Using a Meta-Model to Analyse Sustainable Transport Policies for Europe: The SUMMA Project's Fast Simple Model [1]

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ABSTRACT

Sustainable development has become a central policy objective worldwide. The European Commission, as part of its Programme on Competitive and Sustainable Growth, commissioned the SUMMA project (SUstainable Mobility, policy Measures and Assessment). Among SUMMA's objectives are to define and operationalise the concept of sustainable transport and mobility in terms of its environmental, economic, and social dimensions, and to develop an instrument that can help policymakers monitor progress towards its achievement.

This paper deals with aspects of SUMMA relating to the development of its modelling system. The modelling system consists of three parts: demand generation, impact assessment, and policy assessment. Here we focus on the demand generation, the impact assessment, and the way the model can be used for policy assessment.

The modelling system is called the Fast Simple Model (FSM). Its Demand Response Module (DRM) takes care of the demand generation, and its Impact Assessment Module (IAM) performs the impact assessment.

The DRM builds on earlier work carried out by the EXPEDITE project. It is a meta-model that estimates the effect of transport policies on transport demand. A meta-model is a simple aggregate model that approximates the behaviour of one or more models that are much more complex and detailed. Based on calculations with more detailed transport models for a representative set of countries, a model was estimated that represents transport in the whole of Europe. This model is not a network model, but apart from detailed infrastructure changes it can model a wide range of policies. Unlike a network model, the FSM is very fast. The paper explains the meta-model concept and its possibilities.

The DRM generates the demand for both passenger and freight transport for the EU25 countries at the NUTS-2 level. It distinguishes among six transport modes for passenger transport (car driver, car passenger, train, bus/tram/metro, non-motorised modes, and air); and five modes for freight (lorry, conventional train, combined road-rail transport, inland waterways, and maritime transport). Passenger demand is segmented by travel purpose, household size, household income class, age, gender, occupation, car ownership, area type, and distance class. Freight demand is segmented by commodity class and distance bands. By means of a vehicle stock model, the DRM also disaggregates demand by vehicle type: passenger cars, light duty trucks, mopeds, heavy duty trucks, bus/coach,

[1] This work was supported by the European Commission, as part of its Thematic Programme on Competitive and Sustainable Growth. Further information on the project can be found on the SUMMA Website: www.summa-eu.org. RAND Europe was the coordinator of the project. The other project partners, all of whom contributed in some way to this paper, are: Kessel + Partner (Germany), Gaia Group (Finland), Institut für Energiewirtschaft und Rationelle Energieanwendung (Germany), Transport & Mobility Leuven (Belgium), Synergo, Planning and Project Management (Switzerland), Econcept (Switzerland), and SUDOP PRAHA (Czech Republic).

locomotives, rail freight cars, high speed trains, tankers, pusher ships, dry cargo vessels, and passenger trains.

The IAM calculates the values of outcome indicators related to a range of environmental, economic and social impacts of the generated transport demand on society. In order to operationalise the concept of sustainability, SUMMA developed a wish list of 62 indicators that can be used to judge the movement towards, or away from sustainability. In the FSM, a subset of 34 indicators was implemented: 13 economic indicators, 12 environmental indicators, and 9 social indicators.

The FSM has been incorporated into a user-friendly computer package that allows its users to assess policies by their environmental, economic, and social impacts. The instrument is fast enough to run dozens of policies within an hour and to compare the outcomes graphically as well as in tables. The software allows its users to define their own views of the outcomes, which makes the FSM a powerful instrument. Further analysis is possible by exporting the data to Excel.

KEYWORDS: Sustainability indicators, transport demand generation, impact assessment, policy analysis

INTRODUCTION

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 (SUstainable Mobility, policy Measures and Assessment) helped policymakers to do this by providing tools to develop more efficient and effective transport policies that cater for the need for mobility while reducing transport’s adverse impacts to acceptable levels.

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

- Defined and operationalised sustainable mobility and transport, developed an appropriate specification of the transport system, and defined a set of indicators for monitoring the environmental, economic, and social dimensions of sustainable transport and mobility;
- Assessed the scale and scope of the problems of sustainability in the transport sector;
- Assessed policy measures in the European Commission’s White Paper on transport policy, as well as other policy measures found in the literature, that can be used to promote sustainable transport and mobility at the national, regional, and city levels. The assessment was performed using a modelling system called the Fast Simple Model (FSM)

In this paper we deal with the work carried out in SUMMA related to the development of the FSM. The FSM consists of two parts: demand generation, and impact assessment and policy assessment. In this paper we describe the FSM and how it can be used for policy assessment.

Before going into details about the FSM, we describe the context in which it is embedded. As mentioned above, SUMMA operationalised sustainable mobility and transport. It did so using the ‘systems approach’. This approach structures a problem by identifying the system, its inputs, the means by which it can be influenced (policies), and its outputs. In SUMMA, the system is the transport system. The inputs are all elements that influence the system but are outside the influence of transport policy (e.g. demographics, world politics, oil-prices, weather, etc). The policymaker's goal is sustainable transport. To determine whether a policy would lead to a sustainable transport system policymakers need to decide what aspects of the system's performance they are interested in. These aspects are called outcomes of interest. By monitoring the outcomes of interest, policymakers can decide whether the system is moving in the right direction. Modelling the system allows policymakers to do this evaluation ex-ante rather than ex-post. By changing the policies and looking at the resulting changes in the outcomes of interest, policymakers can select the best policy to reach their goals. The policy assessment framework described above is depicted in Figure 1.

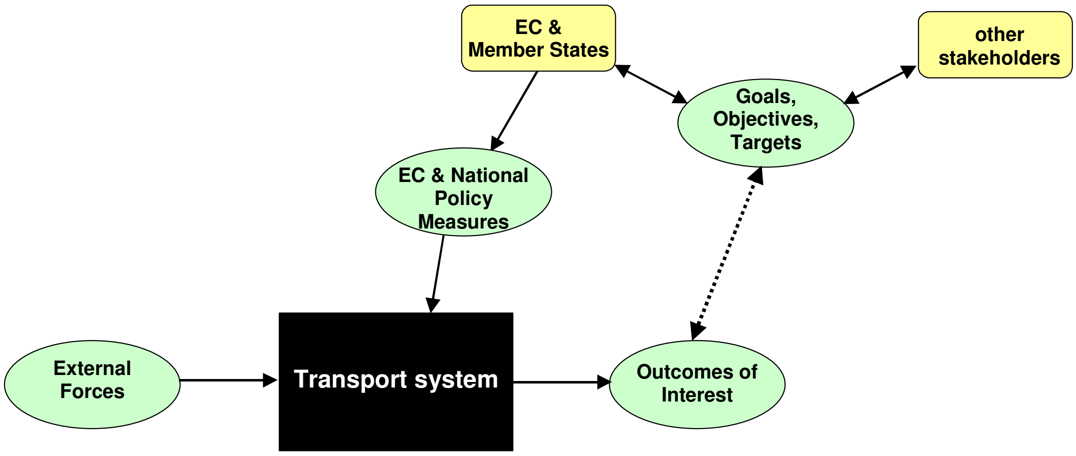

Figure 1 — SUMMA's policy assessment framework

In SUMMA, this policy assessment framework is supported by the FSM, which is a model of the transport system that allows users to simulate different policies and to examine the differences in the outcomes.

In order to design the FSM, it was necessary to answer the following questions:
- What are the outcomes of interest?
- What are the associated outcome indicators?
- What are the transport policies whose outcomes should be estimated?

Outcomes of interest
In workshops with policymakers and researchers, a list of outcomes of interest was composed that operationalized the definition of sustainable mobility and transport[2]. The list was divided into three parts, according to the three dimensions of sustainability: economic, environmental and social. The list is presented in Table 1.

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[2] The definition of sustainable transport and mobility that SUMMA adopted is the definition adopted by the European Union Ministers of Transport (Council of the EU 2001), which states that sustainable transport and mobility:
- *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 minimising the impact on land and the generation of noise.*

Table 1 — SUMMA's outcomes of interest

Economic outcomes of interest (EC)	Environmental outcomes of interest (EN)	Social outcomes of interest (SO)
1. Accessibility 2. Transport operation cost 3. Productivity / Efficiency 4. Costs to economy 5. Benefits to economy	1. Resource use 2. Direct ecological intrusion 3. Emissions to air 4. Emissions to soil and water 5. Noise 6. Waste	1. Accessibility and affordability 2. Safety and security 3. Fitness and health 4. Liveability and amenity 5. Equity 6. Social cohesion 7. Working conditions in transport sector

Outcome indicators

The aspects of the transport system that policymakers are interested in are called the outcomes of interest. However, these outcomes often cannot be measured directly. To represent the outcomes of interest in the model, we defined a set of outcome indicators. These outcome indicators cannot fully represent the outcomes of interest, but by using several indicators, an outcome of interest may be suitably represented. For the list of outcomes of interest presented in Table 1, SUMMA has defined a 'wish list' of outcome indicators. We called it a wish list, since our models cannot estimate all of the indicators (because data are not gathered and/or because they would be difficult to model). The complete list of indicators is presented in Appendix A.

Transport policies

The White Paper (European Commission, 2001), which describes the European Transport Policy, presents a number of policy goals. These are listed below:

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**[3]	
6	**Achieving a sustainable transport system**	

The White Paper also proposes a large number of policy measures, which are designed to guide the transport development in the whole of Europe. In order to reach the White Paper objectives at the local and regional levels, we added policies for the local and regional levels that are in line with the European Transport Policy. We also added a few policies from other sources that are designed to achieve sustainable transport. The list of policies that were examined in SUMMA is presented in Appendix B.

THE FAST SIMPLE MODEL (FSM)

Based on the results of SUMMA discussed in the previous section, two paths can be chosen: develop a monitoring system to evaluate progress towards sustainability ex-post, or develop a

[3] 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.

model with which policies can be evaluated ex-ante. Within SUMMA we have chosen to do the latter.

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 policymakers in their decision-making. Fast, in order to allow policymakers to assess large numbers of policies in a short period of time. Simple in terms of its use and its interpretation (policymakers should be able to use the model). Accurate, in the sense that decisions based on the results are justified. Policymakers could use the model to scan large numbers of policies very quickly. Then, if necessary, a few selected policies could be examined in more detail using other (generally much slower) models.

In order to carry out the analysis based on the framework described in the previous section, we developed a model, called the Fast Simple Model (FSM). The FSM is a user-friendly computer-based tool that estimates the impacts of various policy measures and policy packages. It integrates two modules: (1) a Demand Response Module (DRM), which generates forecasts of demand for passenger and freight transport based on a reference scenario and policy changes, and (2) an Impact Assessment Module (IAM), which estimates the environmental, economic, and social impacts of the transport demand. The structure of the FSM is illustrated in Figure 2. The SUMMA project did not have the resources to build an entirely new model. Thus, the FSM is based on an existing model system called EXPEDITE.

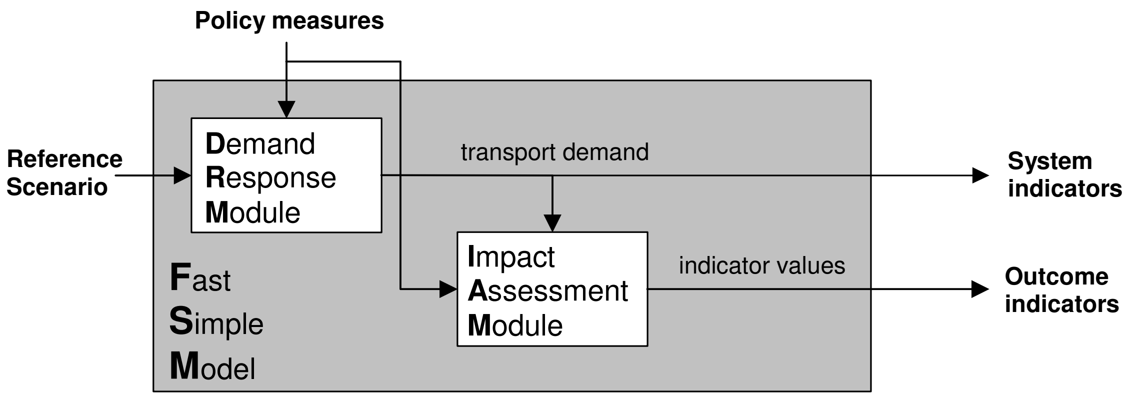

Figure 2 — Structure of the Fast Simple Model (FSM)

The FSM uses the reference scenario from the EXPEDITE project (De Jong et al., 2002) as a basis for its policy analysis. The base year of EXPEDITE is 1995, and the forecasting year is 2020.

The DRM calculates the demand for both passenger and freight transport. For passenger transport, it estimates the number of trips made and the number of kilometres travelled. 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 tonne-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 DEMAND RESPONSE MODEL

The basis for the DRM is the EXPEDITE model system (EXPEDITE is another 5th Framework EC project). The EXPEDITE model system estimates the transport demand at the NUTS-2 level[4] for the EU 25 (excluding Cyprus and Malta) plus Norway and Switzerland (see Figure 3) given a reference scenario. 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 emissions (which depend strongly on the type of vehicle) a Vehicle Stock Model was developed to supplement the EXPEDITE model system.

EXPEDITE is a meta-model, which is a simple aggregate model that approximates the behaviour of one or more other models that are more complex and detailed. Based on calculations with more detailed transport models for a representative set of countries, a model was estimated that represents transport in the whole of Europe. EXPEDITE is not a network model and cannot provide the typical network assignment results that a local, more detailed model can give. But it is fast and can be used to quickly get insight into possible attractive policies, which then can be evaluated using more detailed, slower models.

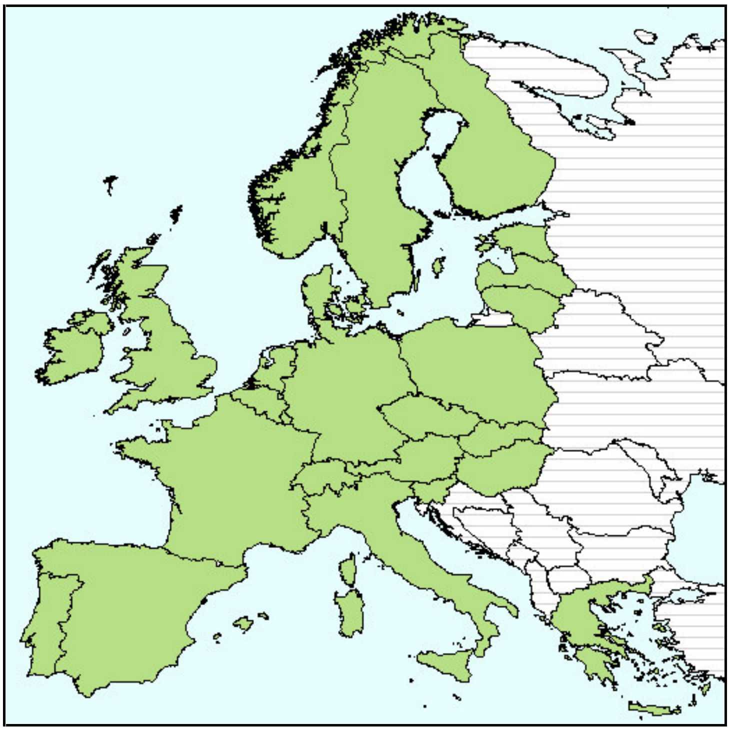

Figure 3 — SUMMA covers almost the whole of Europe

Most policy measures could not be represented directly in the FSM. Changes to the system had to be represented in terms of a set of policy levers. Most of the levers refer to changes in travel time or cost. Although the DRM is not a network model, the models on which it was based are. Thus changes in time and cost could be estimated in terms of changes in transport demand (tours made, kilometres travelled). However, instead of the very specific changes that can be estimated by network models (such as adding or improving a road, or changing the maximum speed on a road), the changes in the DRM have to be represented in terms of

[4] NUTS (Nomenclature of Territorial Units for Statistics) is a geocode standard developed by the European Union for referencing the administrative division of countries for statistical purposes. NUTS level 1 is the country level. NUTS level 2 is typically the provincial level, while NUTS level 3 is at the level of counties, districts, or regions (depending on the country).

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 costs of car transport have been reduced by y%).

The EXPEDITE Meta-Model

For short to medium distance passenger transport, the EXPEDITE meta-model is based on the outcomes from runs with five national passenger transport models that were designed to represent the behaviour of travellers. The results of runs of the underlying passenger transport models were mapped onto other European zones, based on similarities in their population, socio-demographic, and economic characteristics and corrected for specific factors arising from specific geographical differences. Results of the meta-model for a specific zone are obtained by scaling results for a prototypical area[5] to match known totals (e.g. from transport statistics, sector statistics, etc.). Within each of the five national passenger transport models, simulations were carried out to estimate the impact on transport demand of differences in the distribution of the population, employment, incomes, and densities, both by looking at the existing inputs for the country and by making the inputs represent other areas. The outcomes of these simulations were then used in the meta-model.

For freight, the EXPEDITE meta-model is based on the outcomes from runs with four national freight transport models, runs with the SCENES model (SCENES Consortium, 2001), and runs with the NEAC model (Chen and Tardieu, 2000). However, the EXPEDITE freight meta-model is conceptually simpler than the passenger model. Because the national freight transport models focus on mode choice and do not generate demands, the 1995 and 2020 reference situations are not produced by the meta-model itself (as the meta-model for passenger transport does, by expansion factors applied to tour and kilometre rates). The baseline pattern of freight flows originating in some zones comes directly from the SCENES and NEAC models.

For both freight and passenger transport, demand is generated at the NUTS-2 level. For passenger transport, the EXPEDITE meta-model distinguishes five modes of transport: car driver, car passenger, train, bus/tram/metro, non-motorised modes (e.g. walking, cycling), and air (added by SUMMA). Passenger demand is also segmented by travel purpose, household size, household income class, age, gender, occupation, car ownership, area type, and distance class. See Appendix E for a more detailed overview of the passenger meta-model. For freight transport, EXPEDITE distinguishes five modes of transport: truck, conventional train, combined road-rail transport, inland waterways, and maritime transport. Freight demand is also segmented by commodity class and distance class. See Appendix F for a more detailed overview of the freight meta-model.

The EXPEDITE meta-model was developed because of the need to assess the impacts of a large number of policy options on many segments of the transport markets in the European context. Running a large model, such as the SCENES model, for many policy options is cumbersome and time-consuming. Moreover, the SCENES model cannot provide all the segmentations and sensitivities that the EXPEDITE national models can provide, especially for short distance transport (more than 90% of all passenger transport is for trips less than 30 km). On the other hand, the EXPEDITE national models also have long run times and do not cover all of the European Union. The requirements for the EXPEDITE meta-model, therefore, were that it would run quickly and extend the available national models to cover

[5] A prototypical area is a standard (example) area, which is used as the basis for estimating the results for each NUTS-2 zone.

the whole EU. In the meta-model concept, it is not of vital importance that models for all countries in the EU are included, but that the most relevant segments of the local travelling population across the EU are included in the models used and expanded properly, and that the outcomes are calibrated to observed base-year distributions for transport in the respective zones. For a complete description of the EXPEDITE project, see (De Jong et al., 2002).

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 were integrated into a single computer tool. In EXPEDITE, long distance passenger transport was limited to 160 km. The air mode was therefore omitted. In the FSM, distances above 160 km have been included, so air passenger transport was added. Although passenger and freight transport are integrated into a single 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 use the same infrastructure networks. Therefore, in reality, there are dependencies between freight and passenger transport (e.g. via road congestion). These dependencies are currently not taken into account in the FSM.

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 the environmental impacts of transport demand with a reasonable level of accuracy. Since the environment is one of the three dimensions of sustainability within SUMMA, we added 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 and 2020. These shares allow disaggregating the transport activities by vehicle type in addition to mode.

The level of disaggregation differs among the modes, since the level of disaggregation at which emission factors and other data are available differs among the modes. As shown in Table 2, the vehicle stock composition is very detailed for road transport, while there is no disaggregation of vehicle types for the maritime and air modes.

Table 2 — Vehicle stock composition

Road	Rail	Inland Waterways	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 (De Ceuster, 2004). TREMOVE is a European policy assessment model that was developed to study the effects of different transport and environment policies on the emissions of the transport sector. More information on TREMOVE can be found on the website www.tremove.org.

The VSM works together with the EXPEDITE Model within the DRM as follows. First, the VSM disaggregates the number of vehicle-km from EXPEDITE into vehicle types (e.g., as small gasoline cars, medium gasoline cars, etc.) using the actual vehicle stock in 1995. The main source for this is the TRENDS database. Forecasting procedures are then used to determine the vehicle stock in 2020. The disaggregation of total vehicle-km to individual vehicle types in 2020 is derived from a submodule that forecasts the shares of different vehicle types within the total vehicle-km in 2020 using a choice model. The choice model is based on variables that include purchase and usage costs of the vehicles.

THE IMPACT ASSESSMENT MODEL

The Impact Assessment Module (IAM) uses the outputs from the DRM to calculate the values of the outcome indicators. Not all indicators in the original wish-list could be calculated. A subset of 34 indicators could be calculated: 13 economic indicators, 12 environmental indicators, and 9 social indicators. Table 3 shows the indicators whose values are calculate by the IAM. Further details on each of these indicators can be found in Appendix A.

Table 3 — Outcome indicators

Code	Outcome indicator description
EC11	Intermodal Terminal facilities
EC12	Accessibility of origins/ destinations
EC13	Access to basic services
EC21	Supplier operating costs
EC22	Transport- related expenditures of households
EC23A	Transport prices for passenger transport
EC23B	Transport prices for freight transport
EC32	Utilisation rates
EC33	Energy consumption efficiency of transport sector
EC34	Energy efficiency
EC41	Infrastructure costs
EC43A	External transport costs (accidents)
EC43C	External transport costs (environmental costs)
EC44	Energy consumption
EC52	Public revenues from taxes and traffic system charging
EN11	Energy consumption
EN12	Consumption of solid raw materials
EN13	Land take
EN21	Fragmentation of land
EN23	Losses of nature areas
EN25	Light emissions
EN26	Collisions with wildlife
EN31	Transport emissions of greenhouse gases
EN33	Transport emissions of air pollutants
EN41	Hardening of surfaces
EN51	Exposure to transport noise
EN61	Generation of non-recycled waste
SO11	Access to basic services
SO13	Car independence
SO14	Affordability

Code	Outcome indicator description
SO15	Trip length
SO21	Accident related fatalities and serious injuries
SO31	Walking and cycling as transport means for short distance trips
SO42	Traffic calming
SO43	Children’s journey to school
SO52B	Vertical equity (accessibility)
SO63	Long distance commuting

USING THE FSM FOR POLICY ASSESSMENT

The FSM is a user-friendly computer-based tool. At start-up, the FSM presents a menu that includes a choice to look at background information about SUMMA, to look at the SUMMA deliverables, to go to the SUMMA Website, or to starting to use the model (see Figure 4).

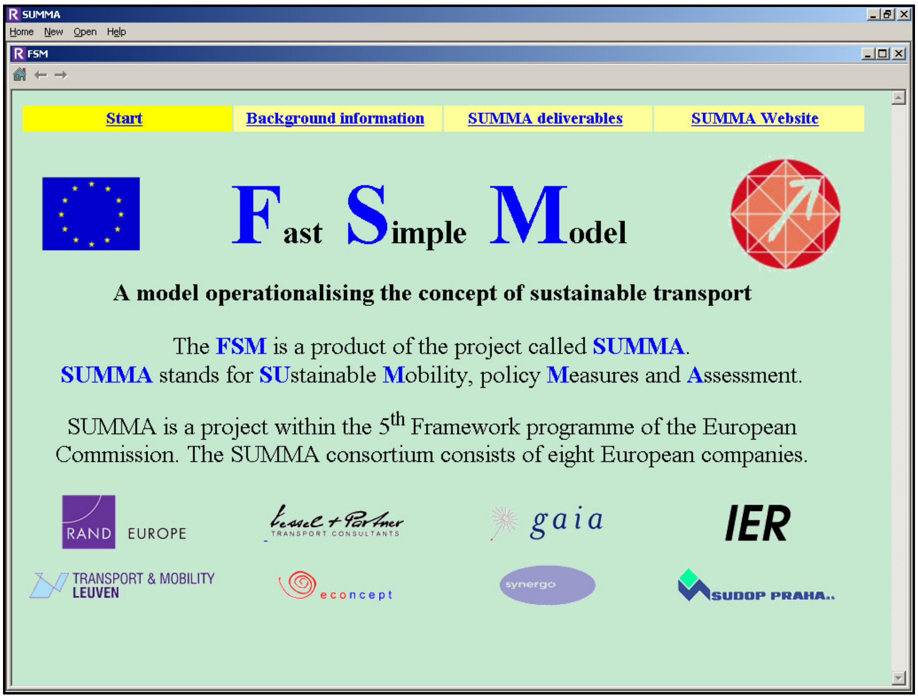

Figure 4 — The introduction window of the FSM

After choosing <u>Start</u>, a screen appears that allows the user to choose among the goals of the White Paper, and then among the different policy measures related to the chosen goal. After selection, the policy measure can be run (it takes about a minute to run a policy, depending on the computer used). At the conclusion of the run, the user is presented with a choice of different forms of output. It is possible to look at outcomes by many different levels of disaggregation, and at the values of many different indicators. These can be looked at in tables, in charts, and in maps (see figures 5, 6, and 7). Basically, the FSM brings the user from policy measure to policy results in three steps (select a policy, run the policy, choose a presentation form).

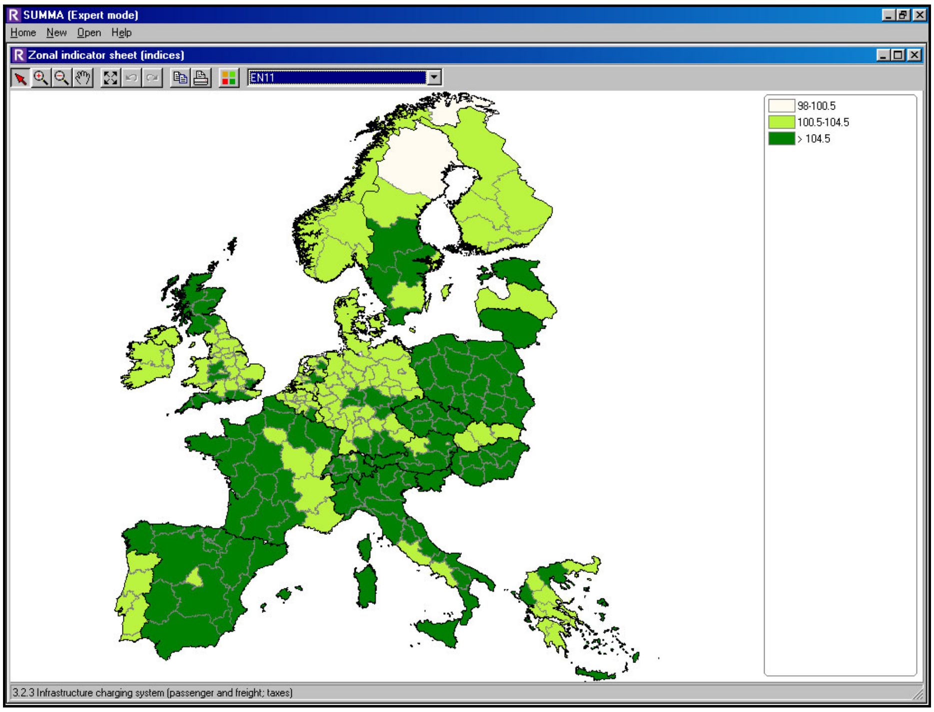

Figure 5 — The map-view of the FSM

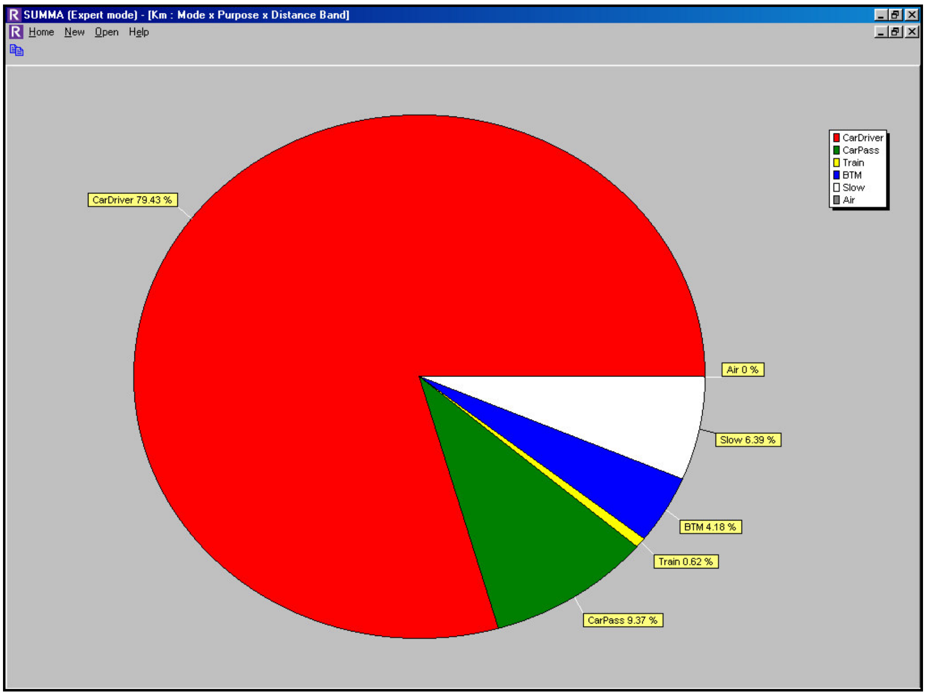

Figure 6 — The pie-chart view of the FSM

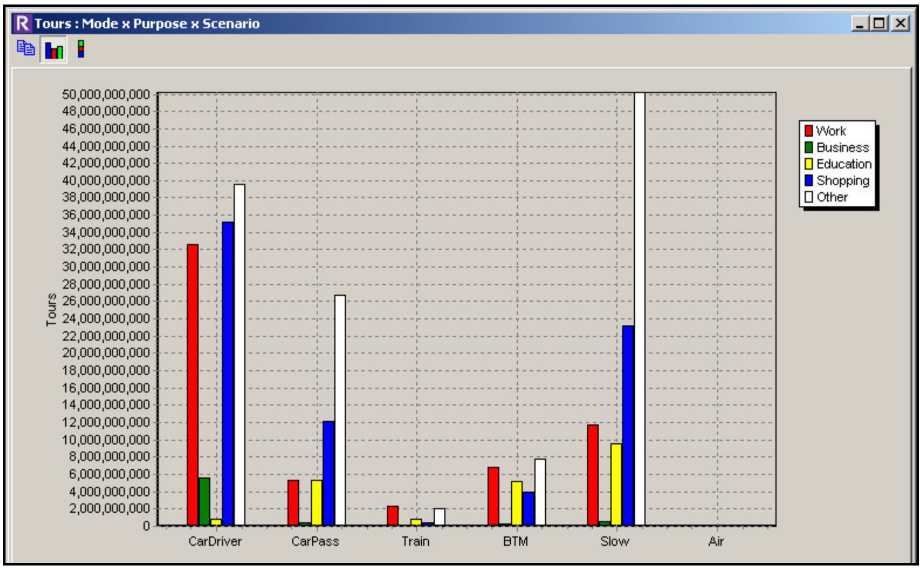

Figure 7 — The bar-chart view of the FSM

The FSM also allows a more experienced user to prepare new policies to be assessed by the FSM, as well as to customize the presentation of results. Results can also be exported to Excel for further analysis. After starting the FSM, the chosen policy can be selected, run, and its results displayed.

Preparing the FSM to run other policies requires the translation of these policies into policy levers (see Appendix C). This is not a trivial or straightforward task and must be done with great care. It is also possible to compose and run policy packages (combinations of individual policies).

After runs with different policies and policy packages the results can be inspected. Using the different views on the data (figures 5, 6, 7, and others) individual aspects of the results can be compared. However to finally assess the policies in order to choose the best policies or policy packages a more integrated method is required. For this stage, we used the DynaRank Decision-Support System (Hillestad and Davis, 1998). DynaRank is an Excel program that is used to generate 'scorecard' displays of the FSM outputs. In these scorecards, the individual policy options appear as rows and the outcome indicators (or their aggregations[6]) 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 a Reference Case and the policy run. So, a value of 100 means that, compared to the Reference Case, the policy led to no change in 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

[6] Aggregations of outcome indicators are based on pre-defined goal hierarchies. Each goal hierarchy relates a White Paper goal to the available outcome indicators.

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. An example of a scorecard is shown in Table 4.

Table 4 — Scorecard of results from policy runs for passenger transport

Policy No.	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)*
1.1.1	102	102	99	103	101	104
1.5.1	101	101	100	102	101	110
5.22	98	94	103	91	102	100
3.2.2	102	103	167	105	100	103
3.2.3	102	103	102	104	99	102
4.1	101	101	100	101	100	107
5.4	101	101	99	102	101	118
5.5	101	101	100	102	100	102
5.12	100	100	105	100	100	100
6.1.1	100	101	100	100	99	100
6.4	100	152	104	100	100	100
6.5	101	102	99	103	99	104

CONCLUSIONS

There is a need for a new generation of transport models that are suitable for evaluating the new generation of transport policies. Past transport policies primarily focused on the costs and benefits from infrastructure projects (roads, bridges, transfer terminals, etc.). Analysis of such policies requires detailed network models, which require lots of data and take a long time to run. Current policies are increasingly focused on changing other aspects of the transport system (e.g., parking charges, congestion charges, scrapping lease cars, car sharing), which do not need networks, but have to include the behaviour of travellers and transporters. Fast, versatile, meta-models are the appropriate tools to handle these types of policies.

The performance of the FSM in SUMMA demonstrated the utility of a fast integrated, user-friendly tool for performing policy analysis. The FSM is a powerful instrument that allows its users to select (and even specify) a wide range of policies, to quickly calculate their impacts in terms of a diversity of outcome indicators, and to present and analyse the results in many useful ways. The FSM is primarily meant for policymakers (easy three step usage: (1) select a policy, (2) run the policy, (3) study the results), but is also a powerful tool for researchers, who can design their own policies and customize the way of looking at the data.

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APPENDICES

Appendix A: Outcome indicators:

Table A1 — *Economic (EC) Outcomes of Interest and Related Outcome Indicators*

Outcome of Interest & Indicator Name		Indicator Definition	Units and direction for economic sustainability	
EC1 ACCESSIBILITY				
	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 (A_{ij})	↑
	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	↑
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	Tonnes of oil equivalent/ passenger- km	↓
		Energy consumption intensities for freight transport by mode	Tonnes of oil equivalent/ tonne-km	↓
EC4 COSTS TO ECONOMY				
	EC41 Infrastructure costs	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	↑

Outcome of Interest & Indicator Name	Indicator Definition	Units and direction for economic sustainability	
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	↑

Table A2 — *Environmental (EN) Outcomes of Interest and Related Outcome Indicators*

Outcome of Interest & Indicator Name	Indicator Definition	Units and direction for environmental sustainability	
EN1 RESOURCE USE			
EN11 Energy consumption	A. Final energy consumption in transport by mode and by energy source	Million ` ones of oil equivalents	↓
	B. Share of final energy consumption in transport produced from renewable energy sources	Million ` ones 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	↓*

Outcome of Interest & Indicator Name		Indicator Definition	Units and direction for environmental sustainability	
	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	↓
EN6WASTE				
	EN61 Generation of non-recycled waste	Total amount of non-recycled waste generated by transport by mode and by type of waste	Tonnes	↓*

Note: Arrows indicate the desired direction of development in the indicator values in order to move toward sustainable mobility. Indicators that need a closer look using detailed data before an interpretation can be made are marked with an asterisk (*).

Table A3 — *Social (SO) Outcomes of Interest and Related Outcome Indicators*

Outcome of Interest & Indicator Name		Indicator Definition	Units and direction for social 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	↓

Outcome of Interest & Indicator Name	Indicator Definition	Units and direction for social sustainability	
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	↑
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	↓

Appendix B: Policies derived from the White Paper.

Table B1 — SUMMA policies

Improving quality in the road sector	
1.1.1	Harmonise inspections and penalties (for passenger transport)
1.1.1	Harmonise inspections and penalties (for freight transport)
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 (for freight transport)
5.21	Allow bigger trucks for long-haul transport (for freight transport)
Revitalising the railways	
1.2.1.1	Open up the national freight markets to cabotage (for freight transport)
1.2.1.2	Ensure a high level of safety for the railway network (for passenger transport)
1.2.1.2	Ensure a high level of safety for the railway network (for freight transport)
1.2.1.3	Update the interoperability directives for all components of the network (for passenger transport)
1.2.1.3	Update the interoperability directives for all components of the network (for freight transport)
1.2.1.4	Open up international passenger transport
Adapting the maritime and inland waterway transport system	
1.4.6	Improve inland waterway transport (for freight transport)
1.4.7	Develop a European maritime traffic management system (for freight transport)
Linking up the modes of transport	
1.5.1	Build and promote multi-modal transport networks and terminals (for passenger transport)
1.5.1	Build and promote multi-modal transport networks and terminals (for freight transport)
1.5.4	Standardise transport units and freight loading techniques (for freight transport)
6.7	Increase service frequency for non-road modes (for freight transport)
Eliminating bottlenecks	
2.1	Revise the trans-European network and guidelines (for passenger transport)
2.1.22	Railway line Athina. Sofia-Budapest-Wien-Praha-Nürnberg/Dresden (for passenger transport)
5.22	Add road infrastructure (for passenger transport)
Unsafe Roads	
3.1.2	Harmonise rules governing checks and penalties concerning speeding in international commercial transport on the trans-European road network (for freight transport)
The facts behind the costs to the user	
3.2.1	Guarantee the interoperability of means of payment on the trans-European road network (for passenger transport)
3.2.2	Establish an infrastructure charging system (for passenger transport)
3.2.2	Establish an infrastructure charging system (for freight transport)
5.11	Implement road pricing (for passenger transport)
5.1	Implement road pricing (for freight transport)
3.2.3	Establish uniform taxation for commercial road transport fuel (for passenger transport)
3.2.3	Establish uniform taxation for commercial road transport fuel (for freight transport)
Managing the effects of transport globalisation	
4.1	Mobilise private sector finance to link the Accession countries to the trans-European railway network (for passenger transport)
4.5	Develop an EU satellite navigation system (Galileo) (for passenger transport)
4.5	Develop an EU satellite navigation system (Galileo) (for freight transport)
Rationalising urban transport	
5.1	Reduce speed limits in urban areas (for passenger and freight transport)
5.2	Implement parking space management (for passenger transport)
5.3	Reduce freight through traffic in urban areas
5.4	Introduce low-price tickets for employees to use on public transport in cities ('job ticket' for passenger transport)
5.5	Improve the performance and service quality of public transport (for passenger transport)
5.6	Increase car -sharing (for passenger transport)
5.10	Promote city logistic centres (systems) in the surrounding of populated areas (last mile logistics) (for freight transport)
5.12	Increase parking fees (for passenger transport)

5.25	Implement congestion pricing (for passenger transport)
6.2	Increase / make uniform time windows (for freight transport)
Increasing sustainability	
6.1.1	Subsidise energy efficient car purchase (for passenger transport)
6.1.2	Subsidise energy efficient car technologies (for passenger transport)
6.3	Subsidise environmentally friendly transport modes (for freight transport)
6.4	Make PM filter mandatory (for passenger transport)
6.5	Change fixed price of car ownership (for passenger transport)
6.6	Subsidise rail transport (for freight transport)

Appendix C: Policy levers

Table C1 — The FSM policy levers

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

Appendix D: The EXPEDITE meta-model for passenger transport

The full meta-model for passenger transport uses a segmentation by:

- Mode: car driver, car passenger, bus/tram/metro, train, non-motorised modes.
- Travel purpose: commuting, business travel, education, shopping, other purposes.
- Age: under 18, 18-65, 65 and older.
- Gender: male, female.
- Occupation: employed, not employed.
- Household size: one-person household, two-person household, three-person household, four-or-more-person household.

- Household income class: net annual income below 11300 Euros, net annual income 11300-18200 Euros, net annual income 18200-29500 Euros, net annual income 29500-38600 Euros, net annual income above 38600 Euros.
- Car ownership (four categories): person in a household without a car, person without a driving licence in a household with a car, person with a driving licence in a household that has more driving licences than cars (car competition in household), persons with a driving licence in a household that has at least as many cars as licences (car freely available).

Furthermore, the full meta-model for passenger transport distinguishes among NUTS-2 zones and among area types and road and rail network types by applying multiplicative factors for this.

Since the mid-1980's, a number of model systems have been developed in Europe, predicting future passenger transport at the national scale, using disaggregate, behavioural (based on the micro-economic concept of utility maximisation) model structures. Within the EXPEDITE consortium, five of these models were available. The five models are (in the order in which they were originally developed):

- the Dutch National Model System;
- the Norwegian National Model;
- the Italian National Model;
- the Danish National Model;
- the Swedish National Model.

In order to estimate the meta-model, a large number of runs were carried out (up to 80 runs per model) with each of the national models and with the SCENES model. For the base-year (1995), outcomes were generated in the form of 'levels matrices'. The levels matrices for tours give the number of tours per person per year by mode and distance band. A 'tour' is defined as a round trip, starting and ending at home. The levels matrices for passenger kilometres give the number of kilometres travelled per person per year, by mode and distance band.

Besides levels matrices for 1995, the outcomes of the national model runs also consist of switching matrices: changes in tours or in passenger kilometres (same units as the levels matrices), as a result of a change in a policy-related model input variable. There are switching matrices for changes in the running cost of the car, travel times by car, and for cost, in-vehicle time, wait and transfer time and access/egress time of train and bus/tram/metro. Runs for different percentage changes (e.g. +10%, + 25%, +40%, -10%, -30%) were carried out, because the travel demand response to cost and time changes may very well not be linear.

For each segment, the levels and switching matrices in tours and kilometres from all five national models were averaged (unweighted) to get the "prototypical" matrices that are used in the meta-model to forecast the demand for all NUTS-2 regions in Europe.

The zoning system in the meta-model consists of around 250 zones. For each zone, expansion factors were calculated depending on the importance of the population segments in the zone (many of these weights could be zero for a specific zone). By multiplying the tours and passenger kilometres from the prototypical matrices by the expansion factors, initial predictions for each of the zones were derived. These are forecasts for all travel demand generated in the zone, with one-way distances up to 160 km, by mode, distance class, travel purpose and population segment.

These initial forecasts were first corrected for differences in travel behaviour by area type and by road and rail network type, based on runs with the Dutch national model, the ANTONIN model for the Paris region and the SCENES model. The area types used in EXPEDITE are:

- Metropolitan;
- Other big cities;
- Areas around the metropolitan areas;
- Areas around the other big cities;
- Medium density areas;
- Low density areas;
- Very low density areas.

For road and rail network type, there are five categories, depending on the density of the network. In this correction, the use of public transport and non-motorised modes in metropolitan areas is increased, as is car use in the areas with lower density, at the expense of the other modes.

The model forecasts for 1995 that result after applying the area and network type correction factors were validated against observed data on the use of each mode (if available by distance class), by country. This resulted in a set of mode-specific, distance-class-specific, and country-specific correction factors, which are also kept in forecasting. In this way, the meta-model accounts for 'residual' factors affecting travel demand, such as climate, hilliness, and historical developments.

This meta-model for passenger transport also includes area-wide speed-flow curves to take account of the feedback effect of changes in congestion due to policies that change the amount of car use.

Appendix F: The EXPEDITE meta-model for freight transport
The EXPEDITE meta-model for freight computes the effect (in terms of tonnes and tonne-kilometres) of changes in policy variables, such as transport time and costs by mode, on top of the levels given by SCENES and NEAC.

The modes used in the meta-model for freight transport are: truck, conventional train, combined road-rail transport, inland waterways transport, and maritime transport. Furthermore the model distinguishes between NUTS-2 zones (which can be aggregated, e.g. to countries), distance class, and commodity class (bulk, petroleum and petroleum products, general cargo).

The EXPEDITE freight meta-model appears to have the same set-up as the passenger meta-model, but it is conceptually simpler. The EXPEDITE meta-model for freight differs in a number of ways. In the freight meta-model both the 1995 and the 2020 reference situation are not produced by the meta-model itself (as is done in the meta-model for passenger transport, by applying expansion factors to tour and kilometre rates). The pattern of freight flows originating in some zone comes directly from the SCENES model (for transport originating in the EU15, both domestic and international) or directly from the NEAC model (for transport originating in the CEEC8 and Switzerland, both domestic and international, and

Norway for international only). The reason for this is that the EXPEDITE national models applied within EXPEDITE focus on mode choice. With the exception of the Italian model, these models are made to distribute a given matrix (e.g. from an exogenous input-output model) over modes and routes. Therefore, by themselves these models are not capable of producing the trends in future freight transport demand, they can only give the response (in terms of modal shift) to policy measures.

Runs with the four national models in EXPEDITE and policy runs with the SCENES model were used to calculate elasticities for each of the policy levers. The meta-model applies these elasticities on top of the base levels provided by SCENES and NEAC, to give percentage and absolute deviations from the base levels.