	*Reduce Lorry kilometers*	*Reduce Lorry kilometers*	*EC34B Lorry*
UPP7	100	101	101	100	99	100	99	99	100
UPP19	100	100	100	100	100	100	100	100	100

From Table 2.46 it becomes apparent that none of the urban freight policy packages contributes significantly to reducing the number of lorry kilometres. The cause of this is in the fact that, as already became apparent in the individual policies' section, only policy 3.2.2F contributed to the goal of reducing lorry kilometres and this policy is not included in any of the urban freight policy packages.

2.6.5. Rankings of Policies Based on the Policy Assessment Module (PAM)

The goal of the PAM is to translate the direct transport effects and the (monetised) sustainability indicators into useful policy terms. It uses a welfare type of objective function that sums and weights effects of a very diverse nature and expresses (all) effects in monetary terms to make them comparable. Given a complete implementation of this function and a correct monetisation, the PAM is a useful indicator for sustainable development in transport. Important to note is that if the PAM implementation is not complete (thus excludes some effects), the welfare function will be out of balance and might (incorrectly) weight some effect more than others. It is therefore always important to know what is included in the PAM and to look at the major contributors to the function. In paragraph 3.3, the implementation of the PAM in the FSM is explained, and some remarks about its limitations are already made. Here we will investigate its functioning in practise.

The PAM combines freight and passenger transport into one function, and therefore the policies can be listed and ranked in one table. The ranking of the policies is done by relating the PAM-result for a policies with the PAM result for the reference case Table 2.47 and Table 2.48 show the ranking of the policies based on the PAM index (100%*(PAM-policy/PAM-reference)) and based on the absolute difference (PAM-policy – PAM-reference). Both result in the same ranking, but the absolute difference gives a feeling for what it means, as it is measured in monetary terms. Rather than listing the exact values Table 2.47 and Table 2.48 are based on a ranking in five groups. The largest group is the group of policies resulting in a PAM index near to 100 or an effect below 10 billion Euro. This group is not shown in the table. Although 10 billion Euro is quite a sum of money, compared to the total reference PAM value, it is relatively small (less than 0.2 %). The four other groups are displayed in the table; two below -10 billion Euro, and two above 10 billion Euro. A boundary has been placed around an absolute difference of 100 billion Euro, or an index change of around 2.5%.

Table 2.47 — PAM ranking for passenger transport

	PAM index	Policy	Policy Name
more than 100 billion Euro	101.1 –	PPP1 PPP2 PPP6 PPP7	5.22P + 3.2.2P + 3.2.3P (Reduce congestion) 6.4P + 3.2.2P+ 3.2.3P (Reduce air pollution) 5.22P+ 6.4P+ 3.2.2P+ 1.5.1P 5.22P+ 6.4P+ 3.2.2P+ 1.5.1P+ 4.1P
more than 10 billion Euro	100.2 – 101.1	PPP3 PPP4 PPP5 1.5.1P 3.2.1P 3.2.2P 3.2.3P 4.5P 5.4P 5.22P	3.2.2P+ 5.12P (Pay full costs) 3.2.2P+ 3.2.3P (Improve road safety) 1.5.1P+ 4.1P (Revitalise the railways) Build and promote multi-modal transport networks and terminals Guarantee the interoperability of means of payment on the trans-European road network Establish an infrastructure charging system Establish uniform taxation for commercial road transport fuel Develop an EU satellite navigation system (Galileo) Introduce low-price tickets for employees to use on public transport in cities ('job ticket') Add road infrastructure

less than -10 billion Euro	99.8 – 98.9	1.1.1P	Harmonise inspections and penalties
less than -100 billion Euro	– 89.9	*(6.5P)*	Change fixed price of car ownership

Table 2.48 — PAM ranking for freight transport

	PAM index	Policy	Policy Name
more than 100 billion Euro	101.1 –		
more than 10 billion Euro	100.2 – 101.1	6.3F	Subsidise environmentally friendly transport modes
less than -10 billion Euro	99.8 – 98.9	FPP2 FPP3 FPP4 FPP5	3.2.2F + 3.2.3F + 1.5.4F 3.2.2F + 3.2.3F + 1.5.4F + 6.6F 3.2.2F + 3.2.3F + 1.5.4F + 6.6F + 1.1.2F 3.2.2F + 3.2.3F + 1.5.4F + 6.6F + 1.1.2F + 1.1.1F
less than -100 billion Euro	– 89.9		

A first observation is that many passenger policies rank high in the PAM ranking (index above 100), while most freight policies rank low in the PAM ranking (index below 100). Although it might be tempting to draw immediate conclusions from this, it is inadvisable. As explained in paragraph 3.3 there is no connection between the passenger and freight domain in the DRM. Thus the effects of passenger policies on freight transport, and the effect of freight policies on passenger transport cannot be taken into account in the PAM. In the PAM elements from both passenger and freight domains are monetised and aggregated to one overall PAM value. For passenger transport policies, only the elements relating to passenger transport will alter, while the freight elements remain unchanged; and vice versa for freight policies. Therefore, it is better to observe the ranking from passenger and freight policies separately. Furthermore, as not all effects of policies are taken into account in the FSM and the PAM, no strong conclusions should be drawn from the fact that a PAM value is above or below index 100. What we can draw conclusions from is the relative position of the passenger policies (or the freight policies) in the ranking. For the elements and policy effects that are present in the DRM and IAM, the PAM function does the accounting well and allows the policies to be ranked.

The fact that four freight policy packages rank the lowest from all freight policies could be investigated further. Excluding the effects on passenger transport from the analysis, infrastructure charging and fuel tax uniformisation for freight transport might be a costly policy measure. Note however that analysis with other models[32] has shown that such negative effects in the freight sector, might be offset by positive effects in the passenger sector resulting from reduced congestion levels. This is especially the case in urban areas.

Next to looking at the ranking of the policies, it is important to look at the major contributing elements in the PAM. For passenger transport the major contributions are the consumer surplus (CS) and the public revenues (EC52). Although the external costs (EC43) do play a role, it is a modest role. For freight transport the major contribution is in the subsidies (SUBS), the supplier operating costs (EC21) and the public revenues (EC52). Again, the external costs (EC43) play a modest role. This supports the rationale that, especially for fiscal policies, the main welfare effects result from the direct monetary effects of the policies. A good analysis of the impacts of changes in transport prices and related changes in government tax income from the transport sector is essential. The marginal cost of public funds therefore is an important parameter in the model.

The highest ranked policies from the PAM ranking are in general also the best according to the “goal-oriented” analysis earlier in this chapter. However there are differences, such as for 4.5P and 5.4P. The goals from the White Paper are not necessarily in line with the sustainability goal. The PAM looks at sustainability as a whole, while the White Paper goals are focussed on subgoals related to sustainability but not representative for sustainability.

[32] Such as most transport network models (e.g. SCENES) and also TRENEN (reports: www.europa.eu.int/comm/transport/extra) and TREMOVE (reports and data: www.tremove.org)

It should be noted that the presence of policy 6.5P (increasing the fixed price of car ownership) as the worst policy is not correct. The problem is that the revenues for the government (EC52A and EC52B) cannot be derived from the FSM, and thus are not represented in the PAM for increasing in fixed price of car ownership. This is not true for increases in variable car cost such as is realised in 3.2.2P and 3.2.3P. For these the effect on government budgets is taken into account, resulting in a high PAM ranking of the policies.

3. LIST OF DELIVERABLES

Deliverable	Nature of deliverable and brief description
D1	Inception Report detailing the data and models to be used in SUMMA
D2	The state-of-the-art in the field sustainable transport and mobility, indicator development, and the relative contribution of different sectors to the problem of sustainability.
D3	Report on the system diagram, monetisation of the environmental, economic and social impacts of transport, and set of appropriate indicators.
D4	CD-ROM with the Fast Simple Model (FSM), the accompanying database, and documentation for using the FSM to assess policies.
D5	Report on the performance of policy measures.
D6	Project website and homepage.
D7.1	Project newsletter — issue 1
D7.2	Project newsletter — issue 2
D7.3	Project newsletter — issue 3
D7.4	Project newsletter — issue 4
D7.5	Project newsletter — issue 5
D8	Final Report describing the models, methods, data and results of the completed project.
D9	Report on the marginal costs of abatement, by sector, for environmental problems caused by the transport sector.

4. RESULTS AND CONCLUSIONS

4.1. LESSONS FROM DEVELOPING THE INDICATOR SYSTEM

One of the aims of this project was to operationalise sustainable transport and mobility. This was needed in order to develop a framework for assessing the functioning of the transport system from the perspective of sustainability

The analysis of sustainable transport and mobility in SUMMA is based on the systems approach. The systems approach has three parts: 1) specification of the transport system, 2) identification of external forces influencing it, and 3) identification of the outcomes of interest. The results of applying the the system approach to the transport system provide a framework for the monitoring system that includes the indicators.

There are three types of indicators, indicators for: 1) the external force (the so-called FDSC), 2) the functioning and performance of the system, and 3) the outcomes of interest. The indicators, proxies for things we cannot directly measure or observe, can be used to assess the performance of the transport system in terms of its sustainability. In this report the main emphasis is on the outcome indicators, because they are the ones that are most relevant for policymakers.

The final list of outcome indicators can be seen in the Table 4.1. There are indicators to capture 18 economic issues, 22 environmental issues and 20 social issues. With sometimes multiple indicators per issue there are thus over 60 outcome indicators.

Table 4.1 *— SUMMA outcome indicators*

Outcome of Interest	Indicator name
EC1 ACCESSIBILITY	EC11 Intermodal Terminal facilities EC12 Accessibility of origins/ destinations EC13 Access to basic services (SO11) EC14 Access to public transport (SO12)
EC2 TRANSPORT OPERATION COSTS	EC21 Supplier operating costs EC22 Transport- related expenditures of households (soc 21) EC23 Transport prices
EC3 PRODUCTIVITY / EFFICIENCY	EC31 Freight haulage-related costs on product costs EC32 Utilisation rates EC33 Energy consumption efficiency of transport sector EC34 Energy efficiency
EC4 COSTS TO ECONOMY	EC41 Infrastructure costs EC42 Public subsidies EC43 External transport costs EC44 Final energy consumption (EN11)
EC5 BENEFITS TO ECONOMY	EC51 Gross value added EC52 Public revenues from taxes and traffic system charging EC53 Benefits of transport
EN1 RESOURCE USE	EN11 Energy consumption EN12 Consumption of solid raw materials EN13 Land take
EN2 DIRECT ECOLOGICAL INTRUSION	EN21 Fragmentation of land EN22 Damage of underwater habitats EN23 Losses of nature areas EN24 Proximity of transport infrastructure to designated nature areas EN25 Light emissions EN26 Collisions with wildlife EN27 Introduction of non-native species
EN3 EMISSIONS TO AIR	EN31 Transport emissions of greenhouse gases EN32 Greenhouse gas emissions from manufacture and maintenance EN33 Transport emissions of air pollutants EN34 Air pollutant emissions from manufacture and maintenance
EN4 EMISSION TO SOILAND WATER	EN41 Hardening of surfaces EN42 Polluting transport accidents EN43 Runoff pollution from transport infrastructure

Outcome of Interest	Indicator name
	EN44 Wastewater from manufacture and maintenance of transport infrastructure EN45 Discharges of oil at sea EN46 Discharges of wastewater and waste at sea
EN5 NOISE	EN51 Exposure to transport noise
EN6 WASTE	EN61 Generation of non-recycled waste
SO1 ACCESSIBILITY AND AFFORDABILITY (users)	SO11 Access to basic services SO12 Access to public transport SO13 Car independence SO14 Affordability SO15 Trip length
SO2 SAFETY AND SECURITY (users, drivers, the affected)	SO21 Accident related fatalities and serious injuries SO22 Vehicle thefts & other crimes SO23 Security on public transport
SO3 FITNESS AND HEALTH (users)	SO31 Walking and cycling as transport means for short distance trips
SO4 LIVEABILITY AND AMENITY (inhabitants, society, the affected)	SO41 Walkability, pedestrian friendliness SO42 Traffic calming SO43 Children's journey to school SO44 Open space availability and accessibility
SO5 EQUITY (users and the affected)	SO51 Horizontal equity (fairness) SO52 Vertical equity (income) SO53 Vertical equity (mobility needs and ability)
SO6 SOCIAL COHESION (inhabitants, society and the affected)	SO61 Public opinion profile on transport and transport policy issues SO62 Violation of traffic rules SO63 Long distance commuting
SO7 WORKING CONDITIONS IN TRANSPORT SECTOR (employees, drivers, operatives)	SO71 Occupational accidents SO72 Precarious employment conditions SO73 Work absence due to accidents and illness

The main criterion used in identifying the indicators was been their importance, relevance and completeness in measuring and monitoring the outcomes of interest. Availability of data or methods to calculate these indicators was not taken into consideration, although it did have an impact on the final list of indicators (there is little point in creating a list of indicators for which there is not data). Thus the list of indicators should be seen as a **wish list**. In future work building on the results of SUMMA, some indicators will have to be modified and adjusted as more and better data become available. Further research to study the relationships among the indicators is also needed.

Another issue in operationalising sustainable transport and mobility is that of the weights (for example monetary weights) assigned to the outcome indicators. Monetisation is attractive as it reduces everything to one common denominator and makes comparisons much easier. Many of the economical outcome indicators are already defined in monetary terms. Here, the important thing is to avoid double counting, which may occur either due to overlaps between the values captured by outcome indicators or the valuation approach used for monetisation. Also for many important environmental outcome indicators valuation approaches and monetary values are available. This is the case for costs of emissions of greenhouse gases, air pollutants and noise. However, it is very difficult to monetise the social outcome indicators. Although, reasonable approaches could probably be identified for most indicators, the data to estimate the monetary values for social indicators is not available. Future work could help in defining approaches for monetising social outcome indicators.

4.1.1. Research needs

For the outcome indicators covering the economic dimension there is a specific need for research on a Europe wide, consistent methodology for data collection on intermodal terminal facilities, international data about freight transport prices, freight haulage related costs on product costs and energy consumption. In the past, research on the external costs of transport has been given a lot of attention, whereas the benefits of transport for the economy have been less well studied. There is no commonly accepted methodology for measuring or modelling these economic benefits from transport. future work should consider this issue.

Concerning the environmental outcome indicators, a lot of research has been done on air emissions, energy, and land use. Despite this, however, methodological and data availability problems still exist.

These problems are especially evident for the emissions and environmental impacts of the manufacturing and maintenance processes, as well as the material and energy consumed by them. What is needed is a shift from a consideration of only the environmental impacts of transport and traffic to a broader consideration of the whole life-cycle[33] of the transport system from infrastructure construction to vehicle disposal.

With regard to social outcome indicators, the really innovative and less researched and consolidated part of our work concerns the equity and social cohesion indicators. A lot more discussion and research is needed in order to overcome these gaps and make the pertinent indicators really operational and useful. In connection with other outcomes and indicators the research needs are less related to the underlying concepts as such and have more to do with more precise definitions and methodological questions of measurement and data availability and quality. Finally, the hitherto existing research and all suggested social outcomes and indicators focus on the need for social stability, but the dynamic moment of social sustainability —personal development, development of societal resources and society— needs to be taken into account and become more feasible and operational in future research.

Another area that also needs further development are the impacts of transport on land-use, activity patterns, lifestyles and quality of life issues. Although some indicators on this are included in the social outcome indicators, more research is needed to measure such subjectively experienced values. The question here is not only about research and methodological problems but also about data collection.

The most obvious shortage of information in all the three types of indicators was the lack of scientifically or politically defined thresholds. For most indicators no thresholds were found.

4.1.2. About thresholds and sustainability

Addressing the complex issue of sustainable transport and mobility requires the consideration of two issues. First of all, we would like to know, what are the features that are necessary for a transport system to be sustainable? This in a way is a description of a "steady state". Secondly, we are interested in finding the best way of getting from where we are now to this sustainable situation? Both questions are linked, depending on the starting level of "non-sustainability"[34].

To say anything specific about the desirable features of the "steady state" is very complicated, due to the intricate and oftentimes contradicting interconnections of various aspects involved. If only environmental burdens and resource use are in question the desirable features would be relatively clear: the least burden and resource use the most sustainable. But this might not always be sustainable from the economic and social point of view — and this makes the task more problematical.

Originally SUMMA was trying to seek an ideal solution by the construction of a set of indicators with definite thresholds: if the system outputs cause the indicator values to be under or equal to these thresholds, we will have a sustainable situation. If some indicators are beyond their thresholds, specific policies are needed to find the path towards sustainability. Then the comparison of the present state and the desired threshold values would indicate the direction in which each indicator has to move towards in order to achieve a development of the transport system which moves closer to a sustainable situation.

The ideal solution, however, was found to be beyond our reach considering the availability of information and research results. Within the available time, only very few thresholds were found that could directly be applied to this set of indicators. There are several reasons for this. First of all, the indicator set that was developed integrated many new ideas and approaches where research is simply not available. Another reason is that the setting of absolute thresholds is in many cases scientifically impossible, we just cannot know, what exactly is the sustainable level of pedestrian friendliness or percentage of hardened surfaces. Some thresholds could be politically defined, but in practise it has not been done.

[33] The term life-cycle is used here in a broad sense, and it does not refer to the methodologies of life-cycle assessment, which in a way would be too complex and detailed to be applied to the whole transport system.
[34] If we are far away from the steady state situation, more effort is needed to reach this ideal level, considering the needs of the presently living generation.

Instead of the thresholds we complemented the list of indicators with indications of the direction that the indicator value should take in order to have impacts that would be more sustainable than before. This solution actually brings us partly the answer to the second question mentioned above. It highlights the changes needed for the progress from now on towards more sustainability. Defining answers to the second question can be done even if there are no exact answers to the first.

Regarding the second question, the question of finding the best way to reach a sustainable situation, defining the directions is a first step. In practice it will be difficult to find solutions where all the indicators would show development in the positive direction. Thus we have to find solutions where the positive and negative developments are in minimal conflict, where the trade-offs are the best value. Making these choices between the trade-offs is an issue of values, no scientifically defined best options exist. There are many options, depending on the weights that are given to the components of sustainability. If the economic development has first priority there will be other solutions than in a society, in which social aspects play a more important role. Discussing these trade-offs and finding the best “policy mix” is an issue that is dealt with in the future work of the SUMMA project.

4.1.3. General observations

Transport has both large positive and negative impacts. Thus policymakers face the challenge of simultaneously promoting the positive effects and mitigating the negative effects. However, there are a number of factors that help to perpetuate the current trends in transport system, namely:

- The externalities, negative and positive, of transport are usually not included in the monetary calculations of transport costs. Thus decision-makers lack the complete picture on the effects of their transport decisions. Similarly, users do not face the full costs, including the environmental and social costs, of their transport choices.
- Transport and mobility are an integral part of the whole society. It is extremely difficult to change the trends in the transport sector without bringing about changes in other sectors of the economy as well
- Existing political and institutional structures are resistant to change. Innovations are only slowly adopted in the market slowly and the capacity of the political system to reflect the increasing needs of political measures is limited.
- Due to the fact that there are so many positive and negative impacts of transport, there are also a number of conflicting interests: the interests of the environment are in conflict with those of the economy, and interests of individuals can conflict with societal interests. These differing interests disperse the willingness and capacity of the society to tackle the problems of sustainability.

4.2. CONCLUSIONS

Project related conclusions:

- The modelling tool developed in SUMMA is a powerful, easy to use tool that allows its users to quickly estimate and present the impacts of policy measures on a whole range of outcome indicators. This tool, in contrast to most other existing models, combines demand generation and policy assessment capabilities in one tool allowing users to: (1) select a policy, (2) estimate the effect of the policy on a variety of outcome indicators, and (3) study the results). The utility and added value of such a tool for both policymakers and analysts is evident.

- The FSM uses a large amount of disaggregate and aggregate data from all over Europe. Unfortunately, the quality and availability of data is not the same for all the countries. From some countries, predominantly the original EU15 we have most of the required information. For the new member states a lot of the data is not available or missing. In many cases where data was not available, by making assumptions about similarities with other countries a reasonable estimate could be made. These assumptions, however, remain assumptions and cannot substitute for real data. Thus, missing data is one of the biggest contributors to the uncertainty in the SUMMA estimates.

- Furthermore, the FSM (EXPEDITE) builds on a limited number of national models, all of which covered an EU15 member state (mostly northern or west European countries). The assumption is made that the travel behaviour in the countries, for which we had the national transport models, is representative for other countries in the EU25. This assumption needs to be tested and if necessary done away with by estimating models for other countries as well. In any case, this assumption is the second source of uncertainty in the SUMMA estimates.

- Despite the uncertainty in the SUMMA estimates, we believe that FSM is a good model for the purpose for which it was developed, namely to compare and choose policies by comparing their impacts on a range of outcome indicators. Thus, as long as the FSM is not used for estimating the absolute level of an impact of a given policy, and is used to compare the relative performance of policies we stand behind its results.

- The usefulness of the tool is evident from the interest of outside parties in using the FSM for their own purposes. To give a few examples, the SUMMA consortium has been asked by a student at the Technical University of Denmark, Center for Traffic and Transport, for a copy of the FSM. We will, once the project has been approved, also provide staff at the University of Karlsruhe, Institut für Wirtschaftspolitik und Wirtschaftsforschung, with a copy of the FSM for further evaluation and use. TRANSTOOLS, another EC financed project, has also requested a copy of the FSM. Finally, several participants at the SUMMA final conference expressed an interest in getting a copy of the FSM. Once the project is approved, the FSM will be provided to all interested users.

- In developing the FSM, the need for a new generation of transport models suitable for evaluating the new generation of transport policies became evident. In the past, transport policies primarily focused on the costs and benefits of infrastructure projects (roads, bridges, transfer terminals, etc.). Estimating the costs and benefits of infrastructure projects requires detailed network models, requiring plenty of data and take a long time to run. Presently, however, policies are also targeted at other aspects of the transport system (e.g. parking charges, congestion charges, scrapping lease cars, car sharing). Assessing the impacts of such non-infrastructure related policy measures does not need network-based models, but does need to model the behaviour of travellers and transporters. Ideally, meta-models that are simple and quick to run should be developed in order to help analysts and policymakers assess the impacts of non-infrastructure policy measures.

- The Policy Assessment Module (PAM) is useful for ranking policies on individual outcome indicators (i.e. the individual contributions to the aggregate PAM value), but, with the current version of the module, using the aggregate PAM value to compare policies is not advisable. Comparing the performance of policies on multiple policies is not advisable as we were not able to estimate defensible monetary values for several of the outcome indicators. Thus, the results provided by the PAM should are biased towards the outcome indicators for which we could get monetary values.

- The development of the outcome indicators was a labour intensive task. At the start of the project 68 outcome indicators were defined. However, the IAM uses only 37 of the original 68 indicators. Although we had never expected to be able to incorporate all 68 outcome indicators in the IAM, we had also not expected to be able to include only 37 of the 68 outcome indicators; 16 of the 21 economic indicators, 11 out of the 22 environmental indicators, and 10 out of the 25 social indicators are included in the IAM. One of the primary impediments to including more of the outcome indicators was the lack of data for the indicators. Thus, going forward it would be important to improve the availability of data for the outcome indicators that are included in the “wish list” but not in the IAM.

- The lack of appropriate data was an obstacle to fully realizing several of the projects’ objectives. Specifically, the lack of data led to difficulties in defining the indicators, monetising the indicators, and in specifying the policy levers. There were problems in finding the needed data as well as in finding consistent and reliable data for all European Union countries.

- The use of scorecards presenting the performance of multiple policy measures on different outcome indicators vividly demonstrated the value of an integrated policy analysis using the systems approach. The scorecards make the tradeoffs among the different outcomes visible and make clear the importance of simultaneously considering the effect of a policy on multiple outcomes rather than a single (or set of) outcomes.

Policy-related conclusions:

- In SUMMA, we found that a policy based on charges performed better than a policy of providing subsidies. This conclusion, while consistent with economic theory, should be treated with caution. The reason for sounding this caution is that the comparison of charging with subsidies does not fully account for the potential positive externalities resulting from subsidising transport. Thus, this conclusion should not be interpreted to mean that subsidies as a policy should never be considered. Depending on the context and specific situation, it is possible that subsidies make sense as a policy.

- An effective policy for realizing the goals in the White Paper, for both passenger and freight transport, is to increase the price for using the road infrastructure.

- Improving the level of service for road transport is not a good way to achieve the White Paper goals or sustainability goals. It attracts transport from rail and inland waterways, and therefore leads to more truck kilometres and more problems on the roads.

- The results from evaluating policy measures in urban areas vary widely across the cities and regions for which we had models. No single policy appears to be attractive for all the cities. This suggests that policies addressing urban transport problems need to be tailored to the local conditions and situation in the city. However, we must add the caveat that in SUMMA we had different models for each city. Given the differences among the models, we are not able to rule out that the differences in the attractiveness of policies across cities stem from the differences in the models rather than representing real differences.

- There appear to be only small variations in the size of the policy effects across the various countries and regions of Europe. This would suggest that the EC could implement these policies across Europe. However, this conclusion needs to be treated with caution as it could simply result from a statistical effect due to the regression to the mean resulting from the aggregation of results from the NUTS-2 level to country level. Thus, caution should be exercised in developing and implementing a Europe wide transport policy without first investigating its impacts at the local and regional level.

4.3. RECOMMENDATIONS

Although SUMMA has demonstrated the usefulness of an integrated assessment tool, future research can improve on what SUMMA delivered in a number of ways. We make a number of specific recommendations that, if implemented, build on the work done in SUMMA.

- The comparison of results from the modelling exercise for cities and regions were limited in their usefulness. The usefulness of the comparison was limited by the differences in the models used to model transport demand and supply in the different cities, and the data used for this modelling exercise. Going forward, given that urban transport is responsible for a large share of all transport problems, it would be worthwhile for the Commission to develop, disseminate, and encourage the use of a standard approach for data collection and modelling urban transport. Doing so would make it easier to compare transport problems in different cities as well as the performance of policy measures in different cities.

- SUMMA did not deal with the interdependency between freight and passenger transport. The demand for transport infrastructure comes from both passenger and freight transport. The volume of freight transport affects passenger transport and vice versa. In the SUMMA models, however, we do not model this inter-dependence. Going forward, the interdependence between freight and passenger transport should be explicitly modelled.

- The FSM included 37 of the 68 outcome indicators. Thus, an obvious step would be to increase the number of outcome indicators included in SUMMA. However, in addition to simply increasing the number of outcome indicators, the way in which the indicators are represented in the model can also be improved. Specifically, the current version of the FSM does not take into account any of the relationships that may exist among the outcome indicators. To be sure, the representation of indicators in the FSM has been limited by the availability of data, and can be remedied by additional data collection. However, and equally important, our knowledge about the relationship between the functioning of the transport system and some outcome indicators, particularly the social indicators, is limited. Thus, we recommend that the Commission devote more attention to improving our understanding of the links between the transport system and outcome indicators.

- Related to the previous point, the availability of data is limited. There are two recommendations we have about data collection. First, the data collected by different cities are not collected according to a standardized format, the data definitions are not harmonized, and there is no core set of data elements that is available for all the cities. Thus, harmonization of the data collected by cities would quickly deliver big gains for analysts and policy makers dealing with urban transport problems. The second recommendation with regards to data collection has to do with collecting data that is currently not being collected. One of the shortcomings of many existing transport models is that they do not focus on activities, behaviour, and preferences of city residents. If urban transport policy is going to be successful in dealing with urban transport problems we need to improve out understanding of all of these and their links with the demand and supply of transport. Thus, we would recommend the development of an urban travel survey that collects data on the activities, behaviour and (stated) preferences of urban dwellers.

- The representation of the policy measures in the SUMMA models can be improved in two ways. First, the range of policy measures that are included in the FSM can be broadened. For example, parking policy is not easy to represent in the SUMMA models. Parking policy, however, is an important policy in the arsenal of cities trying to alleviate urban congestion problems in city centres. The ability to model the effects of these “soft” measures would add to the usefulness of the SUMMA model. The second way in which we can improve the representation of the policy measures in SUMMA is by more explicitly relating the policy measure to behaviour leading to the demand for transport. This would mean refining and improving the relationship between the policy levers and the functioning of the transport system.

- SUMMA provides estimates of the performance of policy measures on a range of outcome measures. This information is essential. However, decision makers could find it hard to digest the sheer volume of information that scorecards provide, and to use this information in making trade-offs. For example, two policy measures can perform equally well on all but two outcome indicators where one policy does better on one outcome indicator and the second policy does better on the other. If everything is the same except for the performance on these two indicators, the choice of the policy comes down to the decision makers’ preferences; i.e., to which outcome does s/he attach more weight? Thus, the need for an overall ranking of policy measures is understandable. Coming up with this single ranking is more problematic. The valuation of environmental and social outcomes is not yet sufficiently reliable so as to be credibly used in developing a ranking of policy measures. Thus, we would recommend to the Commission that it should commission research into valuation of environmental and social outcomes.

- As far as available the work on operationalisation and monetary valuation should be guided by existing knowledge of the importance of certain effects. For instance, it is known from cost benefit analyses that costs/benefits due to travel time changes play an important role in the quantifiable impacts. For this reason the quantification of travel time changes should have priority in the improvement of the underlying models.

- In addition to the assessment of existing policies more emphasis should be placed on generating policies that are considered effective in terms of sustainability. With these policies the FSM can be used to produce policy inventories for every country with policies that seems to be the most effective in terms of sustainability.

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APPENDICES

The appendices can be found in a separate volume.