FINAL REPORT

– for publication –

FANTASIE

"Forecasting and Assessment of New Technologies and Transport Systems and their Impacts on the Environment"

Contract No. ST-96-AM-1109

Project co-ordinator: Industrieanlagen-Betriebsgesellschaft mbH (IABG, Germany)

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Project duration: 01.01.1997 – 31.10.1999

Date: August 2000

Project funded by the European Commission under the Transport RTD Programme of the 4th Framework Programme

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FANTASIE constitutes a merger of tasks 27 and 28 of the 2nd Call in the 4th Framework RTD Programme. For further contact details see Annex B of this document.

The final report was prepared by Wolfgang Helmreich and Ulrich Leiss (IABG).

EXECUTIVE SUMMARY

The project FANTASIE ("Forecasting and Assessment of New Technologies and Transport Systems and their Impacts on the Environment") aimed to identify new technologies and lines of technological development which can be expected to affect European transport systems in line with the objectives of the Common Transport Policy (CTP).

FANTASIE was derived from the need for European level Technology Assessment (TA) and Technology Forecasting (TF) activities. National activities in some EU member states are relatively well developed, but a Europe-wide perspective that takes account of regional differences and the CTP objectives does not yet exist.

Background

Technology is an important factor in the performance of transport systems. Speed, comfort, safety and environmental impacts, all are determined by the technology applied. The FANTASIE project tried to identify those technologies which could improve such impacts. Secondly it was the objective to develop policy options to stimulate the "most desirable" technologies. Nevertheless it must be recognised that technology is not a goal in itself, it functions within and is dependant upon organisational frameworks, demand, regulation, etc.

Objectives

The key objectives of FANTASIE have been:

- identification of new technologies (evolutionary and revolutionary) and lines of technological development which are expected to have a major impact on transport systems in the EU and the attainment of EU's CTP aims;
- development and validation of methods of assessment which enable the scale of this impact to be forecast and quantified;
- assessment of new technologies with respect to their environmental, safety, efficiency and socio-economic impacts, their market potential and cross cutting issues; and
- evaluation of how technologies could affect the attainment of CTP objectives, and the policy levers available to influence the outcome.

Methodology

The FANTASIE approach, which centres around an extensive data collection integrated and evaluated by the team together with experts, stakeholders and policymakers, was developed according to the following structure:

- a six-level model of the transport system: 1) base technologies, 2) components, 3) applications within the transport system, 4) vehicle concepts (VC), 5) transport concepts (TC), 6) transport system;
- four exogenous scenarios: BAU business as usual, UG unrestricted growth, SG sustainable growth, SB sustainable balance;

- five problem areas: urban passenger transport (UP), urban freight transport (UF), rural passenger mobility (RP), interurban passenger transport (IP), interurban freight transport (IF); and
- four time horizons: base (1995), short run (2005), medium run (2020), long run (2030).

The methodology was to build the specific assessments where feasible by a bottom-up approach from lower levels up to higher levels (TCs and transport system). This was followed by a review aimed at identifying critical elements at lower levels which contribute significantly to the impacts. The approach makes it possible to provide at the end, in suitable output formats, the information on TCs and technologies that promise to be most important for improving the future performance of transport systems.

The specific assessments follow a base framework which addresses the different TCs in a given problem area for the four time horizons (1995 base, 2005 short run, 2020 medium run, 2030 long run) in the four scenarios. The TC assessments start with an analysis of different categories of impact, and identify the impact determinants and expected impact signs and levels. This was based on a structured analysis of results from earlier FANTASIE work. In a subsequent stage the FANTASIE partners developed their overall assessment. The assessment includes a descriptive part and a quantitative stage based on the development of impact profiles. An impact profile is the impact level according to either a conventional numerical scale or a quantitative physical measure, over the FANTASIE time frame in a given scenario. The impact profile methodology can be applied to any impact category and allows for a concise and diagrammatic format of results presentation. The internal TC assessments were complemented by expert external review.

The integration of the specific assessments has provided a selection of the most promising and robust TCs and technologies. The integration included an analysis in four stages on a problem area basis plus a complementary analysis, in parallel, on technology and cross cutting issues. The first stage of the main analysis was aimed at assessing TC market shares. The second stage provided the impact assessment at transport system level for each problem area. The third stage aimed at identifying problems and opportunities arising from developments in the EU transport system. In the fourth stage, TCs, vehicle concepts and technology options which are expected to make a significant contribution to the policy problem or benefit have been highlighted.

Building blocks for assessment

Technology survey and forecast (level 1-3)

An initial assessment of potential technological developments which are significant in terms of the objectives of the Common Transport Policy (CTP) has been provided. It was based on authoritative and independent review documents, rather than specialised and potentially biased reports on particular technologies. Much of the available information is at the level of technology applications – this was complemented later in FANTASIE by assessment work at the level of transport concepts and systems.

Information has been organised according to groups and bundles – propulsion systems, vehicle design, materials, information interface, and infrastructure – of technologies, and assessed using a policy-oriented framework of issues.

Vehicle concepts and technology trajectories (level 4)
Findings on vehicle concepts which are expected to have major significance for future European transport to the year 2030 have been presented. It was based on substantial contacts with external contacts, especially within the vehicle supply industries and vehicle operators, together with documentary research. It identifies the outlook for market penetration by different vehicle technologies, key consequences (environmental, safety, efficiency and socio-economic) and any policy implications.

Transport concepts, systems and scenarios (levels 5-6)
An attempt has been made to determine the extent to which transport concepts and systems could be used in the future. First, Europe-wide workshops defined (new) integrated transport systems based on the preferences of users. Based on existing knowledge, other DG TREN (DG VII) projects and previous studies, a demand assessment was then performed for all transport concepts. The future is uncertain and to deal with this, the forecasts were based on four possible future scenarios. Each of these scenarios is predicated upon two groups of variables: economic dynamism (a society is either characterised by high or moderate economic growth) and the importance of sustainability (a society either attempts to pursue an environmentally sustainable path; or does not).

For the scenarios this means that several different economic growth figures are assumed. The scenarios characterised by high economic growth are associated with a greater growth in transport demand, whereas in the sustainable scenarios a decoupling of economic growth and transport demand occurs.

Demand forecasts have been made using elements of both aggregate and disaggregate approaches. The aggregate part is based on the past relationship between income and transport demand, as well as views of how this might develop over the next 30 years. In practice this means the use of vehicle and transport concepts, which are subdivided between passenger and freight transport and assessed for different market segments. A second aspect of the disaggregate approach is that total transport demand is not assessed for the E.U. as a whole; it is based at a national level. As a final step, the demand assessment was systematically reviewed by European experts and up-dated.

Assessment
Following an extensive assessment of technologies highlighted in the survey and forecast phase, a smaller set of technologies with key impacts in the areas safety, environment, efficiency and socio-economics has been identified.

General key technologies

Fuel cell (methanol reformer, multi-fuel, direct methanol, depot reformation); hybrid propulsion; advanced conventional propulsion; advanced diesel; tiltrotor; electric and hybrid systems; defrosting/de-icing systems for aircraft; lightweight materials and structures; and improved aircraft engines.

Key telematic technologies

Combined on-board emissions and engine management; multi-modal traveller information/trip planning; dynamic route planning; in-vehicle traffic information; electronic tolling; navigation; traffic control; parking management; automated driverless transport; anti-collision systems; smart card; drive-by-wire; vision enhancement; autonomous intelligent cruise control; fleet management; integration of information technologies with GNSS; rail traffic management for long-distance passenger and freight; lane keeping; and driver monitoring.

Key intermodality technologies

Multi-modal traveller information/trip planning; parking management; fleet management; unitised packaging systems; transferia; cargo handling; automation, disposition & control technologies (I&C); transhipment (incl. terminals); and container (in combination with I&C).

Many new technologies have positive or negative impacts simultaneously for more than one assessment area and with a great variety of impact areas. Hence a synthesis was done to highlight only the most important impacts.

The dimensions of this neutral assessment view are:

- three time horizons, short-term (S) 2005, medium-term (M) 2020, long-term (L) 2030, baseline year 1995;
- four exogenous scenarios, BAU, UG, SB, SG;
- five problem areas, urban, interurban and rural for passenger and urban, interurban for freight;
- 23 vehicle concepts as described in the abbreviation list;
- 13 passenger and 10 freight transport concepts as described in the abbreviation list; and
- market potential, low (L) below 30%, medium (M) between 30% and 50%, high (H) above 50%.

There are only few technologies having key positive impacts in more than one specific assessment area but others often serve many vehicle and transport concepts with a medium to high market share.

- Of likely benefit for all impact areas are the group of **telematic technologies** – these have indirect positive impacts on the environment and socio-economic issues as well. Robustness of positive impacts can directly be seen where technologies have multiple relevance in the different scenarios. Initiatives are needed to achieve the setting of standards, and to guarantee early interoperability of a great variety of systems and services.

- **Fuel cell** propulsion may be based upon several different fuel and technology combinations, depending upon rate of technological development, fuel availability and infrastructure development. There is uncertainty over the impacts that may be expected from each of these combinations. Full life-cycle analysis is required to fully appreciate the contributions of fuel production and distribution on resource use and greenhouse gas emissions. There is less doubt that fuel cells will lead to very significant improvements (>90%) in local emissions of key pollutant species.

  Fuel cell technologies are expected to be significant in almost all scenarios and with many different vehicle and transport technologies. They are expected to have the most positive impacts on greenhouse gas emissions and air quality, and will deliver improvements to nuisance (mainly urban traffic noise).

  Fuel cells are expected to show a 50% improvement in fuel efficiency in 2030 compared to conventional petrol in 1995. Fuel cell technologies still require a lot of R&D to become more economically viable, and to guarantee equity in transport access.
- **Hybrid propulsion** is also expected to play a significant role in the medium term, and to become an important core technology connected to fuel cell deployment. Whilst enabling significant reductions in resource use and therefore greenhouse gas reductions, hybrid drive technology (for all-purpose cars, buses and possibly freight vehicles) will allow zero emission operation of these vehicles within urban areas, where air quality improvements are of the highest priority. Nuisance impacts will also see remarkable improvements in slow-speed urban operations.
- **Multi-modal traveller information/trip planning**. Providing traveller information over several modes of travel is highly beneficial to both the traveller and the service provider. Enhanced information about intermodal connections will reduce delay at intermodal facilities and improve accessibility. For passengers, better information about transfers means less delays in waiting for transportation services (e.g. transit bus, shuttle, transit van) and reduced uncertainty about making connections. For passenger transport positive impacts are also expected, especially as regards the efficiency of public services like demand responsive systems and car-pooling. The market potential is anticipated to be high.
  - After performing pilots/demos the wider transfer uptake of and access to the information systems needs to become the focus of European policy.
  - Critical problems for the wider uptake exist in information handling (including data protection, information exchange among competing parties) and interface standards between different systems, on-board devices, etc.
- **All-purpose car**. Among all vehicle concepts, the all-purpose car is expected to show the most significant impact improvements. Reduction of air quality impacts is expected through slow turnover of the fleet to advanced conventional diesel turbine engines. Improvements are likely under all scenarios, but especially under BAU and the growth scenarios. All passenger problem areas will be affected across all time horizons. Advanced conventional propulsion systems, followed by hybrid and fuel cell propulsion will be the most significant technologies, combined with other vehicle improvements (weight, friction and aerodynamic drag reduction) over the time period.

  For all scenarios an increase of construction costs is expected, in particular as regards the alternative propulsion systems. For all alternative propulsion systems a cost reduction is possible if considerable R&D investment are made in order to solve the technical and organisational problems related to the implementations of such technologies and their widespread diffusion on the market. Nevertheless, without financial incentives the cost for the user of such vehicles will remain consistently higher.

- **Tiltrotor** technologies enable significant advances in rotorcraft technologies and are likely to establish a niche market. With the combined functionality of helicopters and fixed wing aircraft, these vehicles will allow significant fuel savings as well as considerable noise reductions. Both these impacts currently restrict helicopter deployment, especially within urban zones. Tiltrotor vehicles are the only remaining monopoly of the US aircraft industry. A European uptake complements global competitiveness.
- Modern **airships** are likely to create a niche market for heavy and bulky loads with important indirect benefits in reducing congestion. In addition, they could start a revolution in the construction sector by allowing high quality factory manufactured big modules to be brought to their final destination within cities and outside.
- New systems for **personal rapid transit**. Research on new systems for personal rapid transit has been done over the last years already. Now a wider uptake is needed. It could benefit from a better knowledge transfer, based also on the assessment of pilots and demos, but the main problem for such new systems must be seen in financial barriers and in a mismatch with the dominant public transport technologies. In the implementation of the new regulatory frameworks for a liberalised transport system, the specific conditions that would favour the uptake of such new personal rapid transit systems should be taken into account.
- **Road trains**. Currently road trains are not explicitly considered in European technology policy. The timely establishment of safety regulations could help speed up their introduction, i.e. assuming that in general the use of road trains, be they mechanically or electrically coupled, finds widespread support and acceptance. Monitoring experiences with road trains and their assessment would then be needed, especially to evaluate their benefits in comparison with rail transport.

After the assessment a final forecast was performed and a forecasting process was developed to provide projections of the future market shares of passenger and freight TCs in the different problem areas based on a model of users' preferences. Both the urban and interurban areas have been addressed for passengers. The interurban area has been addressed for freight.

Recommended policy options

Policy options can be generic, trying to improve the conditions for innovations or specific to support certain selected technologies. Some experts on technology policy prefer generic policy options because they create an environment in which barriers have been removed and innovation is more rewarding. However, the realisation of specific technologies often require changes in legislation and regulation. Generic policy measures are not sufficient and specific barriers have to be removed. In most cases, specific technology policy implies that a government chooses a technology and, at the same time, may neglect other competing technologies.

Therefore, generic policy options should be considered in all cases, such as:

- Standardisation
  This is an important factor in the innovation process. The optimal use of standardisation is still a subject of further investigation, e.g. the best timing and co-operation with other countries. Active European involvement in international standardisation is necessary.
  - Stimulation of R&D
    Next to the existing European R&D programmes, one could think of other ways to stimulate R&D by giving financial incentives for innovation that is initiated by the private sector.
  - Knowledge management
  - Infrastructure development
  - Regulation and planning
  - Legislation
  - Pilots and demonstrations
  - Networking

Specific options based on selected technologies and a focus of attention for the EU can be clustered in certain policy packages, i.e. sets of measures aimed at the introduction of selected technologies in specific sub-domains of transport, such as:

- A propulsion package aimed specially at regulations and adjustments of existing policy to enable the fast introduction of new propulsion technology.
- Urban package, to stimulate R&D and pilots in towns and exchange of experiences.
- Intermodality: measures to support R&D and pilots and to stimulate organisations that have an intrinsic interest in intermodal solutions.
- Aeronautics: aeronautics has the first truly European industry, which receives already much attention from the EU. Bottlenecks to be solved are in the ground based systems and air traffic management.
- Rail: this application domain should be stimulated to develop and apply new technologies especially for urban transport.
- Navigation and travel information could be helped by a role playing of the EU with respect to standardisation and interoperability and regulations to make travel information an exploitable product.
- Traffic management, communication and payment: the interactive technologies that support the execution of measures for the CTP goals, such as infrastructure pricing. Common standards have to be stimulated by the EU.

Conclusions

The most important and promising technologies that emerged from a large-scale technology assessment are for the majority already subjects of attention in the European policy context. That means that the technology assessment supports to a great extent the main existing European policy lines, but shifts the emphasis in terms of the most promising technologies to focus on, and the types of policy roles to adopt. An important result of the study is the concentration on a limited number of technologies.

Of course, the result of the selection process has partly a transient character, since in technology – and especially in information technology – changes come very quickly. This indicates that the validity of the current assessment results will need to be updated after some years.

The European policy packages address problem areas that have already attracted the attention of European policy makers. However, the focus on the most important technologies within these areas can help make existing policy programmes more effective in terms of their impact during the innovation process. By enabling the definition of clearer objectives and roles that are compatible with the innovation phase of a promising technology, the co-ordination of policy programmes (transport, technology, energy, etc.) should become easier.

The FANTASIE project has mainly followed a bottom up approach for technology assessment in order to suggest technologies to policy. However, government also needs to select the best role for policy in a contingent way and to change roles if the conditions, e.g. the phase of the innovation process, require it. This flexibility in terms of policy roles is crucial to ensure the continuity of policy involvement during the most critical phases of the innovation process and to avoid R&D projects ending without tangible change in the transport system. The FANTASIE studies also confirmed that innovation policy needs to incorporate a strategy for the diffusion phase of a technology and the phasing out of policy support.

The FANTASIE project has been very broad: it dealt with all modes and all possible technological innovations. Furthermore, the active involvement of stakeholders and users of the transport system has been limited. Therefore the character of the policy options coming out of this project is still generic and for specific technologies rather superficial. Suggesting detailed policy strategies for individual technologies and packages would require a more detailed analysis first. Nevertheless, a number of generic recommendations can be drawn for European innovation policy in the transport field. First of all, practical policy measures on a European scale have to match national actions and the interests of trade and industry, and policy push and market pull have to be co-ordinated. That means that European and national policy makers, stakeholders from trade and industry and users should co-operate in an interactive constructive process to develop effective policy measures.

Secondly, these measures should first of all be aimed at the realisation of policy goals with technological means, where for most transport concepts the choice of the most appropriate technology should be left to the market, the technology providers and users. A top-down choice of a winning technology often leads to sub-optimal solutions. However, in cases where market forces are not likely to deliver socially desirable solutions, it may be necessary to implement targeted, but clearly limited support action to overcome such social dilemmas. In other words, an important objective of innovation policy is to make sure that a variegated portfolio of technology options is kept under development in order to be prepared for changing context conditions, as reflected in the study's scenarios. The recent development of oil prices shows how important it is to have options available that may not be advanced further by industrial research due to their uncertain perspectives.

In both these respects, the development of efficient and effective interactive processes on a European scale in which stakeholders and users are involved is crucial, thus representing one of the challenges for a European technology policy for transport.

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1. INTRODUCTION

The project FANTASIE (“Forecasting and Assessment of New Technologies and Transport Systems and their Impacts on the Environment”) aimed to identify new technologies and lines of technological development which can be expected to affect European transport systems in line with the objectives of the Common Transport Policy (CTP).

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1.1 Background

Technology is an important factor in the performance of transport systems. Speed, comfort, safety and environmental impacts, all are determined by the technology applied. The FANTASIE project tried to identify those technologies which could contribute to improvements in impacts like safety, environment and efficiency. Secondly it was the objective to develop policy options to stimulate the “most desirable” technologies. Technology is not a goal in itself, it functions within and is dependant upon organisational frameworks, demand, regulation, etc.

1.2 Objectives

The key objectives of FANTASIE have been:

- identification of new technologies (evolutionary and revolutionary) and lines of technological development which are expected to have a major impact on transport systems in the EU and the attainment of EU's CTP aims;
- development and validation of methods of assessment which enable the scale of this impact to be forecast and quantified;
- assessment of new technologies with respect to their environmental, safety, efficiency and socio-economic impacts, their market potential and cross cutting issues; and
- evaluation of how technologies could affect the attainment of CTP objectives, and the policy levers available to influence the outcome.

1.3 Structure of FANTASIE

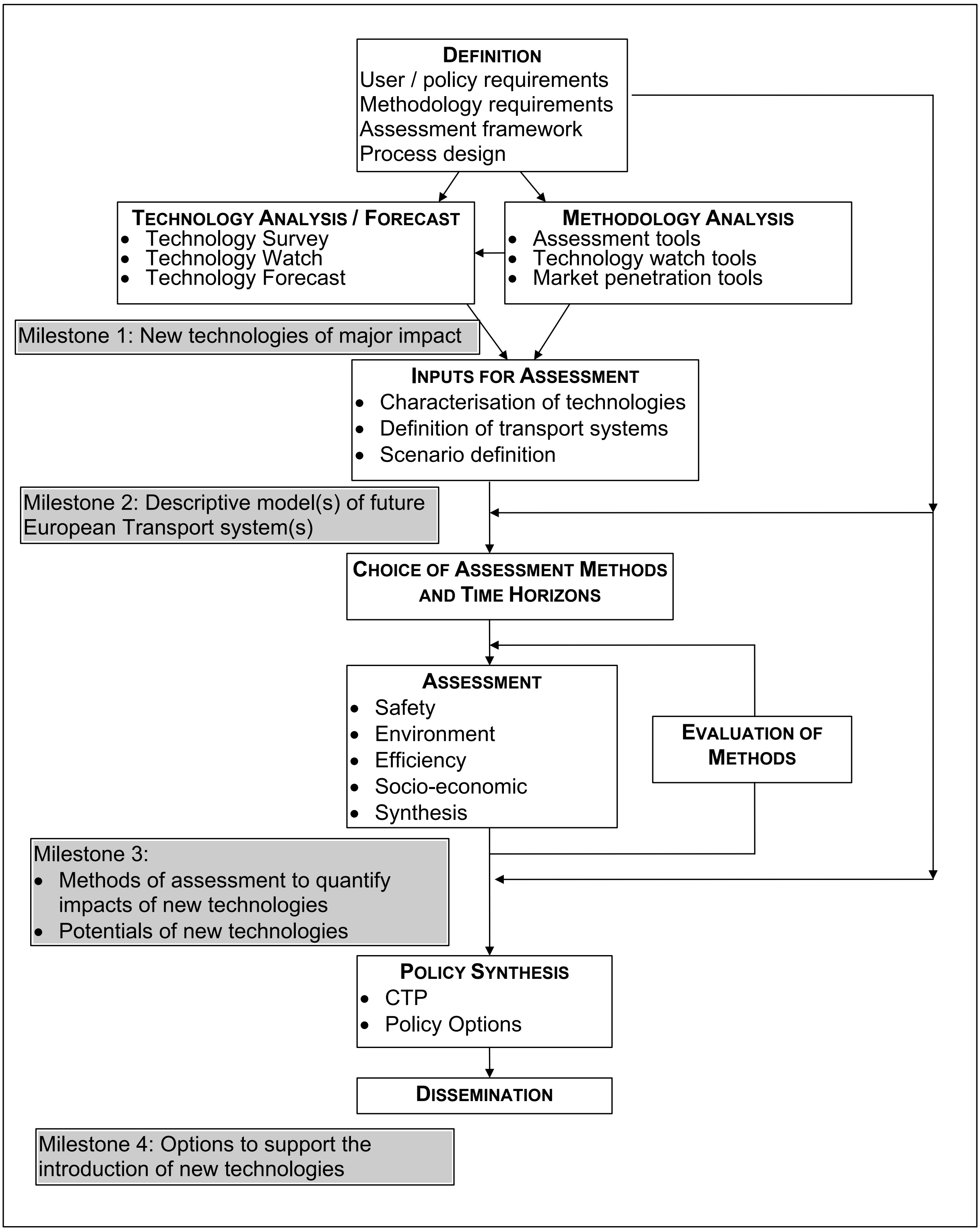

Figure 1.1: The FANTASIE project logics

In the following treatment of FANTASIE activities the reader will be given additional cross reference on more in-depth information at the end of each section. A reference to worthwhile material (i.e. available project deliverables) for further investigation into a specific topic is highlighted as in the example below

- D9 "Forecast of new technologies with major impacts"

Throughout the entire document D is used as an abbreviation for deliverable. For specific abbreviations you may always refer to the attached "Glossary of terms and abbreviations".

For a comprehensive overview on deliverables produced by FANTASIE please consult Annex C. Several documents with the status "public" have been subsequently made available via the project homepage which is accessible at

http://www.etsu.com/fantasie/fantasie.htm

General information on the project's objectives and scope, together with contact details can be found on the Transport RTD Programme site of the Cordis web server

http://www.cordis.lu/transport/src/fantasie.htm

Acknowledgement

The FANTASIE project team would like to thank all experts, stakeholders, policy makers and professional people who did contribute to this comprehensive coverage of strategic transport aspects. In particular the project's in-depth data gathering phase comprising all major transport sectors – laying the groundwork for the later complex forecasting and assessment work – would have been impossible without numerous invaluable external contributions, feedback and communication.

2. DEFINITION

This stage of the project was dedicated to the identification of a policy and user oriented approach, and the outline of a methodological framework for the core assessment work within FANTASIE.

2.1 Policy and user requirements

The main focus has been on DG Energy and Transport (DG TREN, formerly DG VII), however the interests of other potential users have been kept in mind. This has led to the identification of the following six types of inputs which are regarded of particular relevance to transport policy-making:

- information provision on new technologies and their performance;
- development of a knowledge-base on new transport technologies;
- analysis of interactions between political measures and technological developments;
- advice on strategic policies;
- interactive involvement of stakeholders in the preparation of policies; and
- mobilisation of actors.

Issues for policy-making

Ten major issues for policy-making – which indicate the political concerns related to transport – have been identified on the basis of document reviews and interviews for eight member states and the EU. They have been grouped into the following three clusters:

a) Technology-related issues

- quality and effectiveness of transport;
- direct costs to the transport user;
- environmental impact;
- safety;
- technological feasibility and development potential.

b) Socio-economic issues

- economic development;
- quality of life;
- transport demand and acceptance of technologies.

c) Political issues

- distribution of competencies and subsidiarity;
- political feasibility.

The individual issues are far from being independent from each other. They are interrelated and deal with phenomena at different levels of the transport system. Conflicts and complementarities exist between them, but also among different aspects of the individual issues. Such interdependencies and systemic effects are important, but have not yet been understood in detail. Further research work is needed to improve this. Consequently, only a first exploration of such effects has been provided.

Priority themes

Priorities of transport and transport-related policies differ across Europe. Often priority themes are not expressed explicitly in policy documents and statements, but in practice there is always a hidden agenda of priorities. Although a list of such themes may be controversial, an attempt has been made to set up a list. It should be used as a starting point for further debate rather than as a definitive analysis. The main priority themes identified are:

- mobility demand;
- competitive performance of transport markets;
- cost-effective transport pricing;
- connection of peripheral regions;
- traffic problems in urban areas;
- co-ordination between local and other levels of government;
- intermodal freight transport chains;
- an inter-European high-speed rail network;
- harmonisation of European railway systems;
- safety of road transport;
- fuel efficiency;
- local air quality;
- global climate change; and
- air traffic capacity and congestion.

Uncertainties

FANTASIE focused predominantly on the forecasting and assessment of future transport technologies. However, the emphasis given on an appropriate link to policy concerns made it necessary to think ahead in terms of new emerging issues and uncertainties on the political agendas of the future. The five areas where major uncertainties are expected to arise are:

- transport demand and mobility patterns;
- liberalisation and competition;
- environmental concerns and resource depletion;
- technological breakthroughs; and
- policy-making processes.

Transport policy update

During the execution of the project, CTP objectives have been further specified in a new Transport Policy Action Plan which set out the lines of priority for the time horizon 1998-2004. Figure 2.1 gives an overview on the elements of this EC Action Plan and links them in terms of their relevance to FANTASIE assessment dimensions.

Main objectives	*Specifications*	*FANTASIE dimensions*
Improving efficiency and competitiveness	Market access and functioning	Efficiency
	Integrated transport systems	Efficiency
	Fair and efficient pricing	Efficiency
	Economic and social cohesion	Socio-economic
	Marking sure that the rules are applied	Socio-economic
Improving quality	Safety	Safety
	Environment	Environment
	Protecting consumers and improving the quality of transport services	Socio-economic
	Preparing the future	Socio-economic
Improving external effectiveness		Efficiency
A longer-term perspective	Applies to all preceding categories and will be integrated in the respective analyses	Socio-economic

Figure 2.1: Main lines of the Transport Policy Action Programme 1998-2004
(Source: CEC (ed., 1998): The Common Transport Policy. Sustainable Mobility. Perspectives for the Future)

Fifth Framework Programme

The current Fifth Framework Programme (1998-2002) represents a redesign of European research, technology and innovation policy. Transport-related research is distributed over a number of key actions which are rooted in socio-economic objectives and problem areas. Three of them are explicitly dedicated to transport, and their titles already give a first indication of current key technology issues:

- sustainable mobility and intermodality;
- land transport and marine technologies;
- new perspectives for aeronautics.

Further transport-related research is carried out within the key actions:

- "City of tomorrow and cultural heritage";
- "Economic and efficient energy for a sustainable Europe";
- "New methods for work and electronic commerce".

2.2 Assessment framework and criteria

An assessment framework is not a free-standing set of criteria and indicators, rather it is a guide for collecting the most pertinent and policy-oriented information, and analysing or comparing the assessment subjects in a systematic and policy-relevant manner. Figure 2.2 describes how the assessment framework is policy-led, and uses policy targets and goals to define significance criteria. When combined with forecasting information, these criteria will define which technologies or systems are of interest and merit further investigation.

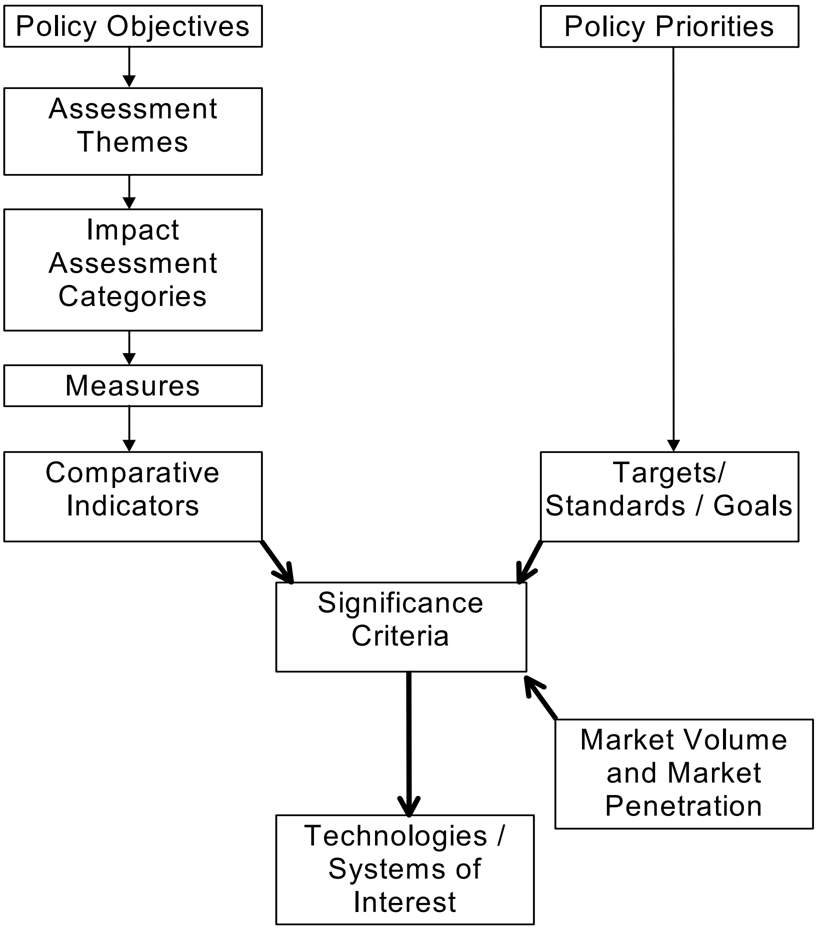

Figure 2.2: Assessment framework – logics and structure

Summaries of the assessment framework are shown in Figure 2.3, and of the forecasting framework in Figure 2.4, respectively.

Assessment area	*Theme*	*Impact / effect*
Environment	Environmental Sustainability	Energy resource use Non-energy resource use Global warming; Stratospheric ozone depletion Biodiversity/habitat destruction
	Local air quality	Health Material damage
	Regional air quality	Agricultural / Forestry impacts Terrestrial and Aquatic Ecosystem impacts
	Nuisance	Noise and vibration Visual intrusion / Landscape degradation Severance
	Waste	Land and Water Contamination Waste disposal
Socio-Economic	Economic Development	Land-use patterns EU competitiveness Exports Employment Security of energy supply Broadening the external dimension
	Completion of single market	Interoperability Pricing efficiency
	Social Cohesion / Quality of Life	Mobility – discretionary Equity Accessibility to transport Working conditions Care for marginal / vulnerable groups
	Public acceptance	Freedom of choice Acceptance by industry Acceptance by society
Safety	Safety of users	Driver safety Passenger safety
	Safety of non-users	Other drivers and passengers Other NMT modes General public High-risk groups
Efficiency	Journey performance	Journey speed Delay Reliability Journey quality
	Cost	Capital; operating Cost to user
	Intermodality	Ease of modal transfer
	System capacity	Load-following capacity

Figure 2.3: Assessment framework summary

Development area	*Theme*	*Issue*
Technical Aspects	Technical Possibilities	R & D needs Compatibility / co-existence of technologies Parallel technological developments needed
Production Aspects	Cost of technology deployment	R & D investment Industrial investment
Commercial Aspects	Technology cost when deployed	Purchase price Vehicle operating cost Competitiveness with existing technologies Initial vs. long-term cost
	Public and user acceptance Market Possibilities	Conservatism / Habits/ Values Dependence on new infrastructure Rate of stock renewal or retrofitting Industrial lock-in System-wide change
Institutional Aspects	Institutional Possibilities	Planning regulations Taxation system
	Subsidiarity	European added value Distribution of competencies Co-operation, trust and conflict potential
Political Aspects	Political feasibility	Convergence of interests Availability of policy instruments Political risk

Figure 2.4: Forecasting framework summary

3. METHODOLOGY

3.1 The six level transport model

Within FANTASIE technologies and their application in the transport system have been structured in what is called the six level approach (refer to Figure 3.1). Broadly speaking, the approach has been to differentiate between the transport demand (transport system and transport concepts) on the one hand, and the technological content (vehicle concept, application, components and base technologies) on the other. Nevertheless, the fact remains that these levels have a great effect on one another. If electrical propulsion in a new vehicle concept were to become significantly less expensive, this would have certain repercussions on a transport concept, e.g. that of a small vehicle for in and around urban areas. In short, there is a great degree of interdependence between the levels. Therefore, the demand assessment was carried out in an iterative manner. Based on the results of the technology assessment the demand assessment was adapted.

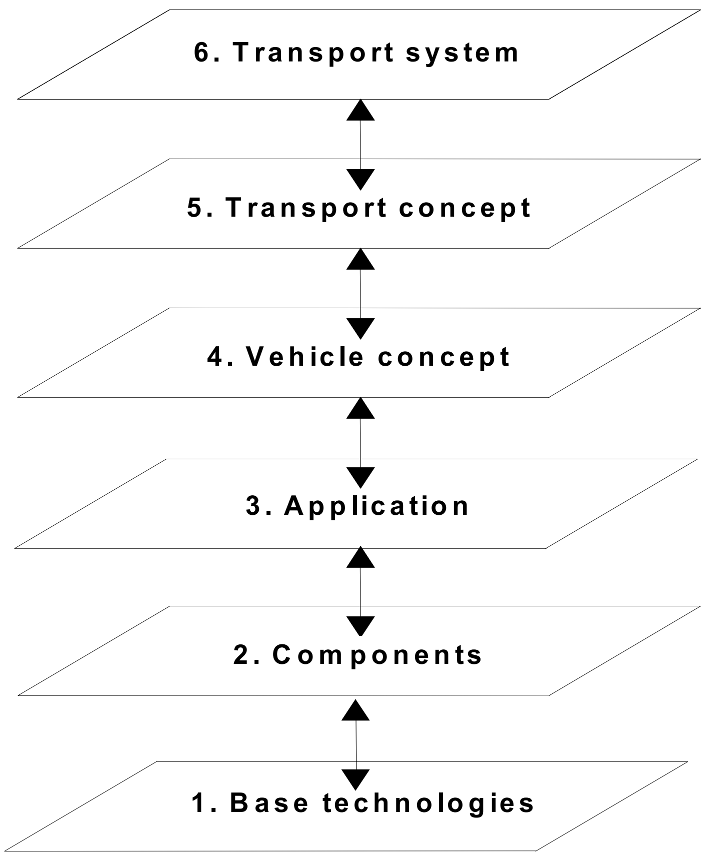

Figure 3.1: The six level approach in FANTASIE

A simplified representation of the transport system can be based on the aforementioned six levels of technology, which can be specified as follows.

Base technologies
These are basic developments in resources, information technology, energy sources, etc.

Components
Basic technological developments are put together for certain components, though not yet geared towards transport.

Applications within the transport systems
Typically, these are components which have been adjusted for use in the transport system. Examples are batteries, propulsion systems, information systems, etc.

Vehicle concepts
New vehicles concepts are often needed in order to achieve the wide use of new transport applications, e.g. small city cars which encompass the application of advanced information and payment systems.

Transport concepts
Beyond the individual vehicle operating in an unaltered environment, new transport concepts also re-conceptualise their operational environment. Elements of this are parking facilities, maintenance and supply system, etc.

Transport system
The most encompassing level is the transport system as a whole, dealing with the interaction of transport concepts, their (intermodal) integration and questions of overall demand and its structure.

For FANTASIE the four higher levels of analysis appeared to be of particular relevance. Base technologies and components cannot be easily influenced by means of transport policy, but by general RTD policy. They became relevant for FANTASIE only once they had been recognised as potential transport applications.

3.2 Adapted methods for assessment

Impact assessment
The FANTASIE approach, which centres around an extensive data collection integrated and evaluated by the team together with experts, stakeholders and policy-makers, was developed according to the following structure.

- A six-level model of the transport system: 1) base technologies, 2) components, 3) applications within the transport system, 4) vehicle concepts (VC), 5) transport concepts (TC), 6) transport system.
- Four exogenous scenarios: BAU business as usual, UG unrestricted growth, SG sustainable growth, SB sustainable balance.

- Five problem areas: urban passenger transport (UP), urban freight transport (UF), rural passenger mobility (RP), interurban passenger transport (IP), interurban freight transport (IF).
- Four time horizons: base (1995), short run (2005), medium run (2020), long run (2030).

The flow diagram of the FANTASIE project is shown in Figure 1.1.

The logic of the assessment methodology development is that of building the specific assessments as far as possible by a bottom-up approach from lower levels up to higher levels (TCs and transport system). This is followed by a review aimed at retrieving all the lower levels (VC and technology options, TOs) which contribute significantly to the impacts. The approach makes it possible to provide at the end, in suitable output formats, the information on TCs and technologies that promise to be most important for improving the future performance of transport systems.

The approach fulfils the following requirements.

R1 The specific assessment is carried out according to the criteria and the main relevant impact categories identified in previous FANTASIE work. Each main impact category is assessed separately. Assessment results are presented at the level of the main impact categories identified or clusters thereof. Where appropriate, the results will stem from relevant impact subcategories.

R2 The assessment work provides the neutral, ”objective” view. This relies on:
- partner expertise;
- previous FANTASIE work based on existing studies; and
- experts involvement.

The expert involvement in the specific assessment work is independent of the stakeholders involvement for the development of policy options.

R3 The specific assessments are carried out on a descriptive base taking as an input the FANTASIE forecasting work. This has two main consequences:
- the hypothesis of absence of feedback effects on TC market shares is assumed for the specific assessments;
- the policies relevant for the different TCs are also an input of the specific assessments according to the different scenarios.

R4 For the impacts where a quantitative assessment is meaningful, specific impacts (for example rates per vehicle-km or passenger-km) are first considered (these can be affected by changes in demand where appropriate).

R5 The specific assessment work helps identify a portfolio of technologies options. The impact assessment considers the effects of the expected trajectories of the TC (taken as an input) over the FANTASIE timeframe (four time horizons, 1995, 2005, 2020 and 2030) in the different exogenous scenarios (BAU, UG unrestricted growth, SB sustainable balance, SG sustainable growth). The TC impact potential is assessed according to the FANTASIE level, from TC down to the technology application level (FANTASIE levels 5, 4 and 3, TC, vehicle concept –

VC, and technology application), which is relevant in each impact category. Technologies which are particularly significant in the different impact categories are highlighted.

The main tasks of the assessment form the following sequence.

- From lower levels to TCs. TCs are ”deconstructed” and relevant trajectories of lower levels identified.
- Impact assessment at TC level. Aggregation procedures provide the impact assessment at TC level in the different problem areas starting from lower levels.
- From TCs to transport system. Market forecasts of TCs driven by end users preferences provide the transport system composition in the different problem areas.
- Impact assessment at transport system level. Aggregation procedures provide the impact assessment at transport system level in the different problem areas based on TC impacts and market shares. Problem areas providing problems and opportunities across assessment areas are identified.
- From transport system to lower levels. Transport system in each problem area are deconstructed and significant VCs and TOs providing problems and opportunities are identified across assessment areas.

The construction of the TC impact profiles was carried out for each selected main impact category, for each relevant problem area and for each scenario. The procedure is shown in Figure 3.2. The procedure is outlined with reference to an assessment based on point systems. Changes to refer the assessment to physical quantities are based on the availability of data. Details of the methodology can be found in Deliverable 15.

D15 "Adapted methods and time horizons for assessment"

Assessment was performed according to a point system (three, five, seven, nine or eleven levels depending on the impact category) which provides information on sign and level of the relative impact. This is the stage where the assessment is made as linguistic information. Points are given for each TC alternative specification based on the opinion that each partner has built on the basis of his own expertise and of results of the analysis. For each impact category the definition of each point (e.g. by percentage variation range of relevant quantity) was provided. The impacts were transformed into crisp numbers according to a transformation scale based on fuzzy theory (Figure 3.3). With the chosen scales, each impact is provided as real number in the range between -0.5 and 0.5. The real numbers are only conventional and cannot provide information on impact ratios compared to base case. In other words they are not associated to any measurable quantity. They are used to provide a common assessment scale which applies to all types of impact category.

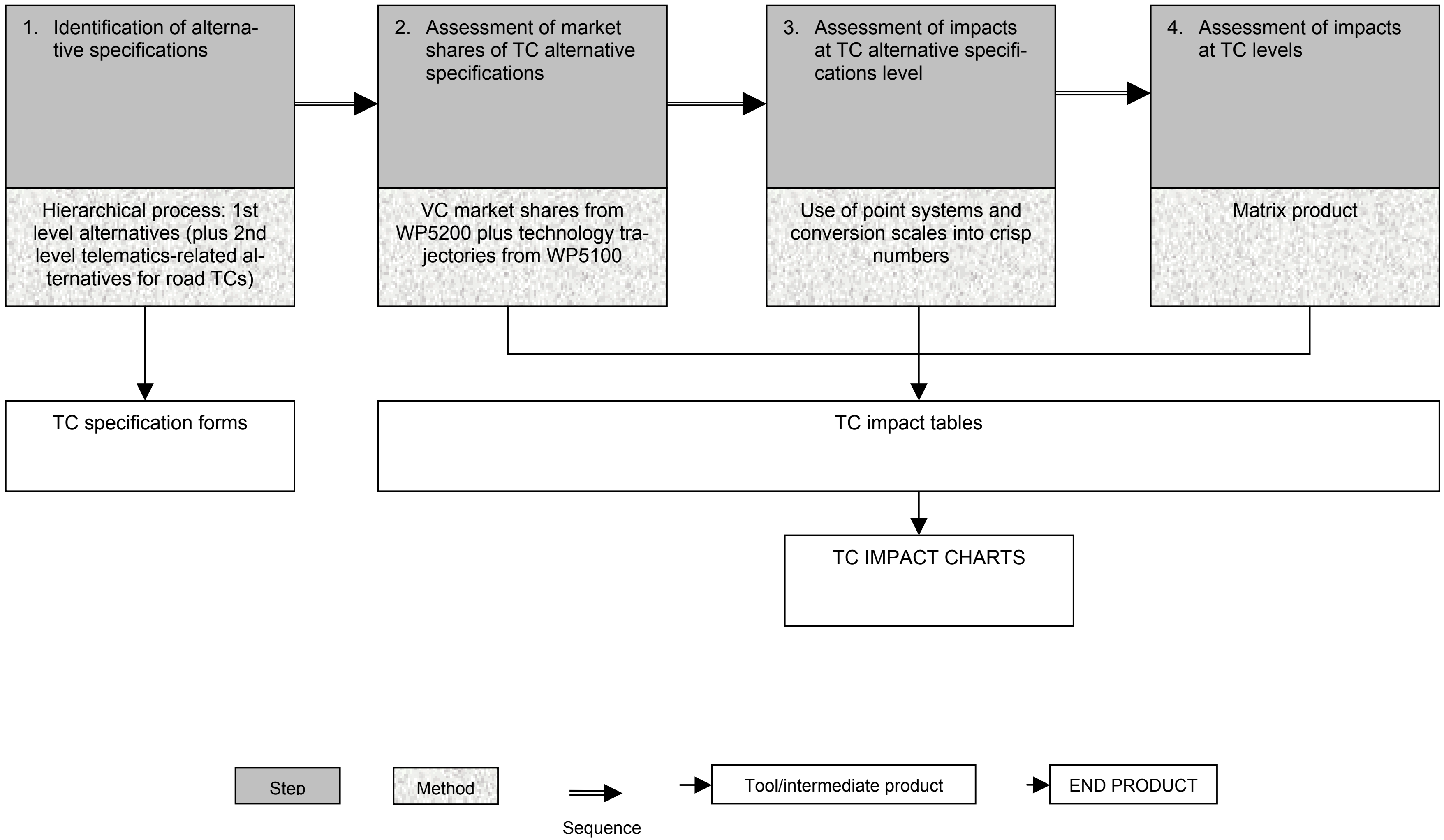

Figure 3.2: Impact profiles production process

Impact change		Point systems									
		3 points		5 points		7 points		9 points		11 points	
Worse	Very high									-5	-0.46
	High			-2	-0.41	-3	-0.41	-4	-0.42	-4	-0.36
	Med-high							-3	-0.38	-3	-0.25
	Medium	-1	-0.33	-1	-0.22	-2	-0.27	-2	-0.25	-2	-0.17
	Low							-1	-0.13	-1	-0.09
	Very low					-1	-0.14				
Negligible change		0	0	0	0	0	0	0	0	0	0
Better	Very low					+1	+0.14				
	Low							+1	+0.13	+1	+0.09
	Medium	+1	+0.33	+1	+0.22	+2	+0.27	+2	+0.25	+2	+0.17
	Med-high							+3	+0.38	+3	+0.25
	High			+2	+0.41	+3	+0.41	+4	+0.42	+4	+0.36
	Very high									+5	+0.46

Adapted from: Chen and Hwang, 1992

Figure 3.3: Point systems and transformation scales into crisp numbers

The final forecast process

The TC market share forecasts are obtained by a process which is aimed at best exploiting the project previous knowledge base and the experts' skills, structuring the experts' judgements and converting them swiftly into numerical formats.

The process includes different kinds of activities:

- background activities to collect the necessary input information and data, implement the spreadsheet model, prepare the expert questionnaires and workshops, pool and process the questionnaire results;
- expert interviews by questionnaires; and
- expert workshops.

The activity flow is shown in Figure 3.4. There are three main *blocks* in series:

- block A, aimed at identifying the relevant primary explanatory variables and assessing their weights, and based on expert questionnaires;
- block B, aimed at assessing the TC priorities in the base year and re-producing the known market shares, and based on expert questionnaires; and
- block C, aimed at assessing the TC priorities in the future, providing the projected market shares and unearthing the hypotheses underlying the projections, and based on workshops.

The process envisages a modular and cascade architecture. In principle all the blocks can provide results in real-time by involving the experts in workshops.

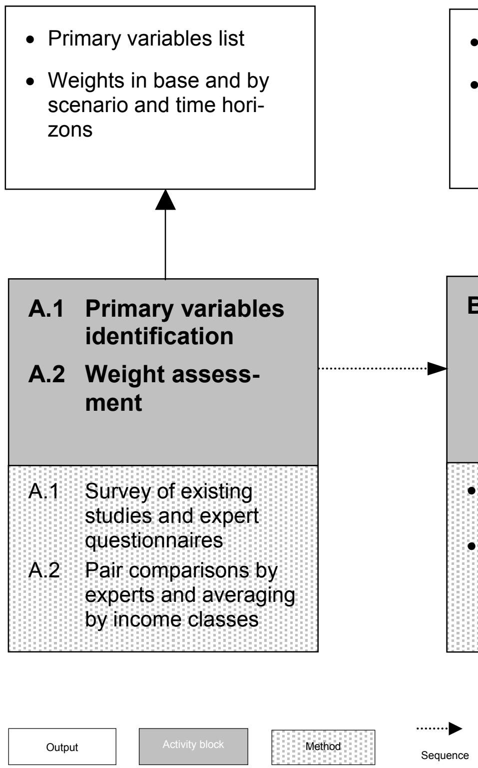

Figure 3.4: The forecast process

4. TECHNOLOGY ANALYSIS AND FORECAST (levels 1-3)

The FANTASIE project aimed to characterise potential technological developments and impacts which are significant in terms of the objectives of the Common Transport Policy.

Four main steps have been performed for the main outputs of this chapter:

- identification of sources;
- collection and characterisation of documents;
- information structuring;
- information synthesis.

4.1 Technology survey

Initially a state-of-the-art survey and review of previous technology forecasts and assessments for the transport sector has been performed. The focus was on authoritative and independent review documents, rather than specialised and potentially biased reports on particular technologies. Much of the available information was at the level of technology applications; while the assessment at higher levels e.g. transport systems was to be performed later in the project.

A great number of relevant studies and other sources (147 documents in total) was identified, collected, characterised and structured. Information has been organised according to groups and bundles of technologies, and assessed using a policy-oriented framework of issues.

➲ D8 "A structured state-of-the-art survey and review"

4.2 Technology watch

For harmonisation with technology forecast (TF) five categories of non-transport technologies similar to the technology bundles have been identified:

- energy technologies;
- material technologies;
- information technologies (transport substitution);
- sensor technologies;
- micro and nano-technologies.

The information was based on particular application of technology watch methods (brainstorming, interviews, patent and bibliometric analysis, and questionnaire survey with support from the ESTO network) and the expert opinion of the contributing consortium partners. The technologies identified outside the transport sector are mainly of generic nature (technology levels 1 and 2) and could feed into a wide range of future transport applications. The market possibilities of those technologies were analysed and the obviously higher uncertainties addressed.

4.3 Technology forecast

Technology forecast was the logical technology survey follow-on activity. An initial assessment of potential technological developments which are significant in terms of the CTP objectives was done.

A list of new technologies, which are expected to have major impact, has been generated. The nature of impact was given as well as the reason why a technology was estimated to be significant. Due to the complexity and the number of technologies details are presented in Deliverable 9.

- D9 "Forecast of new technologies with major impacts"

4.4 Key results

Information in the initial state-of-the-art survey and review of previous technology forecasts and assessments for the transport sector has been organised according to five bundle groups plus one superbundle, and 22 bundles of technologies (refer to Figure 4.3), and assessed using a policy-oriented framework of issues as presented in the following Figure 4.4).

Coverage by mode / vehicle type

Information on the contents of the key reports chosen for further scrutiny (characterisation) within FANTASIE is summarised in the following Figures.

Figure 4.1 shows the number of reports that consider particular modes in some way, whereas Figure 4.2 shows the number of reports contributing to each technology bundle group assessment for each mode. (In Figure 4.2, the numbers are shown cumulatively, and therefore exceed the total number of reports identified in Figure 4.1.)

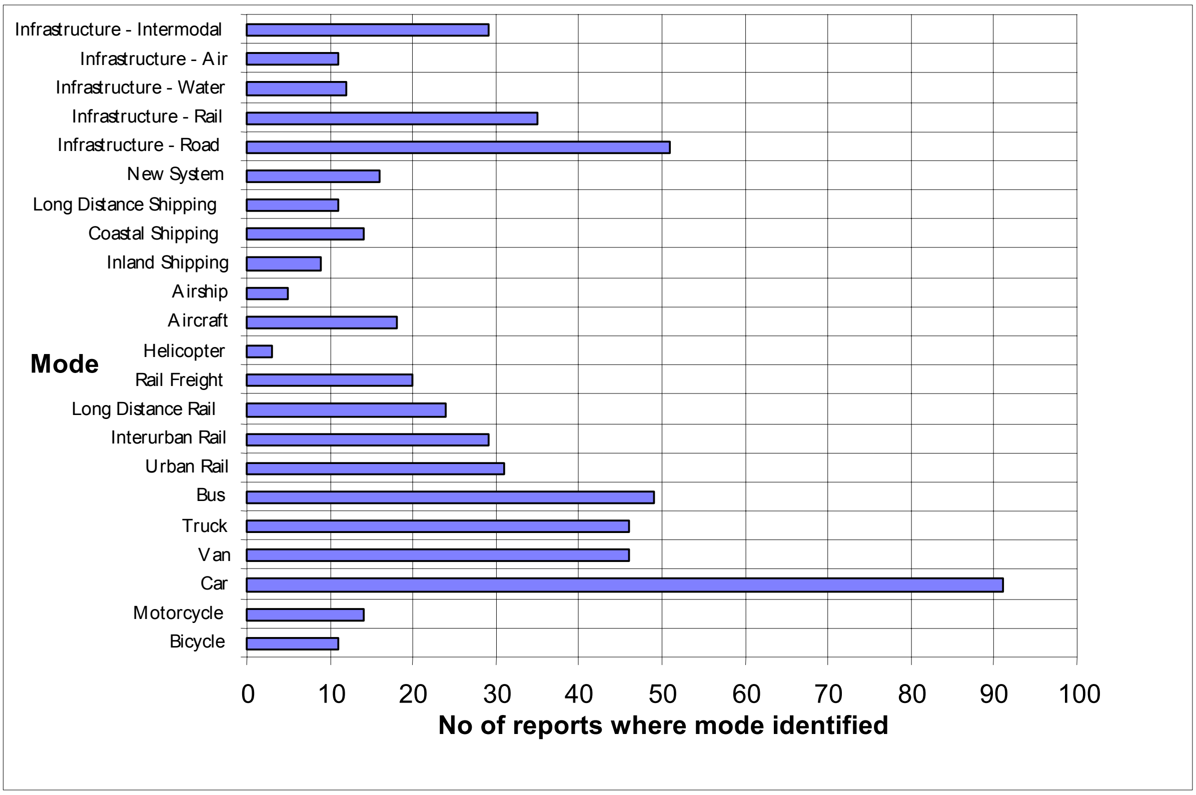

Figure 4.1: Analysis of modal coverage of characterised reports

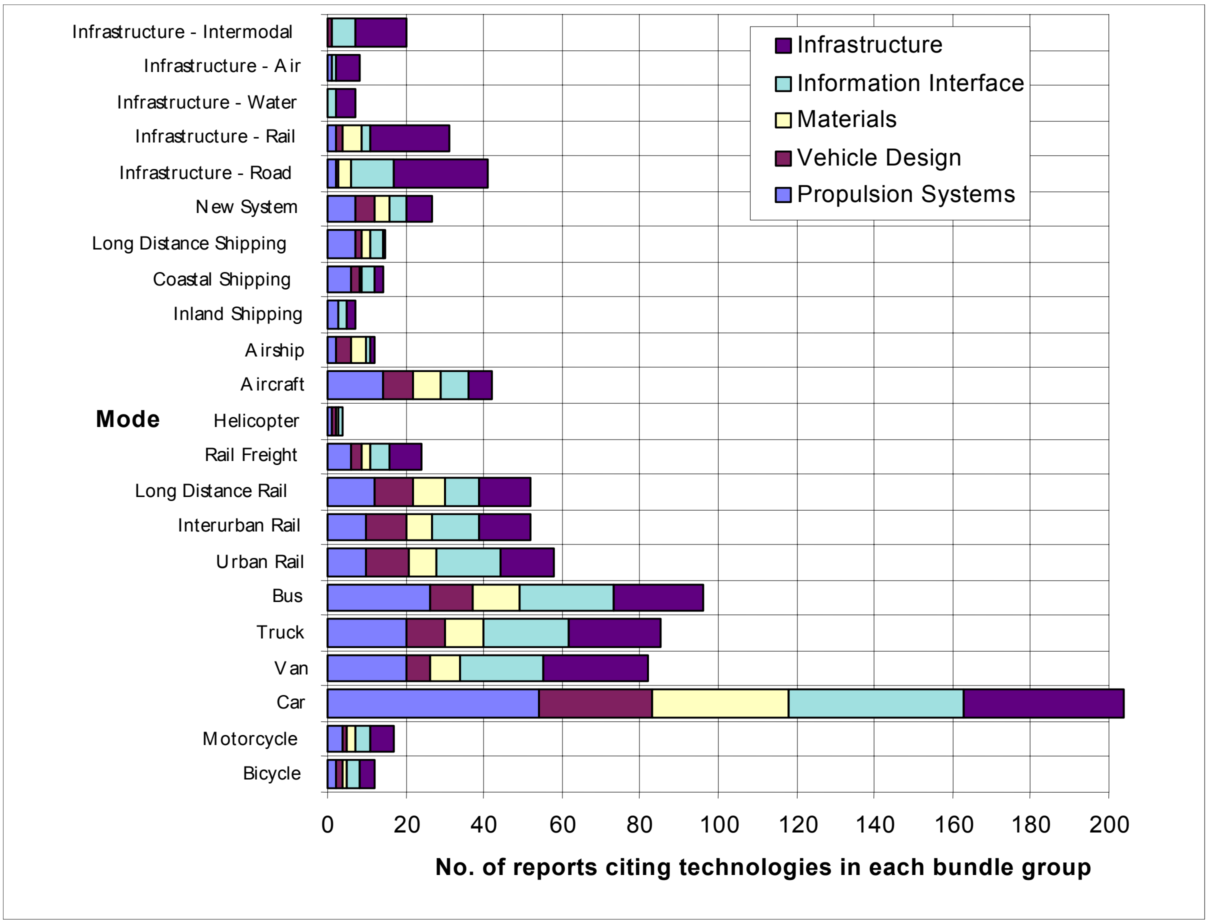

Figure 4.2: Analysis of technology bundle group coverage of characterised reports, by mode

Overview on bundles

Bundle Group 1 – Propulsion Systems • Advanced Conventional Propulsion Systems • New Propulsion Systems • Advanced Conventional Fuels • Alternative Fuels ***Bundle Group 2 – Vehicle Design*** • Body Design • Driveline Technologies • Vehicle Safety Systems • Vehicle Quality Systems • Intermodal Freight Carriers ***Bundle Group 3 – Materials*** • Vehicle Materials • Vehicle Production Technologies • Vehicle Recycling	***Bundle Group 4 – Information Interface*** • Vehicle Control Systems • Internal Vehicle Systems • Traffic Management Systems • Travel and Freight Information Systems • Operations Management Systems • Information Infrastructure ***Bundle Group 5 – Infrastructure*** • Construction Technologies • Physical Infrastructure Innovation • Termini • Energy Infrastructure ***Superbundle: Integrated technology packages at the vehicle level***

Figure 4.3: Bundle groups and technology bundles

TA impacts	Environment Socio-economic Safety Efficiency	***TF aspects***	Technical Production Commercial Institutional Political

Figure 4.4: Technology assessment (TA) and technology forecasting (TF) categories

The primary information base comprised 147 documents with a world-wide coverage, drawn from a larger set of sources. Coverage of topics was variable.

Technology Assessment (TA)

- environmental aspects drive and dominate many studies with a good degree of quantification;
- efficiency aspects also figure strongly, reflecting the importance of cost and user implications of technologies;
- in comparison, details of socio-economic and safety implications are limited, with more qualitative assessment;
- results are drawn fairly evenly from different TA techniques (survey of experts, modelling, and review by expert panel).

Technology Forecasting (TF)

- technical and commercial aspects dominate most TF studies;
- production aspects of technologies (other than shorter-term or incremental developments) and also the institutional and political opportunities and barriers enjoy a much less extensive coverage;

- desk studies and interviews/workshops are the predominant TF techniques, although a good number of Delphi studies have been reviewed.

A series of technologies have been commonly identified in the reviewed documents as having significance (although criteria are often unclear and will vary between documents):

Bundle Group 1 – Propulsion Systems	DISC (Direct injection stratified charge) engine, advanced turbofan and propfan engines, electric and hybrid vehicles, fossil-fuel improvements, biodiesel, CNG and LPG, fuel cells and hydrogen.
Bundle Group 2 – Vehicle Design	Weight and aerodynamic drag reduction, efficiency gains in transmission systems, tyre rolling resistance reduction seat belts and airbags, intelligent cruise control, improved user interfaces, general quality systems, unitised packaging systems, intermodal transport units.
Bundle Group 3 – Materials	Materials for lighter vehicles and higher combustion temperatures in engines, systems for highly integrated design and manufacturing, composite production and joining technology, low cost magnesium and titanium casting technology, non-metallic parts recycling, tyre recycling, battery recycling.
Bundle Group 4 – Information Interface	Automated driverless transport, autonomous intelligent cruise control, anti-collision systems, fly (drive)-by-wire, combined on-board emissions and engine management systems, driver monitoring systems. traffic control – road, air, train modes, intersection control, electronic tolling, parking management, travel and freight information systems, remote emissions monitoring, smart card infrastructure, traffic detectors, satellite navigation systems, wireless communication systems, communications networks/electronic data interchange.
Bundle Group 5 – Infrastructure	Tunnelling, subterranean vacuum transport technologies, naturally regenerative materials, recycling and upgrading waste material, improved infrastructure materials, design of safer roads, guided busways, personal vehicle rail infrastructure, new railway infrastructure, integrated storage systems, transferia (interchange between public and private transport), urban freight transferia, cargo handling technology, liquid, gaseous & other energy carriers, energy distribution, refuelling systems, external electrification of transport.
Superbundle	Groups of technologies applicable in combination to car and aircraft concepts

Figure 4.5: Significant technologies identified

The initial assessment of potential technological developments which are significant in terms of the objectives of the Common Transport Policy (CTP) is presented in Figure 4.6.

		Transport impact				***Policy impact***									
Technology bundle	***Technology***	*Environment*	*Socio-economic*	*Safety*	*Efficiency*	*Quality and effectiveness of transport*	*Direct costs to the transport user*	*Environmental impact*	*Safety*	*Technological feasibility and development potential*	*Economic development*	*Quality of life*	*Transport demand and acceptance of technologies*	*Subsidiarity and distribution of competencies*	*Political feasibility*
Advanced conventional propulsion systems	Improved internal combustion engines	✓						✓		✓			✓		✓
	Improved tailpipe emissions treatment technologies	✓						✓		✓			✓		✓
	Improved aircraft engines	✓						✓		✓			✓		✓
New propulsion systems	Electric vehicles - general	✓	✓				✓	✓			✓	✓			✓
	Hybrid electric vehicles - series and parallel	✓	✓		✓		✓	✓			✓	✓			✓
Advanced conventional fuels	Fuel quality improvements	✓						✓		✓			✓		✓
Alternative fuels	Compressed natural gas (CNG)	✓	✓		✓		✓	✓		✓	✓		✓	✓	✓
	Liquid petroleum gas (LPG)	✓	✓		✓		✓	✓		✓	✓		✓	✓	✓
	Hydrogen (surface and aviation)	✓	✓				✓	✓			✓			✓	✓
	Fuel cell - general	✓	✓				✓	✓		✓	✓				✓
	Battery - general	✓	✓				✓	✓		✓	✓				✓
Body design	Improvements in vehicle shape	✓						✓		✓			✓		
	Reducing vehicle weight	✓						✓		✓			✓		
Driveline technologies	Reducing rolling resistance	✓						✓		✓			✓		
	More efficient transmission systems	✓						✓		✓			✓		
Vehicle safety systems	Increased use of seat belts			✓					✓	✓					
	Head-on and side-on collision protection			✓					✓	✓					
Vehicle quality systems	Intelligent cruise control	✓		✓	✓			✓	✓			✓			✓
Intermodal freight carriers	Intermodal loading units and rolling stock	(✓)	✓		✓	✓				✓	✓	✓	✓		
	Future smart transfer technologies	(✓)	✓		✓	✓					✓	✓	✓		

Figure 4.6: Summary of significant transport technology applications

		Transport impact				*Policy impact*									
Technology bundle	***Technology***	*Environment*	*Socio-economic*	*Safety*	*Efficiency*	*Quality and effectiveness of transport*	*Direct costs to the transport user*	*Environmental impact*	*Safety*	*Technological feasibility and development potential*	*Economic development*	*Quality of life*	*Transport demand and acceptance of technologies*	*Subsidiarity and distribution of competencies*	*Political feasibility*
Vehicle materials	Aluminium	✓						✓		✓			✓		
	Composites	✓						✓		✓					
	Ceramics	✓						✓							
Vehicle production technologies	Computer-integrated manufacture		✓							✓					
Vehicle control systems	Automated driverless transport	✓		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
	Autonomous Intelligent Cruise Control	✓		✓	✓	✓	✓	✓	✓			✓	✓	✓	✓
	Anti-collision systems			✓			✓		✓	✓			✓		
Internal vehicle systems	Improved vehicle condition and use monitoring - in-vehicle	✓						✓		✓				✓	✓
Traffic management systems	Urban and motorway traffic control	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		✓
	Incident management				✓	✓				✓		✓	✓		
	HOV and reversible lane management	✓			✓	✓		✓	✓	✓	✓		✓		✓
	Parking management and speed enforcement	✓		✓	✓		✓		✓		✓		✓		✓
	Weigh-in-motion systems			✓					✓						
	Electronic tolling	(✓)	✓		✓		✓	✓			✓		✓	✓	✓
	Surveillance: network and probe vehicle				✓							✓	✓		
	Emissions and environmental monitoring	✓						✓							
	Automatic train protection, control and operation			✓	✓	✓			✓	✓		✓	✓	✓	✓
	Air traffic management	✓	✓	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓
	Advanced landing systems			✓	✓	✓			✓	✓					
	Airport surface traffic management	✓			✓	✓		✓		✓			✓		✓

Figure 4.6: Summary of significant transport technology applications (continued/1)

		Transport impact				Policy impact									
Technology bundle	***Technology***	*Environment*	*Socio-economic*	*Safety*	*Efficiency*	*Quality and effectiveness of transport*	*Direct costs to the transport user*	*Environmental impact*	*Safety*	*Technological feasibility and development potential*	*Economic development*	*Quality of life*	*Transport demand and acceptance of technologies*	*Subsidiarity and distribution of competencies*	*Political feasibility*
Traffic management systems (Cont'd)	Free flight concept	✓			✓										
	Radar-based traffic control			✓	✓	✓			✓	✓			✓		✓
Travel and freight information systems	Dynamic route planning and guidance	✓			✓	✓	✓	✓		✓			✓		
Operations management systems	Location systems				✓	✓				✓					
	Improved remote vehicle condition and use monitoring	✓						✓		✓				✓	✓
Information infrastructure	Smart card infrastructure		✓		✓					✓	✓			✓	✓
	Satellite navigation	✓			✓	✓		✓		✓			✓		
Construction technologies	Recycling and upgrading waste material	✓						✓							
	Tunneling	✓			✓			✓							
	Subterranean vacuum transport	✓													
	Improved infrastructure materials	✓	✓					✓		✓			✓		
Physical infrastructure innovation	Design of safer roads			✓					✓				✓		✓
	New railway infrastructure	(✓)	✓	✓					✓	✓	✓	✓	✓		✓
	Single-purpose infrastructure	(✓)	✓	✓	✓	✓			✓				✓		
Termini	Integrated storage systems				✓	✓							✓		
	Transferia	(✓)	✓		✓	✓				✓	✓	✓	✓		✓
	Urban freight transferia	(✓)	✓		✓	✓				✓	✓	✓	✓		✓
	Cargo handling technology				✓	✓									
Energy infrastructure	Conventional energy pathway	✓													
	Renewable energy pathway	✓	✓				✓	✓			✓				✓
	External electrification	✓	✓					✓			✓				

Figure 4.6: Summary of significant transport technology applications (continued/2)

In addition, a limited technology watch has identified some base and non-transport technologies which are anticipated to have a significant impact on the transport sector. These technologies are listed in Figure 4.7.

Technology bundle	*Technology*
Energy technologies	• Energy conversion – fuel cells • Energy production – photovoltaics and photocatalysis • Energy storage – graphite nano tubes
Materials technologies	• Smart structures • Nano materials • Superconducting materials
Information technologies	• Transport substitution – teleworking, teleconferencing, teleshopping • Knowledge-based tools – neural networks, fuzzy logic, genetic algorithms, etc.
Sensor technologies	• Sensors • Micro electromechanical systems (MEMS)
Micro- and nano-technologies	• Microsystems • Ultra-precision machining • Nano-sensors

Figure 4.7: Summary of significant base and non-transport technologies

5. VEHICLE CONCEPTS (level 4)

This chapter presents vehicle concepts and their definitions respectively, which are expected to have major significance for future European transport to the year 2030. It is based on substantial contacts with external contacts, especially within the vehicle supply industries and vehicle operators, together with documentary research.

Freight and passenger vehicle concept (VC)	*Abbreviation*
Airship	AIRSHIP
All-electric Ship	ELESHIP
All-purpose Car	APCAR
Conventional Heavy Rail – passenger and freight	CHRAIL
Cryoplane	CRYO
Fast Inland Ferry	FIFERRY
Fast Sea-going Passenger Ferry	FFERRY
High Speed Rail	HSRAIL
Human-powered Vehicle	HPVE
Light rail and People-movers	LRTPM
Long-distance Bus	LDBUS
Magnetic Levitation systems	MAGLEV
Megaliner Aircraft	MEGAAIR
Powered Two-wheeler	PTW
Rail and Guided System Innovations	GSINNO
Rotorcraft	ROTOR
Slow-moving Vehicle	SMVE
Subsonic Aircraft	SUBAIR
Supersonic Commercial Transport	SCT
Truck	TRUCK
Urban Bus	UBUS
Urban Car	UCAR
Van	VAN

Figure 5.1: Abbreviations for vehicle concepts (VCs)

All-purpose car (APCAR)
Definition: The all-purpose car (APCAR) in its various forms satisfies essentially all requirements of individual mobility including urban, long-distance, business, leisure/fun, etc. applications. This includes more specialised variants such as all-terrain vehicles, sports cars, multi-person vehicles.

Urban car (UCAR)
Definition: Vehicles specifically designed for individual mobility in extended urban areas.

Van (VAN)
Definition: A light duty, multi-purpose load-carrying vehicle for commercial use capable of carrying goods, materials, or, when suitably adapted, persons up to a total kerbweight of 3.5 tonnes on both urban and interurban operations.

Urban bus (UBUS)
Definition: A public mobility, multi-user vehicle used specifically in the urban area. This includes both small and large body types.

Long-distance bus (LDBUS)
Definition: A public mobility, multi-user vehicle used specifically on long-distance routes between urban areas.

Truck/Road Train (RTRAIN)
Definition: A road vehicle used specifically to carry heavy goods on medium to long distances. This includes the road train vehicle (for long-distance, high capacity freight movement) as well as designs for freight intermodality.

Powered two-wheelers (PTW)
Definition: a motorised vehicle on two wheels used for private mobility purposes in urban and non-urban environments, comprising motorcycles (>125cc engine size), scooters and mopeds (<125cc).

Human-powered vehicles (HPVE)
Definition: A vehicle, for carrying one or more persons or goods, powered chiefly by, or assisted by, human effort.

Slow-moving vehicles – telematics aspects (SMVE)
Definition: Slow-moving vehicles include vehicles widely used in agriculture, earth-moving construction and in the highway maintenance operations.

Conventional heavy rail – passenger and freight (CHRAIL)
Definition: This concept covers developments of all forms of conventional heavy rail systems. Freight, passenger and combinations of the two. It specifically excludes high speed rail systems (>200 km/h).

Light rail and people-movers (LRTPM)
Definition: This concept refers to light rail and people mover systems, that are usually associated with urban transport. Both mass (MRT; mass rapid transit) and individual (PRT; personal rapid transit) people movers are included within this definition. The development of free (uncabled) elevators is also considered.

Rail and guided system innovations (GSINNO)
Definition: This concept covers the development of new innovative forms of rail/guided transport systems, like underground freight/distribution systems, moving walkways, bicycle lifts and cable cars.

High speed rail (HSRAIL)
Definition: The high speed rail concept is defined by trains using wheels on rails and with a maximum service speed of at least 200 km/h.

MagLev (MAGLEV)
Definition: The MagLev vehicle concept is defined by non-contact vehicles using magnetic levitation, guidance and propulsion (at least at cruise speed).

Megaliner (MEGAAIR)
Definition: An (ultra) high capacity aircraft for subsonic long range (intercontinental) flight for 600-800 passengers.

Subsonic aircraft (SUBAIR)
Definition: A medium range aircraft with a capacity of 220-300 passengers, clearly understood to be developed after Megaliner introduction (priority ranking by manufacturers).

Supersonic commercial transport (SCT)
Definition: A supersonic commercial transport aircraft for long range (intercontinental) flight with a capacity of 200-300 passengers.

Rotorcraft (ROTOR)
Definition: The helicopter and tilt-rotor derivative vehicle concept is defined by a multi-user vehicle used for business transport and public services e.g. rescue and enforcement. This includes both small and large body types.

Cryoplane (CRYO)
Definition: A 180-230 seat aircraft for subsonic medium range flight propelled by liquid hydrogen or liquefied natural gas.

Airship (AIRSHIP)
Definition: A multi-user vehicle with rigid or semi-rigid structure used for niche markets (tourism, research, observation) and for transporting heavy and bulky load. This includes both small and large body types.

All-electric ship (ELESHIP)
Definition: A ship which uses electrical power for all its power requirements. The power needed is derived from an (inboard) electrical-power generation unit.

Fast inland ferries (FIFERRY)
Definition: A public mobility, multi-user vehicle used in sheltered estuaries and bays and inland waterways. This includes both smaller and larger body types and serves passengers and some freight.

Fast sea-going passenger ferries (FFERRY)
Definition: A public mobility, multi-user vehicle used in estuaries and sea straits and for short- and medium distances over sea. This includes both smaller and large body types. It serves (car)passengers and RoRo freight.

Detailed policy implications and technology forecast issues at the vehicle concept level are described in Deliverable 12.

- D12 "Characterisation of technologies for impact assessment"

6. TRANSPORT CONCEPTS (level 5)

Transport concepts within the FANTASIE six level approach are composed of one or more vehicle concepts and associated organisational aspects. For each concept the demand forecast results are shown.

Passenger transport concept (TC)	*Abbreviation*
Individual conventional vehicle	ICONVE
Dedicated car (vehicle)	DECAR
Ride sharing	RIDES
Car sharing	CARS
Individual public transport	IPT
Organised collective passenger transport by road	OCPT
Urban rail transport	URAIL
Regional rail transport	RRAIL
Long-distance rail transport	LDRAIL
On demand road transport	ROADD
Collective rail transport according to demand	CRAIL
Air transport	AIR
Automated vehicle guidance	AVGP

Freight transport concept (TC)	*Abbreviation*
Van/light truck	VANLT
Heavy truck	HTRUCK
Road train	RTRAIN
Conventional rail	CONVRAIL
High speed rail	HSRAILTC
Inland shipping/barge	ISHIP
Ship	SHIP
Air	AIRF
Automated vehicle guidance	AVGF
Underground systems	UNDERGROUND

Figure 6.1: Abbreviations for transport concepts (TCs)

6.1 Passenger transport concepts

Systematic classification

Within passenger transport three main groups of transport concepts are distinguished:

- *Individual vehicle use;* the traveller drives (steers) the vehicle himself;
- *Collective vehicle use;* the traveller is being transported by a professional service provider; and
- *Intermediate concepts*; a combination of independent control of the vehicle and control by another party.

Below is a segmentation according to other variables which should be taken into account:

- vehicle ownership;
- scheduled or demand responsive transport; and
- kind of vehicle concept used.

By combining all these levels a large number of possibilities exist. However to avoid making the assessment (both demand and technology) over complicated, only the most important combinations are taken into account. Figure 6.2 gives an overview of all dimensions.

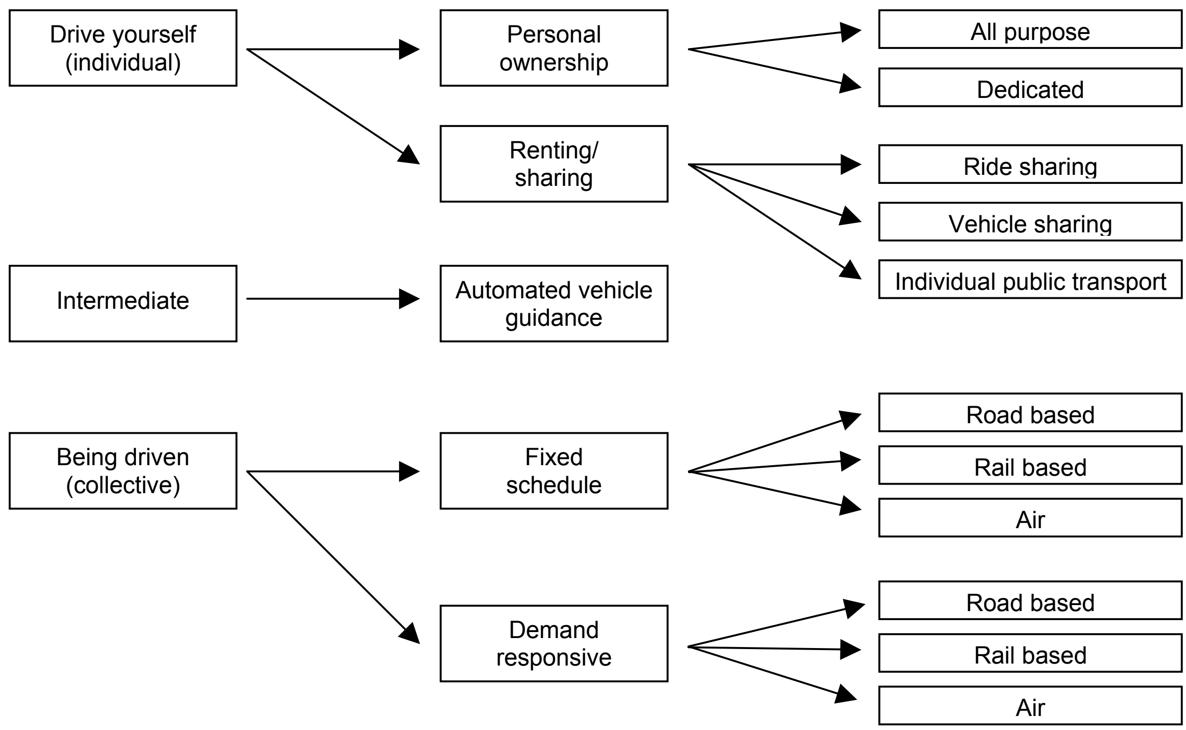

Figure 6.2: Overview of transport concepts for passenger transport

Individual vehicle (ICONVE)
Description: This concept consists of individually controlled vehicles owned by, or allocated to, a household. The vehicles are usually available on demand without reservation. The motorised vehicles require a trained driver and so cannot be used by all household members. The vehicle is suitable for a large number of functions and this coupled with privacy, low marginal cost of operation and convenience is responsible for its widespread popularity.

Dedicated vehicle (DECAR)
Description: This concept consists of a vehicle designed to fulfil one purpose: in contrast to the all-purpose vehicle, commonly in use today. One often cited example of the dedicated vehicle is the urban car. These vehicles are designed for use in densely populated areas where their small size and high energy efficiency offers advantages over conventional cars.

Ride sharing (RIDES)
Description: Ride sharing means that people, on a voluntary bases, share a car ride. The most common form is that members of one household travel together in one car. Transport policies usually aim at stimulating other forms of ride sharing, mainly in home to work travel (car-pooling).

The European countries mainly focus ride sharing on the home to work trip. Until recently most attention was given to improving the attitude and awareness of people. Large and small promotional campaigns were used. More recently, attention has also been given to tools which enable people to find others who wish to car pool. This can be done at different levels: the company level, the regional level (one specific district), the industrial park, etc. These tools can be telephone numbers, but also Internet sites which offer the user the possibility to match his transport demand with others. Initiatives are also developed at the company level. In some countries so-called company demand management is starting to become important.

Car sharing (CARS)
Description: Vehicle sharing is the use of self-drive road vehicles with some form of shared use. conventionally the vehicles are owned by some form of hire company (for example Hertz, Avis, etc.) and rented out. Under some scenarios this concept will be developed from its classic hire-car origins to a more flexible, automated and convenient concept.

Individual public transport (IPT)
Description: Individual public transport offers vehicles on a trip by trip rental basis. These vehicles can be rented, for instance by using a chip card, without any reservation. No driver is included, the vehicles need to be steered by the traveller himself. This system provides, in its most elaborate form, on-demand transport. But in practice it will take some time before such a system will be fully operational.

These systems fill the gap between public transport and private transport. The freedom of (route and destination) choice is guaranteed. IPT will most likely be used in an urban setting. In rural areas transport demand is too low. Within the urban area IPT will be used in those areas where distances to and from the station are relatively long. These are: the suburban areas and in medium and small cities. IPT systems are not meant to be used within the city centre. Buses, people movers, walking and cycling are much better suited. The exception is an IPT system that uses bicycles.

Organised collective transport by road (OCPT)
Description: Organised collective transport by road provides a public transport service on a scheduled basis. These services are commonly provided on short distances by buses and on longer distances by express coach. A driver is usually responsible for revenue protection, though additional staff are sometimes provided for this and to provide refreshments on long distance express routes. The concept is already is widespread operation and the challenge is to see how it will contend with new forms of public transport services. There has been significant decline in the use of this form of transport in the last 30-40 years.

Urban transport by rail (URAIL)
Description: This transport concept cover several types of urban rail system, including: suburban heavy rail, metro and light rail systems. The guideway can be in a conventional steel form or in some alternative form like a raised concrete track. Passengers are thus conveyed to their destination by vehicles running on fixed routes and most of these systems will use electrical propulsion. The vehicles may or may not be manned.

Regional rail transport (RRAIL)
Description: This concept refers to heavy rail systems that provide interurban and long distance suburban journeys. At present most of these are in the form of steel wheel on steel rail. Vehicles run on fixed routes and are usually powered electrically or by diesel engines. Vehicles are usually manually driven.

Long-distance rail transport (LDRAIL)
Description: Long distance rail transport refers to predominantly intercity trains. This concept is most likely to develop on the basis of the conventional steel rail on steel wheel system, though some limited implementation of MagLev type systems could occur under certain conditions. Increasing advances in technology are likely to increase the speeds of long distance rail systems and 250-300 km/h will become commonplace in this concept. Trains will continue to run at fixed schedules and will be mostly manned. MagLev based systems will make little impact within this market due to the need for new incompatible infrastructure. One exception could be the development of underground MagLev systems, operating in a partial vacuum, at high speed: for example the Swiss metro concept.

On demand road transport (ROADD)

Description: This form of transport is currently typified by the dial-a-ride or taxi systems. Passengers contact the service provider by telephone or, perhaps, in the future through an internet terminal and request transport. The flexibility of the service varies, from taxis which can arrive almost immediately and go wherever required, to demand responsive bus services that generally have a fixed destination and make detours to pick up passengers that have made a request. The "Treintaxi" in the Netherlands provides a modern illustration of demand responsive road transport, where special taxis which accept a railway voucher provide a service to and from railway stations.

On demand rail transport (CRAIL)

Description: This most likely manifestation of this concept is in the form of personal guided rapid transit. In these systems individual guided vehicles are picked up by passengers at designated points. The vehicles are then directed by the passengers to other points on the system. Vehicles therefore no longer travel together in trains. Small scale experimental versions of such systems are already in operation in the U.S. The need for new infrastructure poses a significant obstacle to the development of such systems, as there is little available land in urban areas. Any systems that are introduced are therefore likely to be above ground and likely to create significant visual intrusion.

Air (AIR)

Description: This concept consists of aircraft, flown by a professional pilot, which is usually shared by a number of passengers. The trip normally requires reservations to be made in advance and aircraft usually fly according to a fixed schedule. The aircraft can take a number of forms, such as: aeroplane, airship and helicopter.

Automated vehicle guidance (AVGP)

Description: Automated Vehicle Guidance (AVGP) systems are defined as systems in which the driving tasks of a driver are taken over partly or entirely by an automated system. AVGP systems may range from systems that automatically maintain a vehicle's speed, while keeping a safe distance to a predecessor, to fully automated car-driving (hands, feet and brains off). AVGP is regarded as a promising tool to improve road network traffic performance, for instance, by driving at short distances and high speeds. Equally important is the potential of AVGP systems for enhancing safety by replacing human drivers by more reliable automated systems.

6.2 Freight transport concepts

Systematic classification

Freight transport is extremely complex and it is therefore very difficult to derive an exclusive structure to represent the concepts use within it. An initial classification can be made between bulk and non-bulk transport. The former would include things like large flows of raw materials from the point of extraction to the processing site. Non-bulk traffic would include the delivery of goods to supermarkets. Within each of further classification is possible in accordance with the way the traffic is organised (refer to Figure 6.3).

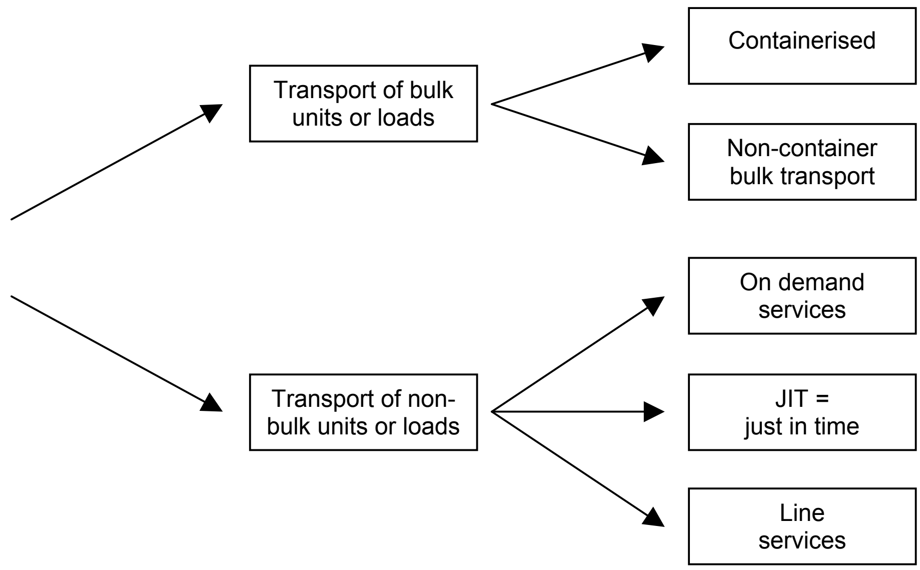

Figure 6.3: Overview of transport concepts for freight transport

Van/light truck (VANLT)

Description: Light trucks and vans are used for freight transport deliveries in round trips and/or for small deliveries in small consignment sizes. The advantages of this transport concept are the flexibility of the vehicles (departures are possible at any time) and the dense infrastructure network (all destinations, even in dense urban areas can be reached).

Heavy truck (HTRUCK)

Description: Heavy trucks (of around 18 meters long) are used for both short and long distance transport. However, accessibility for heavy trucks in city-centres is limited. Heavy trucks are often used to supply the distribution centres of urban freight platforms from where distribution to the final customer takes place in smaller vehicles.

***Road train** (RTRAIN)*

Description: Road trains are trucks with up to three trailers behind the driver's cabin (in total about 25 metres long). Traffic safety requires that road trains are not mixed with busy passenger traffic. This requires driving during quiet hours (at night) or only on quiet roads. The advantage of using road trains, instead of heavy trucks, are the reduced transport cost per tonne-kilometre.

***Conventional rail** (CONVRAIL)*

Description: Rail freight is usually transported in trains of railway wagons hauled by a locomotive that is usually manually driven. Some freight trains are automatically driven, particularly on dedicated freight railways. There are also occasions where individual freight wagons have their own motive power and can travel thus individually around the network. This is sometimes the case with postal traffic for example in the U.K and the Netherlands. Recent developments in intermodal transport have seen railways adopt loading units that allow easy transfer to other modes, examples of this are containers and piggyback systems.

***High speed rail** (HSRAILTC)*

Description: The development of technology for high speed passenger trains has created an opportunity for the development of high speed freight trains for high value goods to compete with air freight on short haul flights. The better access to city centres for rail services can be a significant advantage. High speed freight trains would be able to use the infrastructure developed for high speed passenger trains without causing the capacity problems that would occur if slower conventional freight trains were to be mixed with high speed passenger trains.

***Inland shipping/barge** (ISHIP)*

Description: Inland shipping is used to transport bulk goods like coal, sand and gravel, but also for containers (both maritime as inland containers). Inland shipping is increasingly used as part of a chain in intermodal transport.

***Ship** (SHIP)*

Description: Short sea shipping is used to feed services for maritime containers from mainports to the smaller ports in Europe, and for direct transport between North Africa and Europe or within Europe (e.g. from southern Europe up to the Baltic ports). The distance is limited compared to intercontinental shipping and the ships are relatively small.

***Air** (AIRF)*

Description: Freight by air is carried sometimes in the luggage hold of passenger flights and sometimes on freight only flights.

Automated vehicle guidance (AVGF)

Description: Automated Vehicle Guidance (AVGF) systems are defined as systems in which the driving tasks of a driver are taken over partly or entirely by an automated system. AVG systems may range from systems that automatically maintain a vehicle's speed, while keeping a safe distance to a predecessor, to fully automated car-driving (hands, feet and brains off). AVGF is regarded as a promising tool to improve road network traffic performance, for instance, by driving at short distances and high speeds. Equally important is the potential of AVGF systems for enhancing safety by replacing human drivers by more reliable automated systems.

Underground systems (UNDERGROUND)

Description: Underground guided freight systems have been proposed in an attempt to counter urban congestion. These systems are likely to be exclusively for freight traffic and automatically operated and will not therefore need drivers. Small scale systems are already in operation, for example the Post Office railway in London. These systems allow fast un-congested access to city centres and have been proposed as a means of providing better connections between airports and city or freight distribution centres.

D13 "Definition of European transport systems"

7. EUROPEAN TRANSPORT SYSTEM (level 6)

The European transport system is the sum of all transport concepts used. A transport system is strongly influenced by its environment. The economic situation, infrastructure supply, price levels, technology available, etc. determine the composition of the transport system.

7.1 Scenarios

Scenario approach

The future is unknown and actions based on the results of studies like FANTASIE will also influence future developments. To deal with this uncertainty it is common to work with different possible futures: scenarios. Based on a limited number of design variables possible futures are designed. These stories function as a basis for the technology forecast.

In the FANTASIE project two design dimensions are used, namely:

- *Economic dynamics*; this involves two alternatives. A society characterised by high economic dynamics and the accompanying strong economic growth, and one with more moderate economic dynamics, therefore experiencing relatively little economic growth.
- *Importance of sustainability*; this also presents two alternatives. A society in which the pursuit of a sustainable civilisation, and therefore a sustainable traffic & transport system, is a generally accepted principle, and one in which it is not.

Four environmental scenarios can be derived from the two design dimensions. These are portrayed in the diagram in Figure 7.1. The scenarios are:

- *Unrestricted Growth (UG)*; society is characterised by high economic dynamism. This is accompanied by rapid technological progress. However, there is little public support for the excessive promotion of a sustainable society. Everyone is in favour of the open market philosophy: the individual holds centre stage. The maximisation of income is the guiding principle for the whole of society.
- *Sustainable Growth (SG)*; society is characterised by high economic dynamism. This is accompanied by rapid technological progress. However, there is a great deal of public support for the strong promotion of a sustainable society. Everyone is in favour of the open market philosophy: the individual holds centre stage. Yet, this does not lead to the unrestrained maximisation of income. Thanks to the introduction of a series of market-based policy measures, and the general acceptance of these, the traffic & transport system's environmental and energy impact can be significantly reduced.
- *Business As Usual (BAU)*; society is characterised by medium economic dynamism. This is accompanied by comparable technological progress. Further, there is little public support for the excessive promotion of a sustainable society.
- *Sustainable Balance (SB)*; society is characterised by low economic dynamism. This is accompanied by slow technological progress. However, there is a great deal of public support for the promotion of a sustainable society.

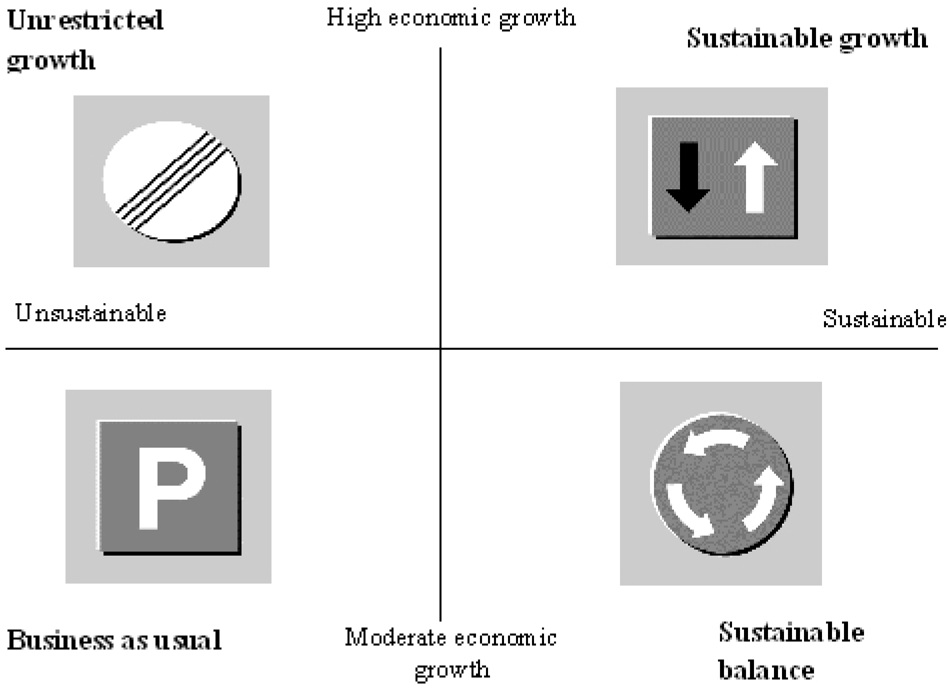

Figure 7.1: Dimensions and position of the various scenarios

Table 7.1 summarises key variables per scenario.

Variable	*Unrestricted Growth*	*Sustainable Growth*	*Business As Usual*	*Sustainable Balance*
Economic aspects				
Average growth GNP	3.0%	2.75%	1.5%	1.0%
Income level (2030) 1995=100	281	258	168	142
Income distribution	not equal at all	fairly equal	not equal	very equal
Energy sources	oil and natural gas	oil, electricity, hydrogen	oil	oil, bio-fuels, electricity
Energy price level[1] 1995=100	120	105	100	95
General energy taxes	no	yes	no	yes
Spatial development				
Urbanisation	low densities	high densities	low densities	high densities
Spatial policies	no government influence	large and strict government influence	small government influence (same as today)	very large and strict government influence
Social cultural elements				
Lifestyle	egocentric	solidarity	egocentric	solidarity
Environmental consciousness (compared to 1995)	higher	much higher	same	much higher
Technology				
General technology development	high	high	medium	medium
Internet connections (2020)	almost everybody, except of small group of have-nots (app. 10%)	everybody (base use is free)	50%	60%
Transport policies				
Management road infrastructure	private companies	private companies	government	government
Speed limits	limited speed restrictions	30 km within urban areas and 90/120 km at motorway network	limited speed restrictions	30 km within urban areas and 90 km at motorway network
Subsidies public transport	none	halving compared to 1995	limited	same level as 1995
Fuel taxes (compared to 1995)	lower	much higher	same	much higher
Parking policies	free market philosophy: no intervention	very strict: low fares for small vehicles	same as today	very strict: low fares for clean vehicles
Parking fares[2] (compared to 1995)	much higher in business districts, low in suburbs	much higher, both in areas with high and low densities	a little bit higher	a little bit higher

1 Energy price is the price level on the free market, without energy taxes and so on.

2 Parking fees are not only determined by government policy, but also by demand and supply factors. In a scenario with high economic growth and limited parking places, higher land rents will lead to higher parking prices.

Table 7.1: Key variables of different scenarios (forecasting year: 2030)

7.2 Problem areas

In order to assess the impacts of the new technologies, the transport system has been broken down in different “problem areas”.

The problem areas are considered as homogeneous transport markets.

The transport system that operate in these areas can be considerate, in some extent, in free competition.

In other words, in an urban area work transport system, or transport mode, that operate for passenger demand can, in principle, satisfy the some user needs.

In order to evaluate the impact of new technologies, according the FANTASIE criteria, the following problem areas have been defined:

- long distance passenger demand: broken-down in two problem areas
  - trips for distances >250 km,
  - trips for distance between 80 km and 250 km;
- urban passenger demand;
- long distance freight demand;
- urban freight demand;
- rural area passenger demand.

A more precise definition of the different problem areas has given in the following sections.

Long distance passenger

This problem area regards all the trips made by the people for distance greater than 80 km.

In order to identify better homogeneous mobility needs this problem area has been broken-down in two different problem areas:

- trips with distance between 80 km and 250 km;
- trips with distance over 250 km.

In effect this subdivision assumes that, in first approximation, the air system is not competing with car and train for trips under 250 km.

Obviously such distances cannot be considered as totally discriminatory for the air transport in practice. A share of air trips are done for distances below this limit.

The same situations occurs for the use of car for trips with distances over this limit.

In particular, important international relations exist in Europe below this limit, where the air transport is used.

In order to better identify these "problem areas" the following assumptions have been made:

- all the international trips belong to the long distance (>250 km) problem area;
- the not scheduled air trips are not considered (given the fact that there are not information);
- the breakdown of the share of trips belonging at each problem areas are estimated using a distance distribution function for each mode and for each European country (that because in most of the European countries these data are not available).

Urban passenger demand

The passenger urban demand has been defined as the daily mobility of the inhabitants of the city with more than 50000 habitants.

The daily mobility is the mobility associated with the "every day" activities (work, school, shopping, local visits and leisure activities).

Such demand can be identified by three dimensions:

- the person who make the trips should be resident in the area;
- the trips purpose should be connected to some daily activity;
- the distance of the trips should be short (approximately <15 km).

Long distance freight demand

In the basis of what generally is used in literature, and particularly in relation to the data available at European level, the long distance freight demand is defined as the mobility of all kind of goods with distance greater than 50 km.

Urban freight demand

As opposite to the long distance, the short distance freight demand regards all the movement of goods with distance less than 50 km.

This kind of demand regards mostly the urban freight distribution

Passenger demand in rural area

The passenger demand in rural areas is defined as the trips made by the inhabitant in low density areas (not in the urban areas).

The trips to which such demand is referred area defined in the same way as the urban mobility (i.e. daily mobility).

7.3 Transport demand

Demand forecasting: thinking in market segments

For demand assessment at the E.U. level no specific tool is available. In different countries forecast models exist, but a forecast model for the whole European Union, which also takes into account cross-border trips is not available. It would be sensible to have some differentiation between different types of transport needs. To deal with this a combination of both disaggregate and aggregate approaches were chosen. In practice this means the use of vehicle concepts and transport concepts, which were subdivided between passenger and freight transport, were assessed for different market segments. A second aspect of the disaggregate approach is that total transport demand is not assessed for the E.U. as a whole; it is based at a national level (derived from the last twenty years). Total transport demand is thus assessed for every country individually.

The aggregate side of the approach is characterised by two major assumptions:

- income and transport demand are at the moment strongly related; and
- it is possible that this relationship could change in the future.

Demand Forecast

Total transport demand

In every scenario both passenger and freight transport demand increase (refer to Figure 7.2). But the level of growth differs per scenario. In general it is the case that the *Unrestricted Growth* scenario shows the fastest growth (approximately. 150% increase) and the *Sustainable Balance* scenario the slowest growth (approximately. 30% increase). The scenarios *Business As Usual* and *Sustainable Growth* are in between. It is notable that within freight transport the *Sustainable Growth* scenario grows faster than the *Business as Usual* scenario; in passenger transport the situation is reversed: the *Business As Usual* grows faster than the *Sustainable Growth* scenario. In general it can be seen that when economic growth figures are higher – which is the case in UG and SG – freight transport grows faster than passenger transport and when economic growth figures are lower the opposite is true.

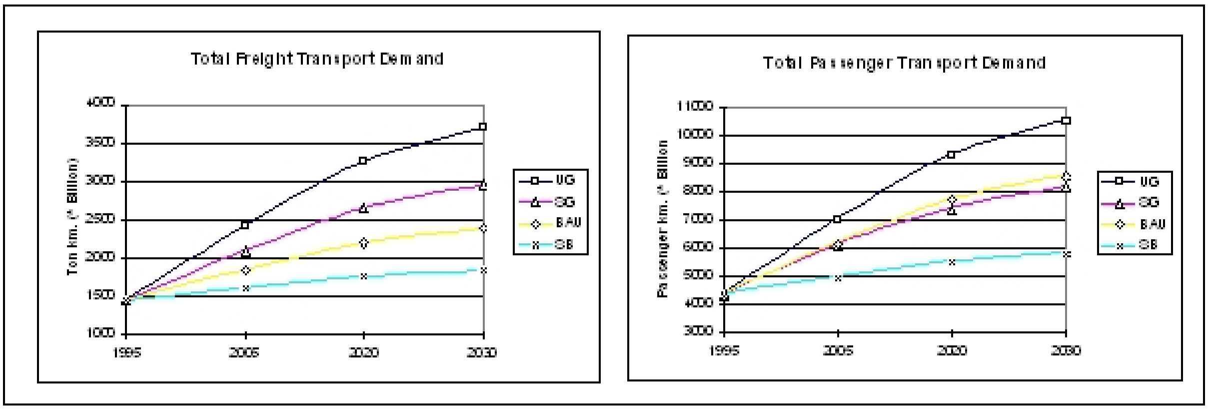

Figure 7.2: Total transport demand for passenger and freight transport per scenario

In Table 7.2 growth indices are given per market segment. Regardless of the scenario, it can be seen that as trip distance increases the growth indices increase as well. People and goods are more likely to travel longer distances. This phenomenon can be seen an a micro basis as well. People and goods are not travelling more – measured in number of trips – but are mainly travelling further. This has a profound effect on total transport demand. For technology innovation policy it is important to note that it is easier to steer development in a growing market that in a declining market. Secondly, instruments for growing and declining markets differ. Thirdly the increase in long distance trips means that these market segments become more important.

Market segment	*Freight transport*				*Passenger transport*			
	UG	*SG*	*BAU*	*SB*	*UG*	*SG*	*BAU*	*SB*
0-15 km (urban)	135	150	110	109	143	131	140	131
0-15 km (non-urban)	210	153	117	115	143	141	140	133
15-80 km	250	197	127	133	250	173	195	125
80-250 km	258	195	175	120	283	209	238	111
250-500 km	292	250	207	140	380	290	230	180
>500 km	306	250	213	140	400	375	300	250
total	257	205	165	127	242	187	196	133

Table 7.2: Growth per market segment until 2030 (1995=100)

Transport demand on the transport and vehicle concept level

Innovation is not only happening at the technical level, but also at the organisational level. The traditional division into modal shares, is not able to cope with the dynamics at the organisational level. Therefore within the FANTASIE project the term transport concept is introduced. This level goes beyond the individual vehicle: new transport concepts re-conceptualise their operating environment. Elements of this operating environment are parking facilities, organisation, maintenance and supply systems, etc.

Passenger Transport

It can be observed that major differences exist between the scenarios. On the other hand, it is also clear that in the next 35 years the European passenger transport system will definitely change; but in 2030 a large part of the transport system will be exactly the same as it is today. Aircraft and rail vehicles have a lifetime of more than 20 years. So, vehicles ordered now will still be in use in 2030.

Table 7.3 shows that private transport (individual vehicle) remains the main transport concept. The only scenario in which the transport volume for the individual vehicle decreases is the *Sustainable Growth* scenario. This is related to the entrance of the dedicated vehicles transport concept. These are still private vehicles, but are especially suited for one trip purpose. In the case of the *Sustainable Growth* scenario these are mainly urban cars. Whereas in the *Unrestricted Growth* scenario these vehicles are mainly all purpose vehicles. In the *Business As Usual* scenario the market share of individual vehicle is the highest of all scenarios. This illustrates that in this scenario the least innovation in transport concepts will take place: the European transport system stays the same as it is today.

It is also notable that sustainability does not automatically imply a completely different traffic & transport system. Although the scenario *Sustainable Balance* does involve new transport concepts like vehicle sharing and individual public transport, on balance the emphasis remains on the individual vehicle. Due to the great emphasis on volume policy and the promotion of the use of smaller vehicles, the consumer is likely to select a small clean vehicle. This causes the competitive position of completely new transport concepts to deteriorate. After all, smaller vehicles are already much cheaper than conventional ones; so the price incentive to switch to a different transport concept is lost.

A major new transport concept will, with the exception of *Sustainable Balance* scenario, be Automated Vehicle Guidance (AVG). Especially in the *Unrestricted Growth* scenario AVG really takes off. Supported by a partly new infrastructure (in parts of Europe a high speed motorway network arises) AVG grows strongly in the *Unrestricted Growth* scenario. But also in the *Sustainable Growth* scenario and the *Business As Usual* scenario AVG starts becoming important. The technical appearance differs per scenario. Whereas in the *Business As Usual* scenario and the *Unrestricted Growth* scenario dedicated lanes will be used, in the *Sustainable Growth* scenario AVG and normal traffic flows will be mixed.

Transport concept	1995	UG	SG	BAU	SB	1995	UG	SG	BAU	SB
Individual vehicle	2301	3935	2239	4327	2414	53 %	38 %	28 %	51 %	42 %
Dedicated vehicle	0	1027	946	110	130	0 %	10 %	12 %	1 %	2 %
Ride sharing	908	1808	1503	1639	1090	21 %	17 %	19 %	19 %	19 %
Vehicle sharing	0	0	308	0	230	0 %	0 %	4 %	0 %	4 %
Individual Public	0	0	84	0	165	0 %	0 %	1 %	0 %	3 %
Organised collective	273	353	323	264	279	6 %	3 %	4 %	3 %	5 %
Urban transport by rail	125	151	157	129	132	3 %	1 %	2 %	2 %	2 %
Regional Rail	116	240	336	292	300	3 %	2 %	4 %	3 %	5 %
Long distance rail	239	504	549	356	311	6 %	5 %	7 %	4 %	5 %
On demand road	54	60	93	82	75	1 %	1 %	1 %	1 %	1 %
On demand rail	0	22	31	11	20	0 %	0 %	0 %	0 %	0 %
Air	314	1311	952	872	615	7 %	13 %	12 %	10 %	11 %
AVG	0	1053	591	415	0	0 %	10 %	7 %	5 %	0 %
TOTAL	4330	10464	8111	8499	5761	100 %	100 %	100 %	100 %	100 %

Table 7.3: Forecast passenger-km in 2030 per transport concept and per scenario

Ride sharing holds, in every scenario, more or less the same market share. This does not mean, however, not that the occupancy rate is constant. This differs strongly by scenario. In the *Unrestricted Growth* and *Business As Usual* scenarios occupancy rates decrease and in the sustainable scenario it increases. In the *Sustainable Balance* scenario it is foreseen that ride-sharing will especially increase in importance.

During the period 1995-2030, the transport share of collective passenger transport increases in all scenarios. The situation varies considerably from one transport concept to the other. For example, in the scenario *Unrestricted Growth* the use of road transport on demand stabilises, whereas this grows considerably in the other three scenarios. Organised collective transport grows especially significantly in the two “growth” scenarios. This is due to the fact that collective road transport aims at long distance markets. The volume in the short distance markets drops significantly in the *Unrestricted Growth* scenario. Another major growth area is long distance rail transport. Under influence of increasing economic development, new high speed links are realised. This leads to a renewal of long distance rail transport.

Table 7.4 gives the outcome per vehicle concept. It can be seen that the scenarios differ much less than they do for the transport concepts. Apparently a lot of innovation takes place in the organisation of the European transport system; but the market shares of the different vehicle concepts stay more or less stable. This reflects the previously noted inertia of the transport system. It is not easy to replace one specific vehicle concept with a new one. The interdependencies with other aspects, infrastructure and so on, are so large that new vehicle concepts need a lot of time to gain market share. Altogether it is assumed that only the urban car vehicle concept will be able to find a space in the market place. In the two sustainable scenarios the urban car realises a fairly significant market share: 8%. In the *Sustainable Balance* scenario, this even implies a reduction in the total number of passenger km with the all purpose car compared to 1995. In the *Sustainable Growth* scenario all purpose car use still increases (+50%); overall mobility growth is too high to be served by the urban car. The market segments which are less favourable for the urban car, grow the fastest: long distance trips. All purpose cars will maintain their market share in these market segments.

Vehicle concepts	1995	UG	SG	BAU	SB	1995	UG	SG	BAU	SB
Urban Car	0	166	631	46	445	0%	2%	8%	1%	8%
Urban Bus	67	72	87	47	115	2%	1%	1%	1%	2%
Truck	0	0	0	0	0	0%	0%	0%	0%	0%
All-purpose Car	3005	7320	4515	6043	2960	69%	70%	56%	71%	51%
Van	0	0	0	0	0	0%	0%	0%	0%	0%
Long-distance Bus	222	299	255	227	183	5%	3%	3%	3%	3%
Slow-Moving Vehicles	0	0	0	0	0	0%	0%	0%	0%	0%
Human-Powered	171	235	255	374	390	4%	2%	3%	4%	7%
Powered Two-Wheelers	71	145	344	102	290	2%	1%	4%	1%	5%
Conventional Heavy Rail	372	395	346	453	357	9%	4%	4%	5%	6%
High Speed Rail	56	382	375	268	199	1%	4%	5%	3%	3%
Rail and Guided	0	64	83	16	36	0%	1%	1%	0%	1%
Maglev	0	0	14	0	0	0%	0%	0%	0%	0%
Light Rail and People-	52	76	255	51	171	1%	1%	3%	1%	3%
Subsonic Aircraft	308	1246	910	832	584	7%	12%	11%	10%	10%
Helicopter	6	10	3	4	2	0%	0%	0%	0%	0%
Cryoplane	0	26	19	17	16	0%	0%	0%	0%	0%
Supersonic Commercial	0	27	0	18	0	0%	0%	0%	0%	0%
Airship	0	1	20	0	13	0%	0%	0%	0%	0%
All-electric Ship	0	0	0	0	0	0%	0%	0%	0%	0%
Fast Sea-going	0	0	0	0	0	0%	0%	0%	0%	0%
Fast Inland Ferries	0	0	0	0	0	0%	0%	0%	0%	0%
TOTAL	4330	10464	8111	8499	5761	100%	100%	100%	100%	100%

Table 7.4: Forecast passenger-km in 2030 per vehicle concept and per scenario

Freight transport

In Table 7.5 the results for freight transport demand are subdivided into the different transport concepts. As stated before, the differences between the scenarios are relatively small. Freight transport by road will continue to dominate. In 2030 light and heavy trucks together will have a market share of at least 60%. If road based systems as road train and Automated Vehicle Guidance are added this market share rises to more than 70%. The exception is in the *Sustainable Balance* scenario; in this scenario the market share of rail and water based systems is almost one quarter (24%) of total freight transport demand.

In all scenarios the market share of air transport jumps ahead to 4% to 5%. Even in the scenario with the lowest growth, the *Sustainable Balance* scenario, air transport increases by 375%. As for passenger transport, air transport will definitely grow in the next 35 years. Environmental problems related to air transport will rise on the political agenda.

The use of van/light trucks increases in every scenario; but at the same time the market share decreases in every scenario. The introduction of new logistics concepts and increasing competition within the freight transport sector, means that carriers try to consolidate shipments as much as possible. This produces a tendency towards larger shipments and therefore larger vehicles. The market share of the heavy truck stays therefore more or less constant, and if the market share of road trains and AVG is included, it can be seen that larger vehicles will become more and more important in the future. With respect to innovation policy this means that opportunities to influence the technological development are increasing.

The transport concept road train is assumed to gain a small market share in most scenarios. It becomes really important in the *Unrestricted Growth* scenario. In this scenario the road trains concept becomes mature and is able to achieve a market share of 4%. In the other two scenarios*, Sustainable Growth* and *Business As Usual*, road trains are only permitted on a limited scale.

Rail use stabilises in the *Unrestricted Growth* and *Business As Usual* scenarios. In the two sustainable scenarios rail transport increases significantly. Nevertheless, the market share of rail transport does not increase in any scenario. Even in the *Sustainable Balance* scenario the market share stabilises at 11%.

Water transport is expected to increase in every scenario. An increase in the scale of the ships used causes costs per ton km. to decrease significantly. Despite the lower speed, water related transport is therefore able to stay competitive. It is remarkable that in the *Unrestricted Growth* scenario the growth of water related transport is the strongest. Due to the overall economic growth long distance freight transport displays a strong increase and in this market water transport is very competitive.

Automated Vehicle Guidance (AVG) is expected to gain a substantial market share in the “growth” scenarios. AVG combines the advantages of road transport with those of rail transport. Especially in freight transport there is strong market pressure to introduce AVG. After all AVG makes it possible to drive a part of the route without the active role of the driver. Within road transport the costs of the driver are a major part of running costs. Saving on this, will make road transport more competitive. There is also a need for a number of technological innovations. In the two "growth" scenarios it is most likely to have an environment in which AVG really can be introduced.

Underground systems will only play a role of importance in the two sustainable scenarios. To realise these systems active (financial) support of governments is necessary. This is not expected to take place in the *Unrestricted Growth* and *Business As Usual* scenarios. Because in the *Sustainable Growth* scenario sufficient financial resources are available, underground systems will really take off in this scenario.

Transport concept	1995	UG	SG	BAU	SB	1995	UG	SG	BAU	SB
Van/ light truck	322	730	449	510	333	22%	20%	15%	21%	18%
Heavy truck	696	1586	1347	1104	925	48%	43%	46%	46%	51%
Road train	0	135	34	28	4	0%	4%	1%	1%	0%
Conventional Rail	155	153	213	148	203	11%	4%	7%	6%	11%
High speed rail	0	13	36	14	0	0%	0%	1%	1%	0%
Inland shipping/barge	100	214	205	151	121	7%	6%	7%	6%	7%
Ship	150	246	214	174	163	10%	7%	7%	7%	9%
Air	16	142	108	112	76	1%	4%	4%	5%	4%
AVG	0	484	315	139	0	0%	13%	11%	6%	0%
Underground systems	0	0	25	0	8	0%	0%	1%	0%	0%
TOTAL	1439	3703	2947	2378	1831	100%	100%	100%	100%	100%

Table 7.5: Forecast tonne-km in 2030 per transport concept and per scenario

7.4 Key issues for the European transport system

- Most change can be expected in passenger transport. In almost every scenario the future situation in 2030 differs significantly from the 1995 situation. For freight transport the differences, between the different scenarios, are relatively small.
- Regardless of the scenario, the privately owned vehicle (including bicycles) continue to dominate the passenger transport system. Even in the most extreme scenarios – the two sustainable scenarios, privately owned vehicle use, maintains a market share of, at least 40%.
- It is interesting that, especially with passenger transport, the differences between scenarios are relatively small – if the results are described in terms of vehicle concepts. Looking at transport concepts, the differences in market shares are much larger. This shows that a lot of innovation will take place in the organisation of the European transport system; but that, more or less, the same vehicles will be used. This reflects the inertia of the transport system. It is not easy to replace one specific vehicle concept with a new one. The interdependencies with other aspects, infrastructure and so on, are so large that new vehicle concepts need a lot of time to gain market share.
- The only newcomer is the urban car vehicle concept. The urban car realises a fairly significant market share, especially in the two sustainable scenarios of 8%.
- Within freight transport air transport shows, in every scenario, the largest growth. In the *Unrestricted Growth* scenario this is greater than 800%. It must be noted that the market share of air transport remains rather limited at 4%.

- In almost every scenario road freight transport at least doubles. The exception is in the *Sustainable Balance* scenario: road transport increases by a moderate 40% in the period 1995-2030.
- Growth figures within passenger transport differ across the scenarios significantly. For instance the strongest growth figures in the sustainable scenarios are for the powered two-wheelers; whereas this same mode shows the smallest growth in the other two scenarios, and even a decrease in the *Business As Usual* scenario.
- Air passenger transport increases in every scenario significantly, but especially in the *Unrestricted Growth* and *Business As Usual* scenarios, respectively a +317% and a +178% increase in the period 1995-2030.
- With the exception of the *Sustainable Balance* scenario the number of car kilometres grows in every scenario. This fluctuates between +71% in the *Sustainable Growth* scenario and 173% in the *Unrestricted Growth* scenario.
- A major trend is that the number of vehicle concepts within one transport concept is increasing. This can be found in every scenario. This underlines the by the experts stated view that interoperability will become more and more important in the future.

D12 "Characterisation of technologies for impact assessment"
D13 "Definition of European transport systems"
D14 "Scenarios"

8. ASSESSMENT

8.1 Safety assessment

Key technologies

The analysis has shown in detail the impact of the most important technologies on safety.

For each transport concept at time horizon of 2030 is in evidence a high reduction of the accident's number (and consequently of deaths and injured) thanks of some innovation technologies, particularly telematic, introduced in the vehicles.

In terms of accidents – considered the main impact category – the results are as follows:

- For road mode the anti-collision system has determined a reduction even at 7% of accidents, driver monitoring between 5% and 18% and lane keeping between 0.8% and 2.6%.

In addition to the direct impact on accident numbers there are other positive effects like: less traffic and a reduction of lost time for congestion caused by accidents; less social costs as social security costs, assistance costs and sanitary costs for all subject involved; a positive effect on equipped and no equipped vehicle.

These results derived from a medium-high market share forecast for the future, in fact anti-collision and lane keeping will achieve a market share at least even at 40% in 2030, driver monitoring at least even at 40% already in 2020.

The other technologies analysed in the study have less effects on safety, some of these are considering instead a normal equipment for the vehicle that will be on the market in the future.

- For rail mode the introduction of new railway infrastructure has caused a decrease of accident even at 7% for passenger transport and 7.5% for freight transport with a forecast market share at least even at 40% in 2020.

Further the direct impact on accident numbers there are other positive effects like: decrease of road congestion; greater efficiency of net; lack of service's interruptions; shift of passenger and freight from road.

- For air mode the main important innovations are air traffic management with a decrease of accidents even at 13.5% and a weather security system with a decrease even at 9%; these results are forecasted with a market share of 40% in 2020.

In addition to the direct impact on accident numbers there are other positive effects like greater punctuality of aircraft and less congestion at airport infrastructures.

Transport system view

The impact on safety is not correlated only with telematic innovation and new technologies, but it also depends on infrastructures development and management systems. Certainly the main impact on safety is to bring about the innovation technologies introduced directly on the vehicles but also the external factors are important to obtain a more consistent global impact, in fact the external conditions could improve or limit the security of equipped vehicles. This is particularly true for the infrastructures that are the most significant external instruments to realise a safe transport system.

Of course the fare structure and the management are important too: the fare structure could change the modal distribution and so it could be a good instrument to improve the security especially of road mode.

The infrastructures development

As concern road passengers transport, new investments to improve the actual infrastructure or to realise a good maintenance are foreseen. This hypothesis is the best to improve and to encourage the introduction of new technologies, in fact a better net can improve the performance of security systems.

In the field of long distance passenger transport, it is necessary to reconcile the development of high-speed railway transport with safety. Combined transport for passengers is, in fact, one of the more promising tools that can struggle against the unbridled use of the private car, with its consequences of system congestion, saturation and negative effects on the environment.

In the field of local rail passengers transport, the urgency concerns the improvement of travel quality to encourage a better balance between the different transport means. The desired quality improvement cannot be achieved without the strengthening of the network and the renewal of the circulating rolling stock, objectives which, obviously, are closely correlated with the use of new safety technologies.

Regarding freight transport, much needs to be done.

Freight transport must be reorganised according to a re-equilibrium between road transport and rail transport, attributing to each their respectively suitable role, that is, using the railway for long distances and letting road transport fulfil the duty of connecting and distributing the flows of traffic. This is the direction followed by the EU policies which envisage restructuring of the motor transport sector and intermodal development, in particular by strengthening or constructing efficient rail-vehicle inter-point terminals. Thus, freight transport can receive huge advantages from the introduction of innovative technological applications regarding safety, the possibility existing for these new technologies to be utilised in the framework of a rehabilitation and improvement of the whole sector.

Fares and transport management systems

The safety-oriented innovative technologies can affect rate and price system reorganisation concerning all modes of transport. In fact the new technologies can:

- lead to an increase in the price of purchase of vehicles through incentives and development supports by the individual national governments or supranational institutions such as the EU;

- bring about rate adjustments aimed at absorbing the eventual investments made in modern equipped public transport vehicles.

The necessary improvement in the transport systems management can only be achieved by carrying out a number of "ad hoc" reforms several of which, however, are already being carried out consequent to community directives. A large number of interventions already being carried out or which are expected to be carried out in the near future can have important impacts on the diffusion and further development of the technological applications concerning safety. The correlation existing with the re-organisation and the improvement of the transport networks is obvious: greater safety implies greater capacity of the infrastructures at equal equipment provision and a better control and management of traffic; that is, the development of one implies and amplifies the other in a circle which, sustained by adequate incentivating policies, can become virtuous.

D16 "Safety impacts and benefits of new transport systems"

8.2 Environmental assessment

Key technologies

In the long-term (time horizon of 2030), a variety of technologies contribute to environmental improvements. This can be illustrated by comparing the contributions to total CO_2 emissions and tonne or passenger kilometres from different vehicles and technologies. The form of chart shown allows the identification of technology and vehicle packages that contribute to meeting transport demand (i.e. passenger km or tonne km), whilst also showing the contribution towards total lifecycle CO_2. Using lifecycle emissions (i.e. including fuel production and electricity generation) enables different propulsion technologies to be compared on a level playing field. Where the left-hand bar is higher than the right, the vehicle/technology combination is less CO_2 efficient, and thus less favourable from a CO_2 point of view.

In the passenger sector, advanced conventional petrol and diesel propulsion meet the majority of demand and emit more than 'their share' of CO_2. However, methanol fuel cell and hybrid propulsion are also likely to meet passenger demand without such high lifecycle CO_2 implications. In addition, it should be remembered that many of these technologies also have positive impacts in other assessment categories, such as air quality and noise. The CRISP propfan aircraft is seen to make a low-CO_2 contribution to meeting passenger demand, with high penetration in 2030, and is another significant technology. High speed rail, whilst meeting a small proportion of demand, has an unfavourably high use of electrical energy (in a average European electricity generating future based on combined cycle gas turbine; CCGT) and this is highlighted in this lifecycle approach. Conventional means of assessing CO_2 emissions would ignore this factor.

In the freight sector, hybrid heavy goods vehicles (HGVs), vehicles using automated vehicle guidance (AVG) and conventional rail technologies contribute to tonne km movements with relatively low lifecycle CO_2 consequences. Ship and inland waterway movements look less attractive using this methodology, but results are sensitive to assumptions on freight load factors; these are unchanged throughout the four scenarios.

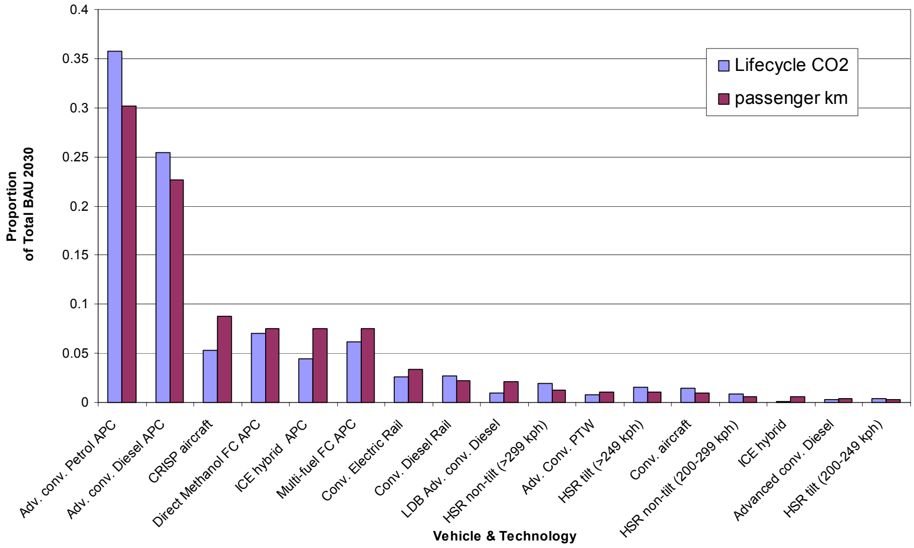

Figure 8.1: Passenger technologies and demand as proportion of total lifecycle CO_2 (BAU scenario in 2030)

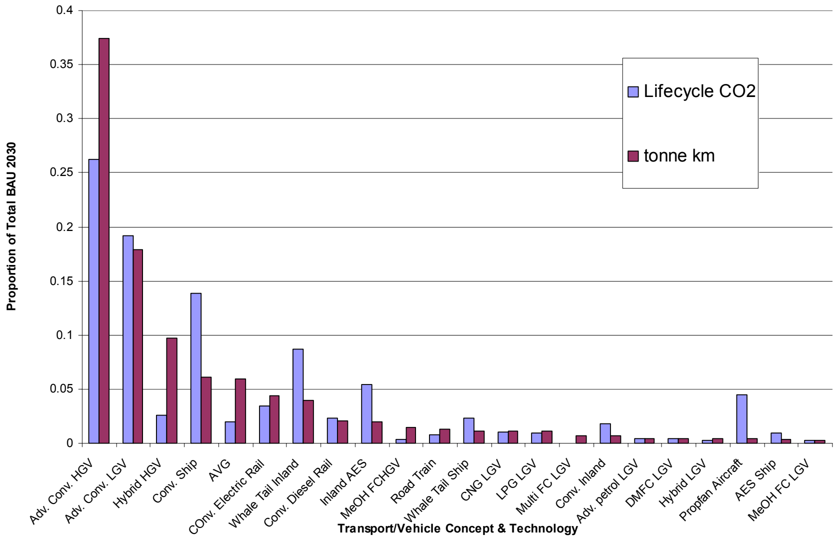

Figure 8.2: Freight technologies and demand as proportion of total lifecycle CO_2 (BAU scenario in 2030)

Urban NO_x and PM emissions

NO_x and particulate matter are key pollutants in urban areas, and are currently under the greatest policy scrutiny, due to their likely short and longer-term effects on human health. Total emissions of these pollutants in urban areas, therefore, are key indicators of environmental impact. As can be seen in the chart below, particulate emissions are set to fall markedly under the BAU scenario (to 31% of their 1995 levels), not least due to legislative measures already set in place for road vehicles, especially freight vehicles.

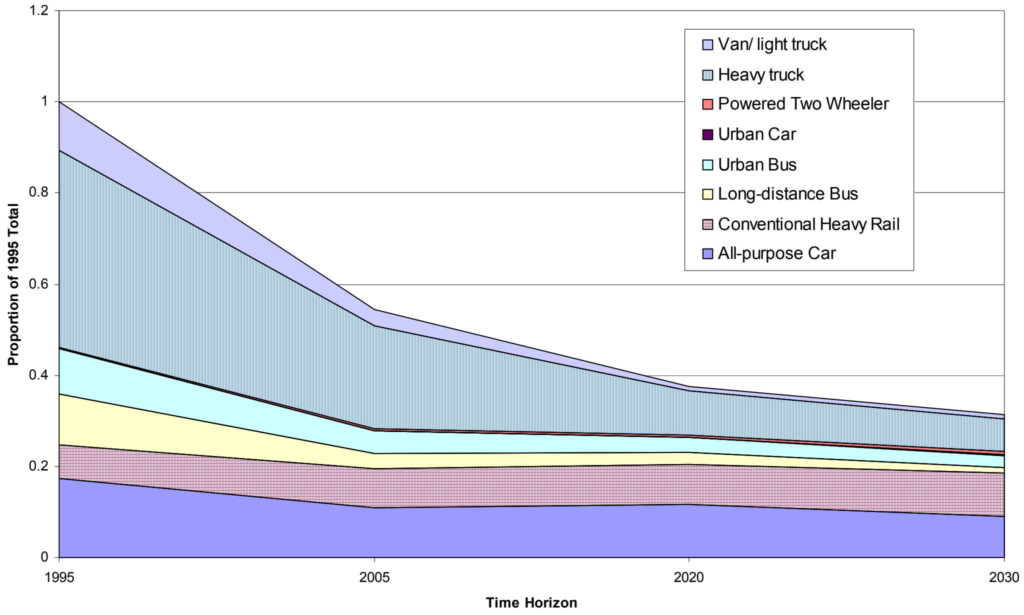

Figure 8.3: Total urban particulate emissions (BAU Scenario)

Urban NO_x emissions show a similar trend but 2030 emissions are even lower at 14% of the 1995 levels, as shown below. The improved performance of the all-purpose car contributes the most significantly to this reduction. Freight emissions in urban areas become insignificant, but may have continued impacts around major interurban routes.

	1995	*2005*	*2020*	*2030*
All-purpose car	81%	20%	9%	6%
Conventional heavy rail	5%	6%	7%	7%
Long-distance bus	1%	0%	0%	0%
Urban bus	5%	1%	1%	0%
Heavy truck	5%	2%	0%	0%
Van/light truck	4%	1%	0%	0%
total (proportion of 1995)	100%	31%	17%	14%

0% implies < 0.5%

Table 8.1: Contributions to and change in total urban NO_x emissions BAU scenario

The contribution of technologies, and to a less degree, transport organisation, in reducing total urban emissions of NO_x and PM can be seen in the following table which compares growth in passenger and tonne kilometres with forecast changes in total emissions.

	Urban passenger			*Urban freight*		
Time horizon	*passenger-km*	NO_x	PM	*tonne-km*	NO_x	PM
1995	*1.00*	1.00	1.00	*1.00*	1.00	1.00
2005	*1.17*	0.30	0.61	*1.04*	0.42	0.49
2020	*1.32*	0.17	0.58	*1.08*	0.11	0.20
2030	*1.40*	0.15	0.51	*1.10*	0.09	0.15

Table 8.2: Transport demand and urban NO_x and PM emissions as proportion of 1995 (BAU scenario)

Key policy issues

The key areas of environmental policy concern for European transport are greenhouse gas emissions and urban quality of life, including air quality, noise and nuisance.

Under the business as usual scenario (BAU) developed in FANTASIE, with various transport demand, organisational and technological changes forecast, direct CO_2 emissions are set to rise by 31% between 1990 and 2010. Only under the sustainable balance scenario, characterised by moderate economic growth and high sustainability, are emissions set to drop (by 3%). Between 1995 and 2030, the base and target years of FANTASIE, this rise is forecast at 24%, under BAU.

Lifecycle CO_2 emissions, taking account of fuel production and electricity generation, are set to increase by 33% between 1990 and 2010 and by 28% between 1995 and 2030, under BAU.

Scenario analysis has highlighted the contributions from transport demand, organisation of supply and transport technologies towards direct CO_2 emissions. Sustainable scenarios show that 225 million tonnes can be saved in 2030 through lower transport demand, but even under favourable economic growth conditions, up to 84 million tonnes can be reduced by changing transport organisation and how it meets demand (e.g. greater use of collective and public transport concepts). Finally, advanced technologies can save up to 126 million tonnes, under the high sustainability, high growth scenario.

For urban air quality, NO_x and particulate emissions are of essential policy interest. Assessment has shown that total emissions of these pollutants is set to fall steadily up to 2030, due to policy actions already set in place and further technological advances expected in vehicles operating in urban areas, particularly electric urban cars and hybrid and fuel cell buses. Freight vehicles (trucks and vans) will contribute significantly to overall improvements, especially in NO_x emissions. Transport demand effects towards the end of the FANTASIE timescale mean that the rate of improvement is slowed markedly by increasing transport activity.

Noise impacts are set to improve within a range of transport concepts. Because of their large projected market shares, all-purpose and urban cars and heavy vehicles using electric and fuel cell propulsion technologies are expected to show the largest overall improvements in this impact category. Development of electric, hybrid-electric and fuel-cell vehicles of all types will particularly benefit the urban environment. Interurban road noise conditions are less easily influenced and high speed rail concepts have the potential to increase noise levels as speeds and train lengths increase.

D19 "Environmental impacts and benefits of new transport systems"

8.3 Efficiency assessment

Efficiency in transportation represents the relationship between the resource use and costs on the one hand and the productivity on the other.

Key road issues

The contribution to the overall system efficiency of the road TCs are assessed in Table 8.3.

Key are the improvement of intermodality and push and pull measures to encourage modal shift from individual cars. Push measures aim to make the use of car less attractive such pricing, pull measures aim to make the other modes more attractive with higher quality services.

The most significant technologies are propulsion systems for the impacts on energy efficiency and telematics for all the other aspects. The contribution which can be expected from telematics in the different problem areas is shown in Table 8.4.

Transport concept (TC)	*Space use and capacity use*	*Availability*	*Flexibility*	*Accessibility*	*Cost to the users*	*Reliability*	*Overall congestion*	*Supporting policies*	*Main problem area and specific demand segment/market niche*
Conventional collective	++				+	+	++	public transport prioritisation push and pull measures	high-demand corridors
Individual conventional		++	++	++				traffic management, demand management, mobility management for car, dedicated infrastructure, awareness campaigns and public advocacy for walking and cycling	all
Dedicated urban car	+	++	++	++			+	special parking and pricing arrangements	urban
Individual public	+	+	+	+	+		+	multi-modal payment, car ownership taxation, parking policies	urban semi-central areas, short distances feeding to primary public transport routes
On-demand collective	+	+	+	+	+	+		publicity, mobility management schemes, subsidies	people with reduced mobility, low density areas
Ride sharing	+			+	++	+	+	special parking and pricing arrangements, high occupancy vehicle lanes, mobility management schemes	urban, local needs of residential estates or business areas
Vehicle sharing	+			++		+	+		egress from main interchanges
AVG	++	++	++	++		++	++	public-private partnerships for market take up	long distance, high demand corridors
+ low benefit, ++ high benefit									

Table 8.3: Main system-level efficiency benefits of road passenger transport concepts

Telematics function	*Rural*	*Interurban*	*Urban*
Traffic control			
Section traffic control		++	+++
Intersection traffic control		++	+++
Network traffic control		++	+++
Localised area traffic control		++	+++
Travel information			
Travel planning		+++	+
Static route information		+++	+
Personal communications		++	+
Traffic information			
Navigation	++	+++	+++
Route guidance direction	++	+++	+++
Dynamic route guidance	++	+++	+++
General management and logistics			
Strategic planning	++	+++	+++
Strategic management		+++	+++
Forecasting		+++	++
General information management		+++	+++
Infrastructure management		+++	+++
User rescue service management		+++	+++
Infrastructure service logistics		+++	+++
Fee collection management		+	+++
Policing/enforcing management		++	+++
Demand management			
Demand restraints		+++	+++
Supply control		++	+++
Parking management			
Parking space management			+++
Parking guidance			+++
Parking reservation and payment			+++
On-street parking management			+++
Public transport management			
Scheduling	+++	++	+++
Operations management	+	++	+++
Passenger information	+++	++	+++
Fare collection	+++	+++	+++
Maintenance	+	+	+++
Freight and fleet management			
Logistics and freight management	++	++	++
Fleet/source management	++	++	++
Vehicle/cargo management	++	++	++
Hazardous goods monitoring	++	++	++
Vehicle control			
Monitoring environment and road			+
Monitoring driver			+
Monitoring vehicle			+
Vision enhancement			+
Collision risk estimation			+
Actuator control			+
Dialogue management			+
Co-operative driving			
Intelligent manoeuvering and control	+	+	++
Intelligent cruise control	+	++	++

Key: - no impact ; + useful ; ++ important ; +++ essential

Table 8.4: Relevance of road telematics to the efficiency of the problem areas

Key rail issues

The key policy conditions required in the efficiency category for this specific TC are:

- An improved network of the transport carriers (rail), including their means of transport and the transfer of traffic towards energetical and ecological transport carriers have to be promoted with more emphasis. A decisive role has to be carried out by the nodes (termini) of the transport network, respectively of the transport infrastructure. They represent the bottlenecks and due to this fact the termini have to be planned, developed and realised in order to remove these deficiencies.
- Disassembly of vehicles and separation of materials is indispensable. A high percentage of its contents should be fed back into the raw material cycle.

The most significant expected contributions to the efficiency-related CTP objectives are:

- New termini, equipped with new technologies, can accelerate significantly the transport process (of persons and goods).
- The reliability, punctuality and the quality of transport processes will increase. This provides a higher system productivity and therefore an improved economy.
- To decrease environmental impacts is a main requirement for the energy supply of the future. The different energy carriers have quite different environmental impacts and depend on the possible pathways describing the energy carriers.
- Physical infrastructure innovations in the transport sector can improve the economic, ecological, technical and, in particular, safety of a transport system.
- To increase train speed and therefore to decrease travel time.
- To reduce the level of stress associated with travel (many telematic functions have this specific goal)
- To improve travel time predictability (very good results can derive from further R&D on traffic control, on incident management and on travel and traffic information).
- Over long term time horizons additional elements in the pathways may appear, like solar thermal power station, fuel cell natural gas power station, fuel cell hard coal power station, etc. (one main element is the application of stationary fuel cells).

The areas of prioritisation for policy intervention which are relevant to the efficiency objective are:

- New technologies and applications have to be stimulated: in particular a need is recognised for
  - recycling and upgrading waste material (urban rail);
  - fuel cell and battery technology (on-demand rail);
  - new railway infrastructure and applications especially MagLev (regional rail);
  - traffic management systems and integration of information technologies with GNSS (Global Navigation Satellite Systems), wireless communication systems and computer communications networks (Internet, LAN, WAN) for long distance passenger and rail (interurban rail).
- With the aim of creating the single market in transport services and support the transition from a national regulatory system, the nee for enforcement of the competition, state aids and legislative initiatives in specific transport sector is recognised.

- Infrastructure mainly involves high capital costs but maintenance costs are relatively low in comparison with these investment costs.

The following policy conditions are urban-specific:

- The gradually increasing traffic problems of the cities can only be solved by exploiting other levels of transport. Underground and urban railway construction, road tunnel construction and subterranean parking facilities are the logical consequence.
- With the prime objective of preserving, and if possible further developing the mobility of the citizen while counteracting destruction of the landscape and keeping cities in their historic structures as centres of culture, trade and communication, subsurface constructions have been developed considerably.
- Although to better use of transport resources is very high up on the agenda of the CTP to reduce congestion, it still appears difficult to overcome traditional preferences for individual traffic privacy. In this context great efforts have to be produced in order to limit the congestion by means of ad hoc legislation.

Key air issues

Construction and Maintenance Costs (CMC)

- Significant investment is required in refuelling infrastructure for the alternative fuel and renewable energy/fuel production trajectories of the cryoplane VC.
- There may be some increases in vehicle usage charges associated with the alternative fuel and renewable energy/fuel production trajectories of the cryoplane VC.
- The could be substantial reductions in vehicle usage charges associated with the airship VC.

Vehicle Operating Costs (VOC)

- Possible large reductions associated with megaliner VC.
- Civil tiltrotor technology as a part of helicopter VC could offer substantial reductions over traditional helicopter.
- Cryoplane VC operating costs dependent on fuel prices.
- Airship VC could offer substantial reductions over conventional aircraft.

Travel Time Savings (TTS)

- Civil tiltrotor technology as a part of helicopter VC could offer substantial savings over traditional helicopter.
- Supersonic commercial transport VC offers travel times about half that of conventional aeroplane.
- Airship VC is substantially slower than conventional aircraft.

Comfort

- None.

Key waterborne issues

Maritime transport and inland waterways have been dealt with separately.

The efficiency assessment for the waterborne TCs was carried out for the four main impact categories: CMC, VOC, TTS and comfort.

Maritime transport results

Construction and Maintenance Costs (CMC)

- Possible reductions associated with improved operational efficiency and fuel consumption of all electric ship VC.
- Fast sea-going ferry VC will have higher fuel consumption but improved operating efficiency.

Vehicle Operating Costs (VOC)

- Possible reductions associated with improved operational efficiency and fuel consumption of all electric ship VC.
- Fast sea-going ferry VC will have higher fuel consumption but improved operating efficiency.

Travel Time Savings (TTS)

- Significant savings associated with the fast sea-going ferry VC.

Comfort

- Improved ship design and transport quality will offer potential for increased comfort in the all electric ship VC.
- Improved comfort will be one element of the fast sea-going ferry VC.

Inland waterways results

Construction and Maintenance Costs (CMC)

- Possible reductions associated with whale tail ship VC

Vehicle Operating Costs (VOC).

- Possible reductions associated with whale tail ship VC

Travel Time Savings (TTS).

- Significant savings associated with the fast inland ferry VC.

Comfort

- Improved ship design will offer potential for increased comfort in the whale tail ship VC.
- Improved comfort will be one element of the fast inland ferry VC.

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8.4 Socio-economic assessment

Socio-economic impacts can be broadly categorised into three types:

- direct effects, where changes occur as a result of a development or new transport concepts;
- induced effects, where indirect effects are promoted;
- catalyst effects, where changes in other economic sectors or geographic regions by be catalysed by the developments.

Socio-economic impacts have mainly an indirect character and as mentioned above five main impact areas have been assessed:

- economic development;
- completion of single market;
- social cohesion and quality of life;
- public acceptance;
- others, like enlargement, global trends and lifestyle.

In the following the impacts on problem areas are shown.

Urban passenger transport

Within urban passenger transport the individual vehicle (IV) has the dominating impacts. For the scenarios BAU and UG positive impacts are mainly based on the higher amount of vehicles. In terms of social cohesion it means an increase of individual availability and accessibility for those, who are owners. For non-owners this will become a problem, because public transport concepts will loose some importance relative to the other TCs and in some cases also absolute. In the scenarios SB and SG the IV concept has negative impacts, especially in the field of economic development, because the trend concerning production of individual vehicle concepts goes towards to lower value vehicles, e.g. dedicated cares, as urban cars or human powered two wheelers. In these scenarios transport supply by collective TCs is growing in relative and absolute terms. This provides an improved mobility through all groups of society. It is very likely that these specific scenario conditions promote the objectives of the Completion of the Single Market, especially the formulated requirements of the EC papers Citizen Network and Fair and Efficient Pricing. External costs will be considered in the costs for transport as well as sustainability in the transport supply. Dedicated vehicle in all scenarios and vehicle sharing and IPT in the sustainable scenarios will appear as new TCs, which will provide some positive impacts concerning availability and accessibility to transport. OCTR will loose importance relative to the other TCs in all scenarios, whilst on demand rail will get some positive impacts. General spoken the scheduled transport will decrease in favour to demand oriented collective TCs. In sum the social functions concerning these TCs will be ensured.

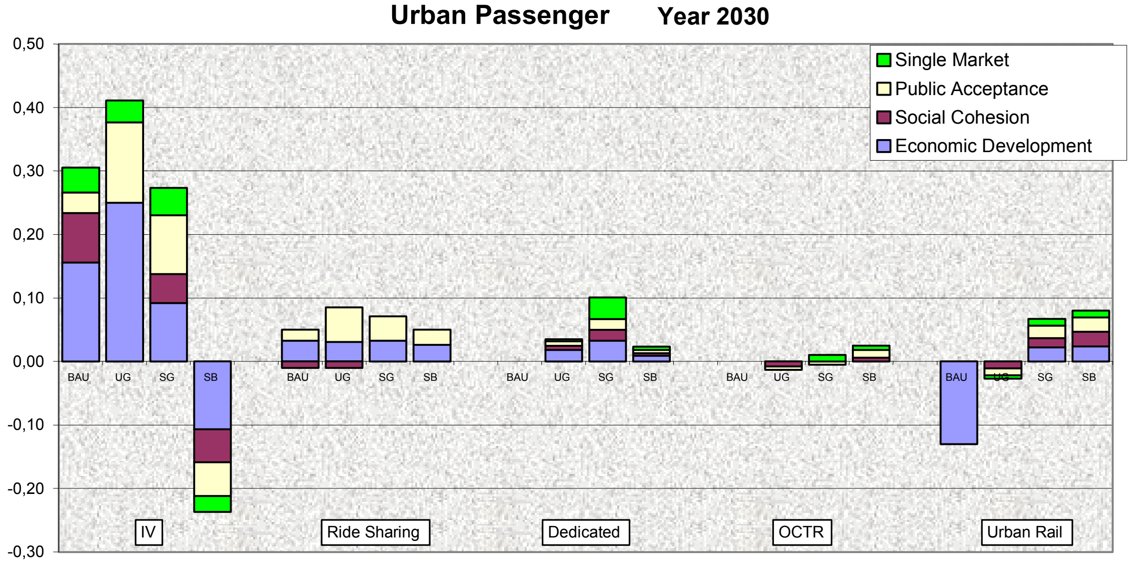

Figure 8.4: Urban passenger transport

Rural passenger transport

Except for the SB scenario, starting from a high level (base case) the IV will still represent the most important TC with all the advantages in availability and accessibility to transport for those, who are owner of an vehicle and the disadvantages for non-owners. Dedicated vehicles, which are adapted to the users' needs will come into the market. Scheduled public road transport decreases in favour to on demand road transport, which means an improvement in availability. Especially in the sustainable scenarios collective transport concepts will increase positive impacts and ensure mobility for broad social classes, which has positive influence in view of equity. IPT and vehicle sharing also appear in this context which will also provide more consciousness for mobility in the society.

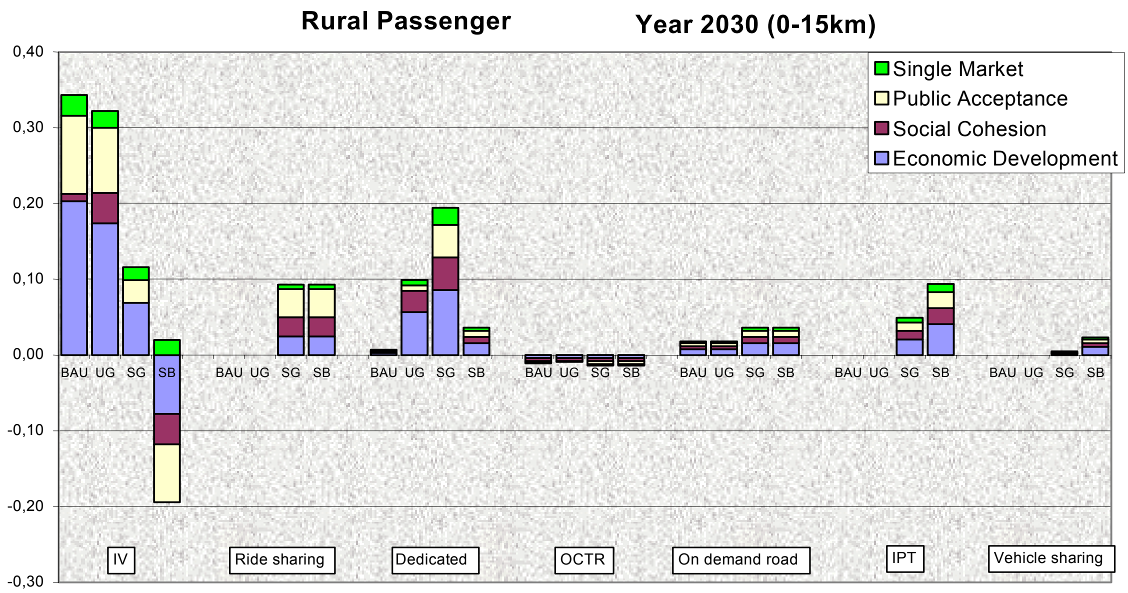

Figure 8.5: Rural passenger transport

Interurban passenger transport

Interurban passenger transport from 15 km up to 250 km represents over 50% of transport market share, and therefore this segment represents the most important area in the socio-economic context. The IV is again in this problem area the dominating TC. In BAU and UG impacts are positive and means that mainly caused by the increased amount of vehicles availability, including the possibility to make discretionary trips and accessibility to transport is growing significantly for vehicle owners. In the sustainable scenarios negative impacts mean that social cohesion will decrease in relation to this TC.

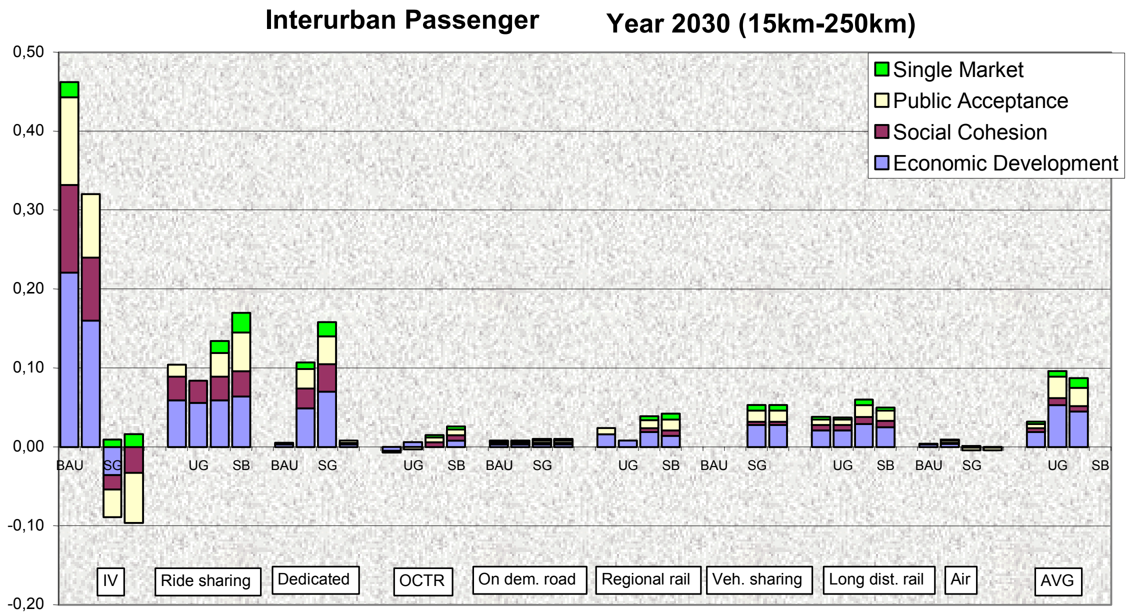

Figure 8.6: Interurban passenger transport (15-250 km range)

For interurban passenger transport with distances over 250 km the IV concept has positive impacts in all scenarios, which means that the availability and accessibility will grow. For the segment over 250 km, which represents a market share over 10% the transport demand and in connection all socio-economic relevant impacts are growing dramatically for the air transport concept. This means that availability and access to this TC is growing for broad classes in the society, which may differ by different scenario conditions, e.g. income distribution.

For the complete interurban transport ride sharing will increase its positive impacts which provides a more common sense. Together with the TC vehicle sharing ride sharing can compensate the negative IV impacts in the sustainable scenarios. AVG as a new TC will come into the market with significant positive impacts, by relieving tasks from the driver. This includes potentials for specific groups, using this TC. Rail transport will gain more importance with some emphasis on long distance rail concept. These positive impacts result also in a higher availability and accessibility to transport. Nearly all collective transport concepts in this area take care for specific groups. For solving the increased future transport demand they will follow the objectives for Completion of the Single Market with emphasis on operational features (social dimension).

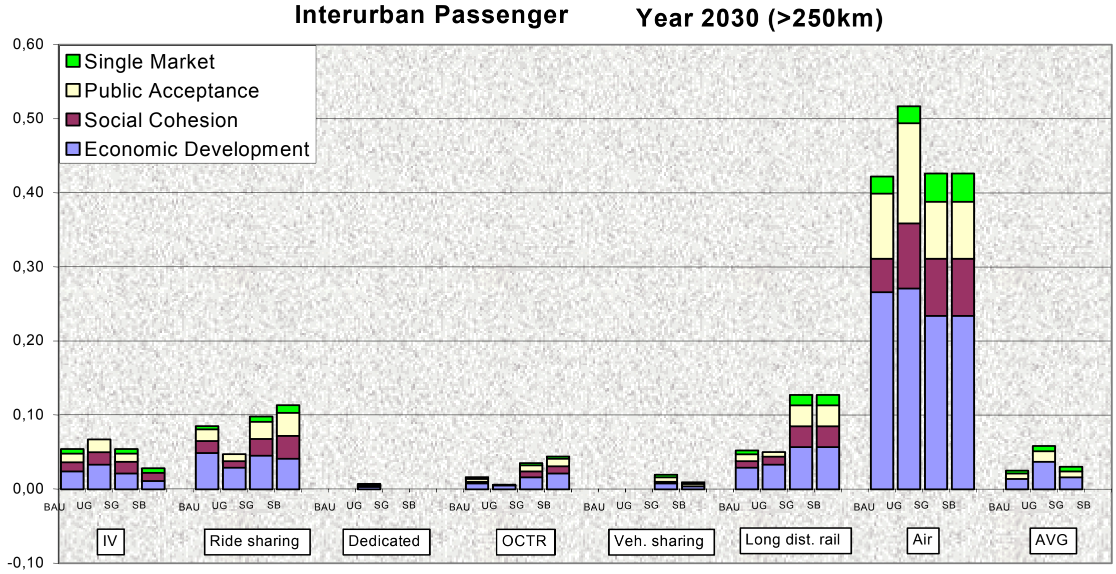

Figure 8.7: Interurban passenger transport (>250 km range)

Urban freight transport

Urban freight up to 15 km has a market share of approximately 5%. Van/light truck will keep the dominating role. This TC is characterised by high flexibility and ensures supply of economy and industry. The impacts for Completion of Single Market will be only improved under the SG scenario conditions. In BAU and UG role of heavy truck will slightly be increased. Driver assistance systems will support operation of these two TCs and may have positive impacts concerning the working conditions of employees. Underground freight concept will only come into the market under the SG and SB conditions.

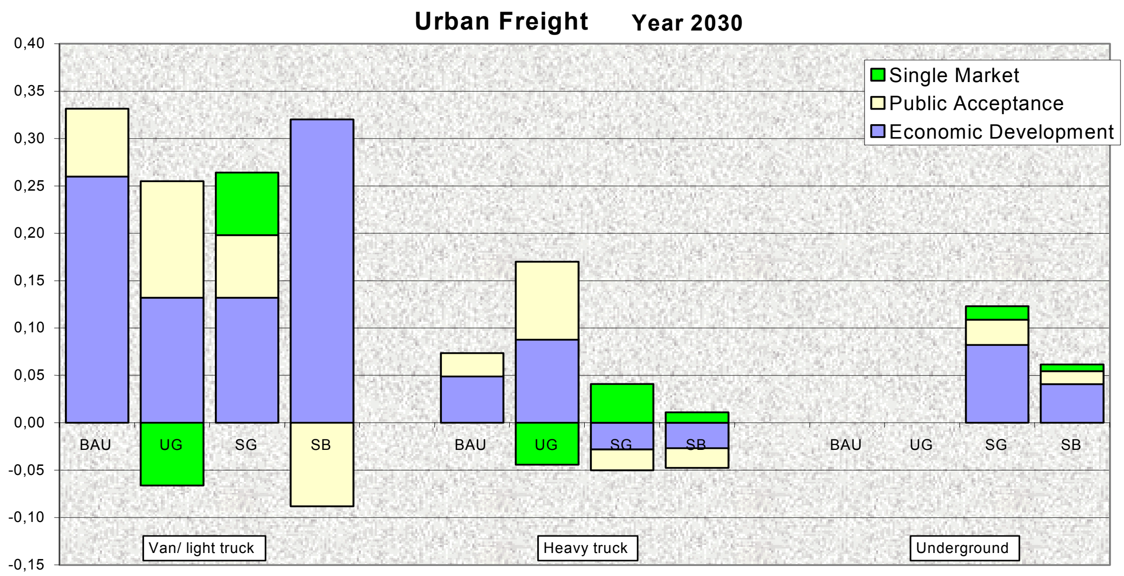

Figure 8.8: Urban freight transport

Interurban freight transport

Interurban freight transport with distances over 15 km represents approximately 90% of freight transport demand and is mainly affected by the increased future transport demand and needs improved intermodal and interoperable transport chains. The most important TCs in this problem area are van/light truck and heavy truck. Advanced telematics and MMI improve the working conditions for the drivers. Starting from a high level, the growth rates for these TCs represent a specific challenge for the infrastructure provision. In this context AVG as a specific telematics application will come into the market (except SB). The most significant growth rate for freight transport over 250 km is in the air sector, which needs efforts in further development of airports and operational features, e.g. ATM. Importance of the waterborne TCs will grow, which also requires further development of physical and informational infrastructure. In BAU and UG importance of rail freight will decrease in absolute terms and in all scenarios freight transport by rail decreases relative to the other modes. In other words the scenarios do not provide the conditions to increase the share of freight transport by rail. Nearly all politicians postulate to strengthen this mode and therefore additional efforts are necessary.

Except for the UG scenario, where the market conditions have the dominating influence impacts concerning the objectives of the Single Market are significantly positive nearly for all TCs.

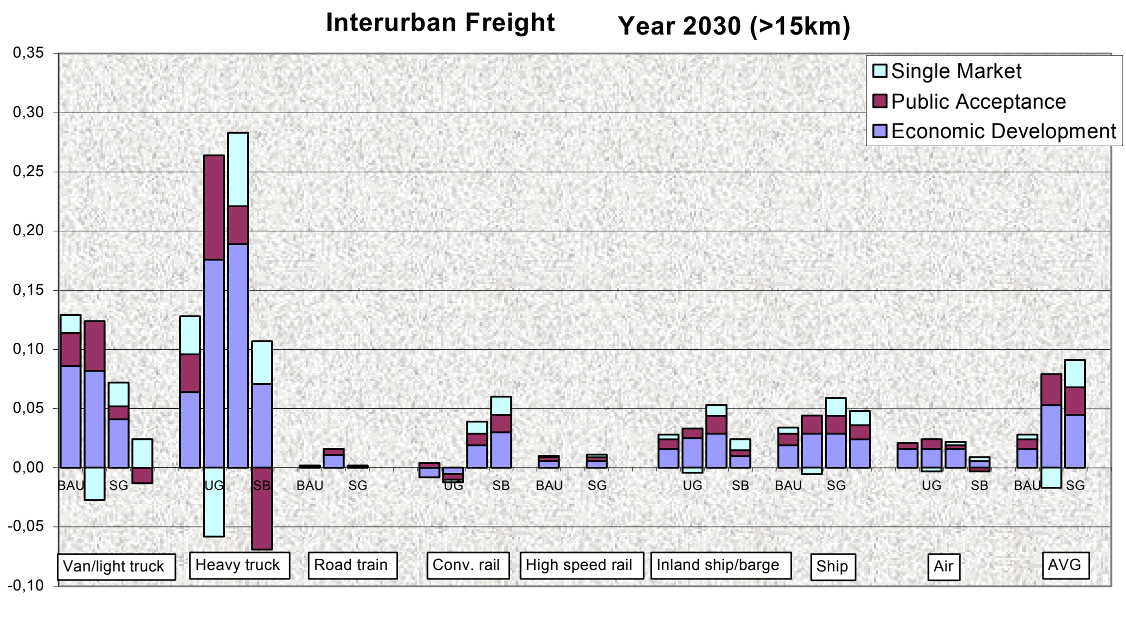

Figure 8.9: Interurban freight transport

8.5 Socio-economic aspects of safety, efficiency and environment

The socio-economic importance of transport within Europe can be highlighted by the following values, published by EUROSTAT and the German Forum for Transport for the year 1996.

Contribution to gross national product

- 470 billion Euro, which represent 7% of GNP or 1300 Euro per person
- 70 billion Euro for infrastructure investment or 1% of GNP
- 6 million employees in transport services (4% of all employed persons)
- 2 million employees in transport equipment industry
- 6 million employees in transport related industry, where 1/3 is assigned to freight transport and 2/3 to passenger transport
- Households spend 600 billion Euro/year of their disposable income for transport purposes

The negative impacts are shown by the external costs of transport which were estimated, as

- 27.0 billion Euro/year for air pollution (= 0.4% of GNP)
- 13.5 billion Euro/year for noise (= 0.2% of GNP)
- 135.0 billion Euro/year for congestion (= 2.0% of GNP)
- 102.0 billion Euro/year for accidents (= 1.5% of GNP)

which makes an amount of 277.5 billion Euro per year or 700 Euro per person.

Following issues highlight some results of the specific assessment areas, which are assumed to have specific importance in the socio-economic context. These issues cannot be quantified in comparison to above mentioned values, but they should indicate specific trends.

In the safety area driver assistance systems have the highest positive impacts in road safety. Anti-collision systems for passenger transport are estimated with 7% and driver monitoring systems for freight transport are estimated with 5-18% to reduce accidents. These technologies fully meet the objectives of EC transport policy, where increasing road safety is on top of agenda. Avoiding accidents means also avoiding congestion by these incidents. This has positive effects on net capability but also reduces external costs. Further extension and new implementation of railway infrastructure reduces accidents at about 7% in the rail sector. Further development of physical infrastructure is accompanied by further development of information technology infrastructure and implementation of advanced rail traffic management systems. Beside the improvement concerning the safety this also will include positive impacts in the efficiency sector. Air traffic management (ATM) systems are the most promising technologies for increased safety in the air sector and is estimated by a rate of 13%. Similar to the rail sector this technology will increase net capability and therefore is a boundary condition to solve the enormous increased transport demand.

Physical infrastructure and telematics infrastructure are of decisive importance in the efficiency area. For further extension or upgrading of physical infrastructure use of recycled and local materials will become more and more important. In the socio-economic context this means beside positive employment impacts also saving of resources. Further development of physical infrastructure is scenario independent. Only in the sustainable balance scenario there is no emphasis on road infrastructure. Additional in all scenarios further development of IT, respectively telematics and their infrastructure is essential. Telematics development and application have a lot of opportunities as an employment factor. New services and operating schemes create new qualitative jobs and open new companies and especially SMEs high potentials. Looking at the net capability generally it is not so expensive to invest in telematics than to invest in physical infrastructure construction. But nevertheless there has to be found a compromise between these two possibilities to reduce congestion on one side and solve the increased transport demand on the other. The EC is required to provide a framework for further infrastructure development. A specific role in this context will become intermodality, where the strengths of the specific TCs have to be used. To provide almost seamless interfaces in different terminal and transferia infrastructure and technologies is necessary, where also EC is required to give the relevant impulses.

To increase safety on the one hand and efficiency on the other represent adverse requirements. One solution of the problem will be the introduction of advanced traffic management systems. ERTMS and ATM developments are positive examples, where this contradiction can be met. The solution for infrastructures, which are used by different modes with their different TCs is quite more complex, e.g. in the road sector. This represents a challenge, which concerns also EC transport and research policy.

For the environment area almost in the near and middle term time horizon technical progress will provide for conventional vehicle a decrease of NO_x and particulate in air pollution and noise and therefore improve urban quality of life.

Beside in the SB scenario it is estimated that CO_2 emissions are growing with its negative impacts on the global climate, which is assumed to influence the global economy in a negative way by global warming. Another aspect is in the limitation of mineral oil, which is also affiliated with the efficiency assessment area. One solution may be the broad introduction use of alternative and/or CO_2 neutral fuels for propulsion, mainly in the road sector. This requires a lot of effort in the development in relevant infrastructure, beginning by the supply of the relevant fuels up to the refuelling facilities and adaptation of the propulsion units of the vehicles. Because there are different possibilities it is necessary to agree on some paths on an European level, which may use the advantages of location factors within Europe. Additional important points of view are also be in the reduction of dependence of imported energy carrier and saving resources. One contribution to the solution of this problem is in a broader use of electric vehicles, including combination with combustion engines as hybrid vehicles which assigns the problem to earlier stages of the energy chain. This provides additional advantages concerning local emissions (pollution and noise), especially in the urban areas. This positive impacts induce also positive impacts for the concerned individuals, e.g. by improving the living conditions.

The question of the future energy supply of transport is also an affair of energy policy within Europe and one of the biggest challenge for policy, where the course have to be set in the next time, by all relevant political levels.

8.6 Synthesis of impact assessment

Many new technologies have positive or negative impacts simultaneously for more than one assessment area and with a great variety of impact areas. Hence a synthesis was done to highlight only the most important impacts and the corresponding dimensions.

These dimensions are:

- three time horizons, short-term (S) 2005, medium-term (M) 2020, long-term (L) 2030, baseline year 1995;
- four exogenous scenarios, BAU, UG, SB, SG;
- five problem areas, urban, interurban and rural for passenger and urban, interurban for freight;
- 23 vehicle concepts as described in the abbreviation list;
- 13 passenger and 10 freight transport concepts as described in the abbreviation list; and
- market potential, low (L) below 30%, medium (M) between 30% and 50%, high (H) above 50%.

There are only few technologies having key positive impacts in more than one specific assessment area but the others are often serving many vehicle and transport concepts with a medium to high market share. Likely beneficial for all impact areas are the group of telematic technologies having indirect positive impacts on the environment and socio-economic issues as well. Robustness of positive impacts can directly be seen on multiple relevance in the different scenarios.

Modern Airships are likely to create not only a niche market with important indirect benefits to avoid congestion in context with heavy and bulky loads but can start a revolution in the construction sector to bring high quality factory manufactured big modules to their final destination within cities and outside.

Supersonic transport is very unlikely due to strong negative environmental impacts.

8.6.1 General key technologies

Key Technologies	Key Impacts	Scenarios				Time	Market	VC		Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Fuel Cell:	GHGs	X	X	X		M – L	Small	APCAR	ICONVE	X	X	X	X	X
Methanol reformer	Air quality	X	X	X				UBUS	DECAR	X	X			
Multi-fuel	impacts							VAN	RIDES					
Direct methanol	Resources	X	X	X					CARS	X	X	X	X	X
Depot reformation	Nuisance	X	X	X					OCPT	X	X			
	Improve-ment of fuel efficiency Negative: Increase of construction costs	X		X		M - L	L	APCAR UBUS VAN	ICONVE RIDES CARS OCPT VANLT AVGP	X	X	X		X
	Economic develop-ment Public ac-ceptance	X	x	X		M – L	Medium	APCAR UCAR UBUS VAN	ICONVE DECAR RIDES AVG IPT CARS OCPT	X	X	X	X	x

Fuel cell propulsion may be based upon several different fuel and technology combinations, depending upon rate of technological development, fuel availability and infrastructure development. There is uncertainty over the impacts that may be expected from each of these combinations. Full life-cycle analysis is required to fully appreciate the contributions of fuel production and distribution on resource use and greenhouse gas emissions. There is less doubt that fuel cells will lead to very significant (>90%) improvements in local emissions of key pollutant species.

Fuel cell technologies are expected to be significant in almost all scenarios and within many different vehicle and transport technologies. They are expected to have greatest positive impacts on greenhouse gases and air quality impacts, but will bring improvements to nuisance (mainly urban traffic noise) impacts.

Fuel cells are expected to show a 50% improvement of fuel efficiency in 2030 compared with conventional petrol 1995. Fuel cell drives are characterised by the highest fuel efficiency and the market share of such vehicles (APCAR, urban bus and van) in SG and BAU scenarios is a key element for the positive trend of the impact profiles. But construction costs are expected to be higher in the range of 50% than conventional petrol 1995. Fuel cells may also have a negative impact on interoperability unless the technology develops at uniform pace and with common standards for recharging primary fuels (hydrogen or methanol). The refuelling infrastructure for fuel cell powered vehicles will be highly dependant on the on board technology development. If on-board petrol to hydrogen conversion systems are successfully developed, conventional refuelling infrastructure will be used and no investments will be required for new infrastructures and the refuelling time will be comparable to petrol. The short-term potential for fuel cells lies in using fossil fuels such as natural gas and methanol.

Fuel cell propulsion /hybrids may be based upon several different fuel and technology combinations, depending upon rate of technological development, fuel availability and infrastructure development. There is uncertainty over the impacts that may be expected from each of these combinations. Changes in energy supply and introduction of new propulsion systems will have positive employment effects on the one hand, but also negative effects to the general costs of transport on the other hand. Depending on the energy carrier a lot of investments into new infrastructure will have to be done. This will have influence not only for the transport industry, but also on non transport industry. Fuel cell technology has additional positive socio-economic impacts like enabling more independence of imported energy carrier and technological progress in specific industry segments. Fuel cell technologies still require a lot of effort in R&D to become more economic. Nevertheless it seems that investment costs will increase for users. So people with a higher income will still have good access to transport, whilst people with low income may have negative impacts concerning the social functions of transport.

Key Technologies	Key Impacts	Scenarios				Time	Market	VC	TC	Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Hybrid Propulsion	GHGs	X	X	X		S - M	Small-medium	APCAR	ICONVE	X	X	X	X	
	Air quality impacts	X	X	X				UBUS	DECAR	X	X			
								VAN	RIDES					
	Resources	X	X	X					CARS	X	X	X	X	
	Nuisance	X	X	X					OCPT	X	X			

Hybrid Propulsion is also expected to have a significant role in the medium term, and be an important stepping stone technology to fuel cell deployment. Whilst enabling significant reductions in resource use and therefore greenhouse gas reductions, hybrid drive technology (for all-purpose cars, buses and possibly freight vehicles) will allow zero emission operation of these vehicles within urban areas where air quality improvements are of the highest priority. Nuisance impacts will also see remarkable improvements in slow-speed urban operations.

Key Technologies	Key Impacts	Scenarios				Time	Market	VC	TC	Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Advanced Conventional Propulsion	GHGs Air quality impacts Resources	X X X		X X X	X X X	All	Medium – Large	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT	X X	X	X X	X X	X X
	Economic development Public acceptance	X		X	X	All	Large	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT AVG	X	X	X	X	X
Advanced diesel	Improvement of fuel efficiency	X		X	X	All	M - H	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Advanced conventional propulsion describes the development of more efficient and cleaner propulsions systems based upon existing norms (e.g. Otto and diesel engines). These advances are likely to take the form of packages of technologies applied to various systems e.g. variable valve timing or turbocharging as part of the engine system and de-NO_x catalyst or particulate traps in the exhaust after-treatment systems.

Advanced conventional propulsion describes the development of more efficient and cleaner propulsions systems based upon existing norms (e.g. otto and diesel engines). Under the assumption that sustainability is not promoted by policy and/or societal forces advanced conventional propulsion is the dominating propulsion system, even in 2030. The technological advances are based on the conventional technology trajectories and therefore less efforts in new infrastructure is necessary. But nevertheless these propulsion systems are affiliated to the individual transport modes in passenger transport and the most common concepts with the highest growth rates in freight transport. In other words advances in these technologies will indicate extension of conventional physical infrastructure, which can be compensated with improved telematics application and for transport with advanced transhipment technologies.

For advanced Diesel engines improvements in fuel consumption (and therefore CO_2 emissions) from individual technologies are expected to be up to 20% compared with conventional petrol 1995. Advanced Diesel vehicles will be predominant in the BAU and Unrestricted Growth scenarios due to their durability, fuel economy and torque advantages. As regards the refuelling infrastructures, the established fuel distribution and supply infrastructure gives conventional petrol and diesel technologies a considerable advantage over others for all the efficiency impacts.

Key Technologies	Key Impacts	Scenarios				Time	Market	VC	TC	Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Tiltrotor	GHGs	X			X	M	Small	ROTOR	AIR	X		X		
	Nuisance									X		X		

Tiltrotor technologies enable significant advances in rotorcraft technologies. With the same functionality as helicopters, these vehicles will allow significant fuel savings and also considerable noise reductions. Both these impacts currently restrict helicopter deployment, especially within urban zones.

Key Technologies	Key Impacts	Scenarios				Time	Market	VC	TC	Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Electric and Hybrid Systems Negative:	Improvement of fuel efficiency Increase of construction cost	X	X	X		S - M	L – M	APCAR UBUS UCAR TRUCK VAN	ICONVE DECAR RIDES CARS OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Electric and Hybrid Systems. The Electric and Hybrid systems are currently significantly more expensive than their conventional counterparts and for such vehicles high costs are foreseen until 2020 because of the technology deployment. As the alternative vehicles penetrate the market, economies of scale are expected to bring down the high initial costs in the longer term. In particular, in Sustainable Growth scenario the high level of economic growth favour faster technological development of alternative propulsion systems, especially hybrid. This technology requires a large amount of R&D and adequate incentive polices will enable the technology to achieve the necessary industrial breakthrough. In the near term hybrid systems, both series and parallel, for their technical features are the best option to achieve significant improvement in fuel efficiency. The major requirement for electric vehicles is to have their batteries recharged on a regular basis. Consequently, recharging facilities are a key infrastructure requirement. The existence of large electricity production, transmission and distribution networks can easily accommodate markets of EVs for niche applications in urban areas. Overnight and normal recharging processes, using household electricity plugs, are expected to prevail during the early stages of EV introduction. Market penetration might be improved through the development of public charging stations, as are being established in some locations. Specific standards have to be introduced for safe and cost-effective charging. An other issue to be addressed regards the payment system. Smart card is the more reliable but other user interfaces could be developed. Hybrid vehicle’s requirements broadly mirror those of conventional and electric vehicles, assuming an electric/petrol vehicle.

Key Technologies	Key Impacts	Scenarios				Time	Market	VC	TC	Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Defrosting/de-icing system	Accidents				X	2030	85%	SUBAIR	AIR			X		

Defrosting/de-icing system. A system for defrosting/de-icing the wings, structures and equipment of aircraft. The subsonic aircraft maintain its very high diffusion (85-90% in the different scenarios) and it will be equipped also with intelligent-co-pilot, fly by-wire, advanced landing system and air traffic management with high score on safety impact.

This system protects the wings, structures and equipment of aircraft in case of snow, ice and if there are very low temperatures.

According to the last studies this system is very efficient to improve the level of safety for the air mode, in fact it causes a decrease of accidents even at 9% these results are forecasted with a market share of 40% in 2020.

There are other positive effects like greater punctuality of aircraft and so a less congestion of the airport infrastructures.

This system achieves a market share of 85% in UG at time horizon of 2030: in fact only in this scenario and at this time horizon is possible to equipped the largest part of air fleet with this system security.

Key Technologies	Key Impacts	Scenarios				Time	Market	VC	TC	Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Lightweight materials and structures	Reduction of operating costs per payload Negative: Increase of construction costs	X	X	X	X	M	Not available	MEGAAIR SUBAIR ROTOR SCT AIRSHIP	AIR			X	X	
	Economic development	X	x	X	X	M	large	all VCs	all freight	X	X	X	X	X

Lightweight materials. This technology allows for weight savings in air vehicles with primary benefits consisting in increased payload and secondary in reduced consumption (the latter benefit is higher for megaliner).

Light weight technologies can be used for each vehicle concept and represent an important future construction principle (energy consumption, decrease of resource use, etc.). This provides also changes in production technologies, where also some R&D is necessary, even to improve EC-competitiveness. Changes in production will always have positive employment effects.

Key Technologies	Key Impacts	Scenarios				Time	Market	VC	TC	Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Improved aircraft engines	Improvement of fuel efficiency	X	X	X	X	M	H	MEGAAIR SUBAIR SCT	AIR			X	X	
Negative:	Increase of construction costs													

Improved aircraft engines. Fuel economy improvements in the range of 10-15% seem to be possible by design and materials (ceramics allowing for higher combustion temperatures) improvements to turbofan engines in the short-term. Larger benefits of 20-30% are likely to come from the introduction of inducted (propfan) engines in the medium term. Costs are currently slightly higher but are likely to decrease to competitive levels if applied on a large scale.

8.6.2 Key telematic technologies

Key Telematic Technologies	Key Impacts	Scenarios				Time	Market	VC	TC	Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Combined on-board emissions and engine management	Improvement of fuel efficiency	X	X	X	X	S - M	M – H	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Combined on-board emissions and engine management. The major impact of this function is to contribute to the improvement of the engine efficiency.

Key Telematic Technologies	Key Impacts	Scenarios				Time	Market	VC	TC	Problem Areas				
		BAU	SB	SG	UG	Horizons	Potential			UP	UF	IP	IF	RP
Multi-modal traveller information/trip planning	Travel Time Saving Improvement of comfort	X	X	X	X	S	H	APCAR UCAR VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT VANLT AVGP	X	X	X		X

Multi-modal traveller information/trip planning. Providing traveller information over several modes of travel can be beneficial to both the traveller and service provider. Enhanced information about intermodal connections will reduce delay at intermodal facilities and improve accessibility. For passengers, better information about transfers means shorter delays in waiting for transportation services (e.g. transit bus, shuttle, transit van) and reduced uncertainty about making connections. For passenger transport positive impacts are also expected, especially as regards the efficiency of public services like demand responsive systems and car-pooling.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Dynamic route planning	Travel Time Saving	X	X	X	X	S - M	M – H	APCAR UCAR TRUCK VAN UBUS LDBUS	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Dynamic route planning. In-vehicle Route Guidance systems, which provide drivers with turn-by-turn instructions based upon prevailing traffic conditions to guide them to their destinations, are estimated to provide savings in travel times of 4-8%.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
In-vehicle traffic information	Travel Time Saving Improve-ment of comfort	X	X	X	X	S	H	APCAR UCAR TRUCK VAN UBUS LDBUS	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

In-vehicle traffic information. Systems as RDS-TMC (Radio Data System - Traffic Message Channel) provide drivers with easy to understand information on current traffic conditions via their radios are estimated to provide savings in travel times of 3-9%. The main likely impacts are reduction in travel time, increases in speeds, decrease in number of stops for equipped vehicles, some benefits for non equipped vehicles. The benefits are expected to decrease with higher market penetrations.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Electronic tolling	Travel Time Saving Improve-ment of comfort	X	X	X	X	S	M – H	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Electronic tolling. Deployment of Electronic Tolling is being driven mainly by cost savings to the operators. A recent study carried out by Hughes Transportation Management Systems, Canada, has showed that Electronic tolling can reduce the cost of staffing toll booths by 43.1%, money handling by 9.6% and roadway maintenance by 14.4%. Electronic tolling for motorways is estimated to produce benefits for both equipped and non-equipped vehicles and over 40h/year for the average European motorway commuter. Increases in throughput on a per-lane basis up to 250% have been reported in the US. European trials have so far reported no evidence of car usage due to the spatial and time redistribution of traffic.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Navigation	Travel Time Saving Improve-ment of comfort	X	X	X	X	S	M – H	APCAR UCAR TRUCK VAN UBUS LDBUS	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Navigation. Vehicle navigation devices can benefit users in terms of travel time and route finding. Field operational test experiences are producing data that suggest an increase of travel time saving for equipped vehicles of about 20%.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Traffic control	Travel Time Saving Improve-ment of comfort	X	X	X	X	S	M – H	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Traffic control. Traffic control for interurban applications is estimated to produce 10% reduction in congestion when added to incident detection. The application of a real-time variable message sign control and re-routing strategy has produced reductions in traffic delays of up to 20% in European trials. For urban areas is estimated to increase network capacity by 3% equivalent to a 3% decrease in congested network and significant reductions in travel time. European field trials have reported increases in mean road speed in the range between 10 and 20% and up to 20% reduction in travel time. Applications in the US have reported decreases between 8 and 15% in travel time, increases between 14 and 22% in travel speed, decreases up to 35% for vehicle stops and decreases between 17 and 37% of delays. Variable Message Signs, which provide up-to-date accurate information to drivers, have shown up to 20% reduction in traffic delays.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Parking management	Travel Time Saving Improvement of comfort	X	X	X	X	S	M	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Parking management. Parking management is estimated to produce benefits to the general level of traffic congestion. European trials report increase of Park & Ride usage which more than doubled with non quantified effects on congestion.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Automated Driverless Transport	Travel Time Saving Improvement of comfort	X		X	X	L	L	APCAR TRUCK VAN LDBUS	ICONVE RIDES CARS IPT OCPT HTRUCK VANLT AVGP			X	X	

Automated Driverless Transport. The introduction of this function can lead to a reduction of driving stress and tedium, elimination of adverse driving behaviour, and saving of travel time.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Anti-collision	Improve-ment of comfort	X		X	X	M - L	M	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X
	Accidents reduction	X			X		40%	APCAR UCAR UBUS	ICONVE OCPT	X		X		

Anti-collision. Anti-collision and warning systems are expected to result in safety and effective capacity benefits by reducing the number of accidents. European surveys on workload effects resulting from display use has shown no significant variations in workloads, with resulting enhanced comfort conditions.

This device is able to make the vehicle keep the safety distance from the preceding vehicle. Thus, it reduces the risk of collisions.

According to Prometheus assessment, the use of this technological trajectory (TT) allows up to 7% reduction in the number of accidents and has extremely positive effects on the reduction in the number of deaths and injured. These good results derive from a medium-high market share forecasted for the future, in fact anti-collision will achieve a market share at least even at 40% in 2030.

There are also other positive effects like less traffic and a reduction of lost time for congestion caused by accidents; less social costs as social security costs, assistance costs and sanitary costs for all subject involved.

The anti-collision has a good market penetration in BAU and UG scenarios where it has a market share at least even at 40% for all vehicle concept at time horizon of 2030; particularly for the vehicle concept of urban car is forecasted a very fast diffusion with a market penetration even at 85% in BAU at time horizon of 2030.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Smart card	Improve-ment of comfort	X	X	X	X	S	H	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Smart card. Results of the DRIVE Project GAUDI showed that with many users using the smart card for other modes as well, queuing time for exit by motorists with smart cards was significantly reduced.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Drive by wire	Improve-ment of comfort	X	X	X	X	M	H	APCAR UCAR TRUCK VAN UBUS LDBUS	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Drive by wire. This function permit the replacement of mechanical sub-systems by electronics-based equivalents, with resulting better comfort.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Vision enhance-ment	Improve-ment of comfort	X	X	X	X	S	M	APCAR TRUCK VAN LDBUS	ICONVE RIDES CARS IPT HTRUCK VANLT AVGP			X	X	X

Vision enhancement. In-vehicle vision enhancement cam improve comfort and safety for driving conditions involving reduce site distance due to night driving, inadequate lighting, fog, snow, or other inclement weather conditions.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Autonomous Intel-ligent Cruise Con-trol	Improve-ment of comfort	X		X	X	S - M	L – M	APCAR TRUCK VAN LDBUS	ICONVE RIDES CARS HTRUCK VANLT AVGP			X	X	X

Autonomous Intelligent Cruise Control. This function potentially can provide a substantial increase in driver comfort and safety. Critical vehicle control indicators such as speed choice and distance keeping can be substantially improved by specific applications.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Fleet Management	Travel Time Saving	X	X	X	X	S	M – H	APCAR UCAR TRUCK VAN UBUS LDBUS	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Fleet Management. Commercial vehicle operations improved by telematics technologies allow benefits of service efficiency for fleet managers and drivers. Recent trials in Europe showed that Freight and Fleet (F&F) management functions should provide savings in travel time close to 5% (trials range 0-16.5%) and savings in dispatch time above 12% (trials range from -4.2 to 35.2%). Travelled distance should accordingly be reduced by over 6% (trials range 0.3-21.3%). Other results showed that, using Transport Telematics and Mobile Data Communications for F&F management functions up to 37,5% of the currently wasted time (waiting time, pick-up time, delay time) could be saved and the number of delayed arrivals decreased by 35%. As regards public transport, transit management systems have demonstrated that they are capable of reducing travel time both by improving the operation of the vehicles and the overall operation of the transport network. Transit management systems improve schedule adherence resulting in a reduction in passenger wait time and improvement in transfer co-ordination. Also, the application of advance transit systems reduce the operating costs and improve staff productivity and the use of facilities and equipment.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Integration of Information technologies with GNSS	Travel Time Saving	X	X	X	X	S	M	CHRAIL HSRAIL MAGLEV LRTPM GSINNO	LDRAIL CRAIL	X	X	X	X	X

Integration of Information technologies with GNSS. A better integration of information technologies with GNSS can enhance rail traffic, with better management of timescales and consequent improved travel time.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Rail Traffic Management for Long Distance Passenger and Freight	Travel Time Saving	X	X	X	X	S	M	HSRAIL CHRAIL LRTPM GSINNO MAGLEV	LDRAIL CRAIL			X	X	

Rail Traffic Management for Long Distance Passenger and Freight. Rail traffic control reducing headways by transmission-based control systems is seen as a key method of increasing track capacity and improving performance.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Lane keeping	Accidents reduction		X	X		2030	40%	APCAR UCAR	ICONVE	X		X		

Lane Keeping. This prevents the vehicle from accidentally passing over the line of separation between lanes, thereby reducing the risk of side and front-side collisions. In case of accidental deviation, the device can autonomously realign the vehicle's direction. According to Prometheus' assessments, it reduces the number of accidents by 0.8 to 2.6% and, consequently, it reduces also the number of deaths and injured; these results derive from a medium-high market share forecasted for the future, in fact lane keeping will achieve a market share at least even at 40% in 2030.

This telematic innovation has a good market penetration in SB and SG scenarios, in which it achieves a market share even at 40% for all-purpose car and urban car at time horizon of 2030, but it hasn't a very fast and large diffusion because in some vehicle concept it is not present.

Key Telematic Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Driver monitoring	Accidents reduction			X	X	2030	45%	APCAR	ICONVE	X		X		

Driver Monitoring. This is a device that permits to define the physical conditions of the driver and in case of detection of fatigue, stress or excess of alcohol situations emits a sound alarm. It does not intervene in immobilising the vehicle automatically. It can reduce the number of accidents by 5 to 18% and obviously it reduces also the number of deaths and injured; these results derive from a medium-high market share forecasted for the future, in fact driver monitoring will achieve a market share at least even at 40% already in 2020.

This telematic innovation has a large diffusion, even at 45% in SG and UG scenarios at time horizon of 2030, particularly for the VC all-purpose car.

All the telematic functions that contribute to reduce congestion are expected to benefit also fuel efficiency and emission reduction.

Telematics technologies have not been assessed explicitly for their environmental impacts.

Telematics technologies that promote smoother traffic flow will reduce fuel consumption and CO_2 emissions from road vehicles. The same principle is true also for other modes. Examples include autonomous intelligent cruise control and guidance and navigation systems. Roadside emissions monitoring technologies are likely to be too complex and costly for wide deployment, but on-board sensing and engine management systems may be significant, especially for heavy vehicles.

Secondary benefits may be gained from the modal shift that is promoted by use of Telematics and traveller information systems as part of public transport provision.

8.6.3 Key intermodality technologies

Key intermodality technologies – technologies for intermodality can be divided in physical and informational connectivity and components for intermodality. Physical connectivity will be provided by transhipment and terminal technologies, information connectivity by I&C technologies and components are presented by the different vehicle concepts (e.g. as an element of intermodality) and container technologies.

Key Intermodality Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Multi-modal traveller information/trip planning	Travel Time Saving Improvement of comfort	X	X	X	X	S	H	APCAR UCAR VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT VANLT AVGP	X	X	X		X

Multi-modal traveller information/trip planning. Providing traveller information over several modes of travel can be beneficial to both the traveller and service provider. Enhanced information about intermodal connections will reduce delay at intermodal facilities and improve accessibility. For passengers, better information about transfers means shorter delays in waiting for transportation services (e.g. transit bus, shuttle, transit van) and reduced uncertainty about making connections. For passenger transport positive impacts are also expected, especially as regards the efficiency of public services like demand responsive systems and carpooling.

Key Intermodality Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Parking management	Travel Time Saving Improvement of comfort	X	X	X	X	S	M	APCAR UCAR TRUCK VAN UBUS LDBUS PTW	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Parking management. Parking management is estimated to produce benefits to the general level of traffic congestion. European trials report increase of Park & Ride usage which more than doubled with non quantified effects on congestion.

Key Intermodality Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Fleet Management	Travel Time Saving	X	X	X	X	S	M - H	APCAR UCAR TRUCK VAN UBUS LDBUS	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP	X	X	X	X	X

Fleet Management. Commercial vehicle operations improved by telematics technologies allow benefits of service efficiency for fleet managers and drivers. Recent trials in Europe showed that Freight and Fleet (F&F) management functions should provide savings in travel time close to 5% (trials range 0-16.5%) and savings in dispatch time above 12% (trials range from -4.2 to 35.2%). Travelled distance should accordingly be reduced by over 6% (trials range 0.3-21.3%). Other results showed that, using Transport Telematics and Mobile Data Communications for F&F management functions up to 37,5% of the currently wasted time (waiting time, pick-up time, delay time) could be saved and the number of delayed arrivals decreased by 35%. As regards public transport, transit management systems have demonstrated that they are capable of reducing travel time both by improving the operation of the vehicles and the overall operation of the transport network. Transit management systems improve schedule adherence resulting in a reduction in passenger wait time and improvement in transfer co-ordination. Also, the application of advance transit systems reduce the operating costs and improve staff productivity and the use of facilities and equipment.

Key Intermodality Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Unitised packaging systems	More efficient use of space in vehicle and travel time savings	X	X	X	X	S	M	all Freight	HTRUCK VANLT CHRAIL HSRAIL				X	

Unitised packaging systems. They represent an attempt to develop a form of containerisation for inland transport. The successful implementation of such a scheme would allow easier transhipment and more efficient use of space in vehicles.

Key Intermodality Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Transferia	Higher system productivity with reduced vehicle-kms Negative: higher costs	X	X	X	X	S	M	All	ICONVE DECAR RIDES CARS IPT OCPT HTRUCK VANLT AVGP		X			

Transferia. They relate to both passenger and freight to serve urban areas. In the passenger sector they include transfer-parks, innovative P&R terminals, railway stations, airports, seaports and river ports including operation guiding systems and communication technologies. In the freight sector they include goods transfer parks, freight centres, city terminals, with the necessary technical, operational and management tools. Transferia equipped with new technologies can accelerate significantly the transport process of both passengers and goods. The reliability, punctuality and quality of transport processes will increase. This provides a higher system productivity and therefore an improved economy. Higher costs of investments will be required than conventional installations. Operating and maintenance costs will decrease by the relevant use of capacity with positive impacts to the users' costs.

Key Intermodality Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Cargo Handling	Higher system productivity with reduced vehicle-kms Negative: higher costs	X	X	X	X	S	M	TRUCK VAN CHRAIL HSRAIL ELESHIP FIFERRY	HTRUCK VANLT URAIL RRAIL LDRAIL SHIP		X		X	

Cargo handling technologies. They include a range of technologies for automating the interfaces between different rail, road and waterborne modes. They include storage modules and guidance and control. Design is modular and customer orientated. Times of loading and unloading will be reduced, reliability increased. Economic viability for high volumes of goods only due to high costs.

Key Intermodality Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Automation, Disposition & Control technologies (I&C)	Economic development Public acceptance Social cohesion	X	x	X	X	S-M	Large	GSINNO APCAR VAN TRUCK CHRAIL URAIL LDRAIL HSRAIL SUBAIR	AVG SHIP AIR RAIL OCPT	X	X	X	X	x

I&C technologies describe a wide area of application in transport. It includes the telematics application as well as internet technologies. Pre-trip and on trip information, electronic payment systems, etc. will improve access to public forms of transport and make it more comfortable to potential users. Traffic management systems, also including disposition systems are necessary to solve the increased future transport demand, so that physical infrastructure extension can be limited. These technologies area are seen as one of the dominating growth sectors in the industry. It will provide big chances for new companies (industry, service provider, operator, etc.) and especially for SME. I&C technologies provide the informational connection within intermodal and interoperable transport chains. They are also important for EU competitiveness as well as for the social cohesion and quality of life of EU inhabitants. Further development and implementation of these technologies have to follow the objectives of the single market.

Key Intermodality Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Transhipment (incl. terminals)	Economic development Public acceptance	X	X	X	X	S-M		all freight	all freight		X		X	

Transhipment including advanced terminal technologies are boundary conditions for improved intermodality and interoperability. Intermodality and interoperability may be one key to provide the future transport demand, especially in the freight sector. These technologies have to be linked with I&C technologies so efficiency could be improved in a system's context. A higher grade of standardisation and common regulation is necessary to meet these objectives. Transhipment technologies in combination with I&C technologies offer a lot of opportunities for new market actors in the field of service and infrastructure providers, supply industry, etc. These high potentials are also open for SME. Standardised transhipment is also important for the enlargement process in Europe.

Key Intermodality Technologies	Key Impacts	Scenarios				Time Horizons	Market Potential	VC	TC	Problem Areas				
		BAU	SB	SG	UG					UP	UF	IP	IF	RP
Container (in combination with I&C)	Economic develop-ment Public ac-ceptance	X	X	X	X	S-M		TRUCK CHRAIL SHIP AIR	all Freight				X	

Container technologies and their standardisation is an important element of transhipment and a necessary boundary condition to improve intermodality and fairly meets the objectives of the single market.

Bulk containerised transport, in combination with intermodality features is one key for the prognoses in growth, but requires standardisation and investment in infrastructure, e.g. loading / unloading facilities, cargo tracking and monitoring systems, automated payment systems. Automation of loading/unloading leads to reduced employment, also to less physical jobs, requiring higher education of staff as computer control becomes more important. In CEEC reduction of demand for bulk transport continues with industrial restructuring. Optimisation will require logistics technology to be introduced Depending on the scenarios, containerised transport could be nearly exclusively based on road transport, or on a rail/intermodality combination. The latter case would imply a fast upgrading and construction of new transhipment facilities before a "lock-in" into road-based transport takes place in CEEC. Waterways, but also rail infrastructures will require upgrading in the future in order to be able to absorb a larger fraction of non-bulk freight transport (e.g. containers).

Key intermodality technologies – technologies for intermodality have not been explicitly identified and assessed for environmental impact. However, some general remarks can be made on the possible indirect environmental impacts of intermodality e.g. effect of land use for intermodal transfer points, possible effects on local air quality and nuisance (noise) of vehicles timed to meet at one point. No technologies that contribute to intermodality can be identified in the environmental context.

D22 "Synthesis of impact assessment and potentials"

8.7 Final forecast of market shares

If the actors considered are the users, the level that is most relevant in the FANTASIE generalised model of transport systems is that of TC. The TC is the level represented by a population of different VCs framed in an operating environment such that a specific transport service is provided to the users. TCs can basically be interpreted as transport modes. The mode domain is that where the users' choices apply. Other domains relevant to users' choices are those of vehicle ownership and trip frequency but these are mainly affected by factors in the socio-economic sphere. The FANTASIE primary focus is on the impacts on future transport systems which can be expected from the developments in the supply of transport services and in technologies.

The assessment of the users' preferences in the FANTASIE perspective is mainly represented by the forecast of the future demand for transport modes – the TCs in the FANTASIE terminology.

Evidence of large-scale and long-term demand model of transport systems is relatively scant (a recent study on future world mobility patterns is in Schafer and Victor, 1997). A preliminary forecasting exercise for EU future demand of transport systems was carried out as of chapter 7.

The stage here is aimed at developing a forecasting process which provides TC market shares based on the assessment of the relevant impacts and their future expected changes which were not taken into account in the preliminary forecasts. The process takes as input the technology developments and the lines of developments of the different TCs which can be expected according to the behaviours of the other decision-makers – producers, operators and policy makers – in the set of the four FANTASIE exogenous scenarios. The forecasts apply to the different problem areas and market segments.

To match the strategic perspective of the whole study where estimates of transport demand at EU level are relevant, the approach considers a conceptual model of the items which are object of the users' choices. The conceptual model-based approach draws upon the definition of a notional transport system and its operating environment and is suitable for a strategic perspective which provides visions of the future EU systems in an aggregate way rather than building them by summing up a number of different site-specific items. The alternative approach, consisting in considering specific cases, would have yielded results that are inevitably case-laden and therefore the EU strategic perspective of the study may have been impaired.

The urban passenger area

The users consider the availability as the most important variable in mode choice decisions, whatever the income class. Cost shows a decreasing importance as the income per head increases. Comfort ranks the lowest.

The market in base year 1995 is dominated by private conventional modes, i.e. individual conventional and dedicated vehicle. These TCs are given the highest priority in terms of time, comfort and availability. Ridesharing and urban rail show considerably lower shares. Ridesharing shows the highest priority for cost, urban rail for ranks highest for reliability.

Significant increases in cost of individual conventional and dedicated vehicle are expected in sustainable scenarios due to pricing policies. Fare of urban rail is expected to increase in BAU and UG, to decrease in SG and SB as consequence mainly of hypotheses on subsidisation.

Improvements in travel time are expected only in SB due to mainly reduced road congestion and service level improvements in urban rail consequent to favourable financial conditions.

Comfort is expected to increase in individual modes due mainly to technology improvements. Comfort improvements are expected in urban rail in sustainable scenarios.

The reliability of individual modes is expected to decrease, except for the SB, due mainly to increased road congestion while technology improvements are expected to improve urban rail reliability in UG and SG.

The availability of individual conventional and dedicated vehicle is expected to increase in BAU and UG following increasing car ownership, while the reverse is expected in sustainable scenarios due to car restriction policies. Encouraging and prioritisation policies area expected to increase the availability of ride sharing. Urban rail is expected to show higher availability in sustainable scenarios due to more favourable financial conditions.

Individual public transport, which enters the market in SB long-term time horizon, is expected to have a high rank for comfort, being it second after individual conventional and dedicated vehicle.

The individual conventional and dedicated vehicle is expected to maintain its dominance in the urban market in all scenarios but with opposite variations. In BAU and UG its market share is expected to increase, in SG and SB to decrease. Ridesharing is expected to decrease in all scenarios with higher rates in UG and SG.

The market subtracted in sustainable scenarios to individual conventional and dedicated vehicle is expected to be captured mainly by urban rail which shows increasing share and becomes the second TC in these scenarios. The individual public transport shows the lowest share which is subtracted mainly to individual conventional and dedicated vehicle.

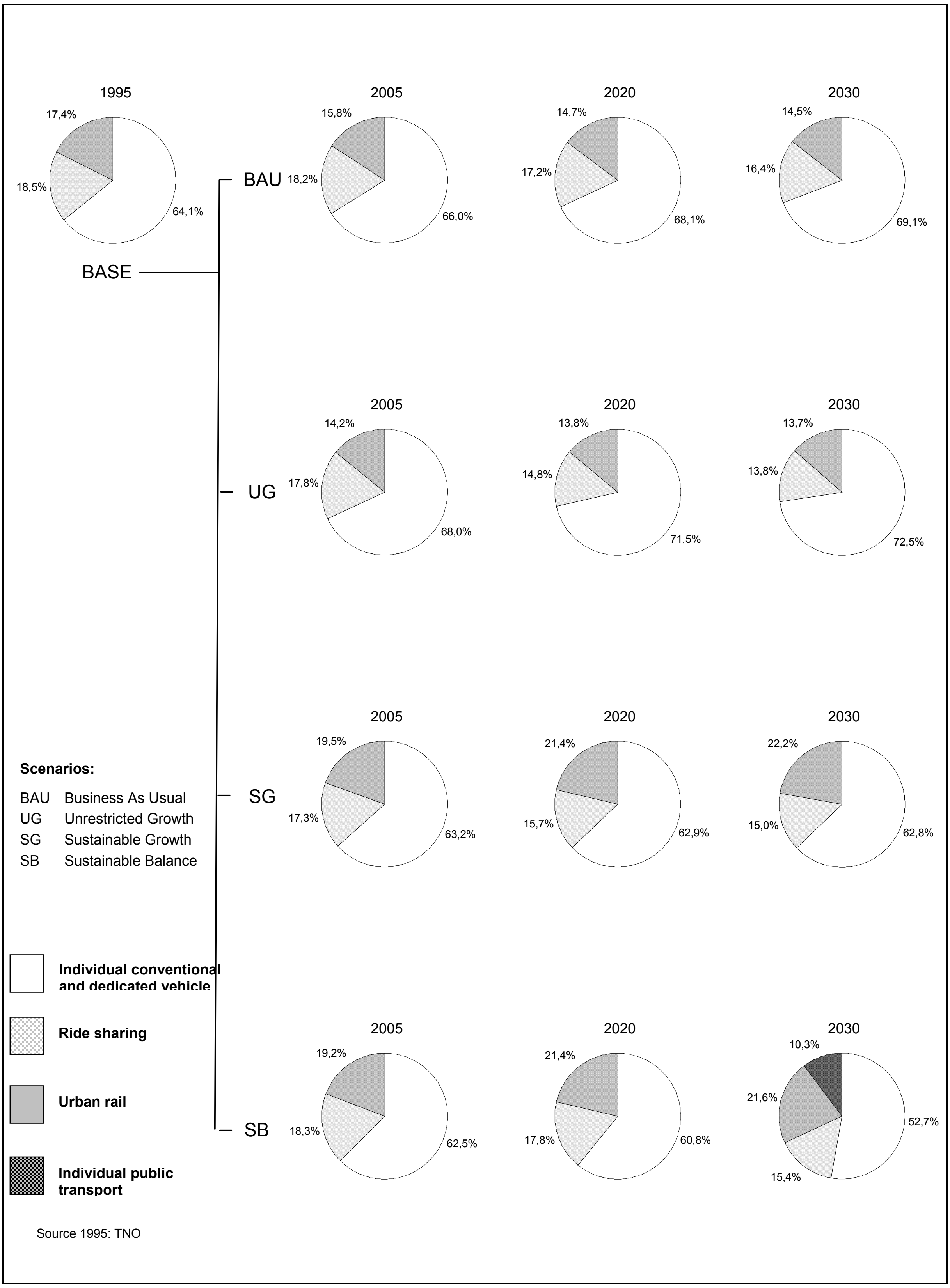

Figure 8.10: Expectations on market shares of EU urban passenger trips

The interurban passenger area

Two separate market segments are considered:

- medium-distance trips (<250 km); and
- long-distance trips (>250 km).

The users consider the availability the most important variable and time the least. In the future this ranking is maintained with decreasing weights of cost and increasing weights of availability.

In the medium-distance segment the market in base year is dominated by private conventional transport (individual conventional and dedicated vehicle). Ridesharing ranks second and rail (regional services are considered in this market) third. Private conventional transport ranks first for time, comfort, availability and reliability. Ridesharing ranks first for cost.

In the long-distance segment the market in base year is dominated by air transport. Considerably lower shares are shown, in decreasing order, by individual conventional and dedicated vehicle, ridesharing and long-distance rail. Air ranks highest for time, comfort and reliability. Air shows the same priority of individual conventional and dedicated vehicle for availability. Ridesharing shows the highest priority for cost.

The Automated Vehicle guidance (AVG) TC is expected to enter the market in 2020 in UG and SG, in 2030 in BAU.

Cost of individual conventional and dedicated vehicle and of ridesharing are expected to increase dramatically in SG and SB as consequence of internalisation policies which increase tolls. Reductions are expected in BAU and UG due to less fuel consumption. Rail fares follow the trends of urban rail in the medium-distance segment and show increases in BAU and UG and decreases in SG and SB. In the long-distance segment rail operators are expected to pay access cost to the network and to pass this cost onto the users. Fare increases are expected in UG and SG, slight decreases in SB only. Air fares are expected to decrease in all scenarios.

Travel time on individual conventional and dedicated vehicle and on ridesharing is expected to improve slightly in BAU, UG and SG due to congestion reduction. Rail travel time is expected to improve in the medium-distance segment in UG and SG due to improved rolling stock, to improve in all scenarios in the long-distance segment due to the extension of the high-speed rail network. Improvements are expected in air travel time as consequence of congestion reduction in the air and on the ground due to improved air traffic control.

Higher comfort of individual conventional and dedicated vehicle and of ridesharing is expected in all scenarios due to telematics and vehicle technologies. Higher comfort in rail is expected in SG and SB due to higher investments for improved stations and rolling stock. Improvements in air travel comfort are expected in UG and SG due to increased system accessibility.

Individual conventional and dedicated vehicle and ridesharing are expected to be more reliable in BAU, UG and SG where reductions in road congestion are expected. Advanced traffic control technologies are expected to bring about reliability improvements in rail in UG and SG, and in air travel in all scenarios.

The availability of individual conventional and dedicated vehicle is expected to increase in BAU and UG following increasing car ownership, while the reverse is expected in sustainable scenarios due to car restriction policies. Encouraging and prioritisation policies in sustainable scenarios are expected to increase the availability of ridesharing. Rail availability is expected to increase in sustainable scenarios in both segments due to investments. Air travel availability is expected to increase in all scenarios as consequence of increasing competition and number of operators.

AVG is expected to provide higher comfort than individual conventional and dedicated vehicle, lower cost and time due to smoother flows in BAU and UG where the concept is implemented in dedicated lanes, much lower availability.

In the medium-distance segment the individual conventional and dedicated vehicle maintains its dominance in the market in all scenarios and maintains almost its base market share before the appearance of AVG. Ridesharing is expected to decrease slightly except for SB where it maintains its base share. Rail shows a decreasing share in BAU and UG and an increasing share in sustainable scenarios but the increases are modest. The AVG shows to be given a high priority by passengers in that it ranks second after individual conventional and dedicated vehicle.

In the long-distance segment air travel maintains its dominance in the market in all scenarios. In BAU and UG air almost maintains its base market share, in sustainable scenarios slight increases of air share are expected as consequence of the decreasing market of road modes. The individual conventional and dedicated vehicle is expected to increase its market in BAU and UG. These gains are made at the expense of rail which decreases its market share in BAU and UG. Rail shows modest increases in SG and SB. Ridesharing shows in all scenarios a decrease but at a very low rate.

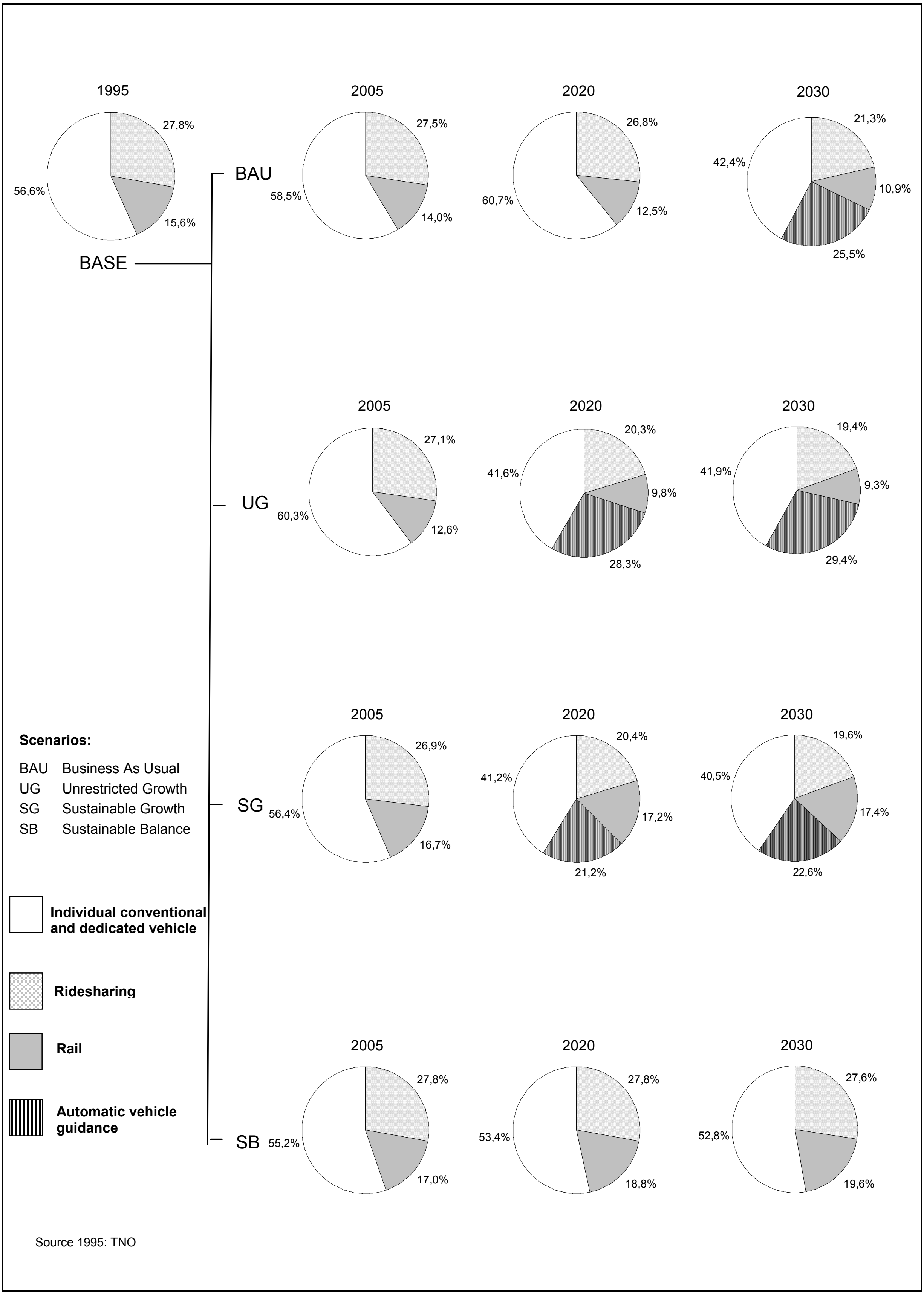

Figure 8.11: Expectations on market shares in EU interurban passenger trips: medium distance (<250 km)

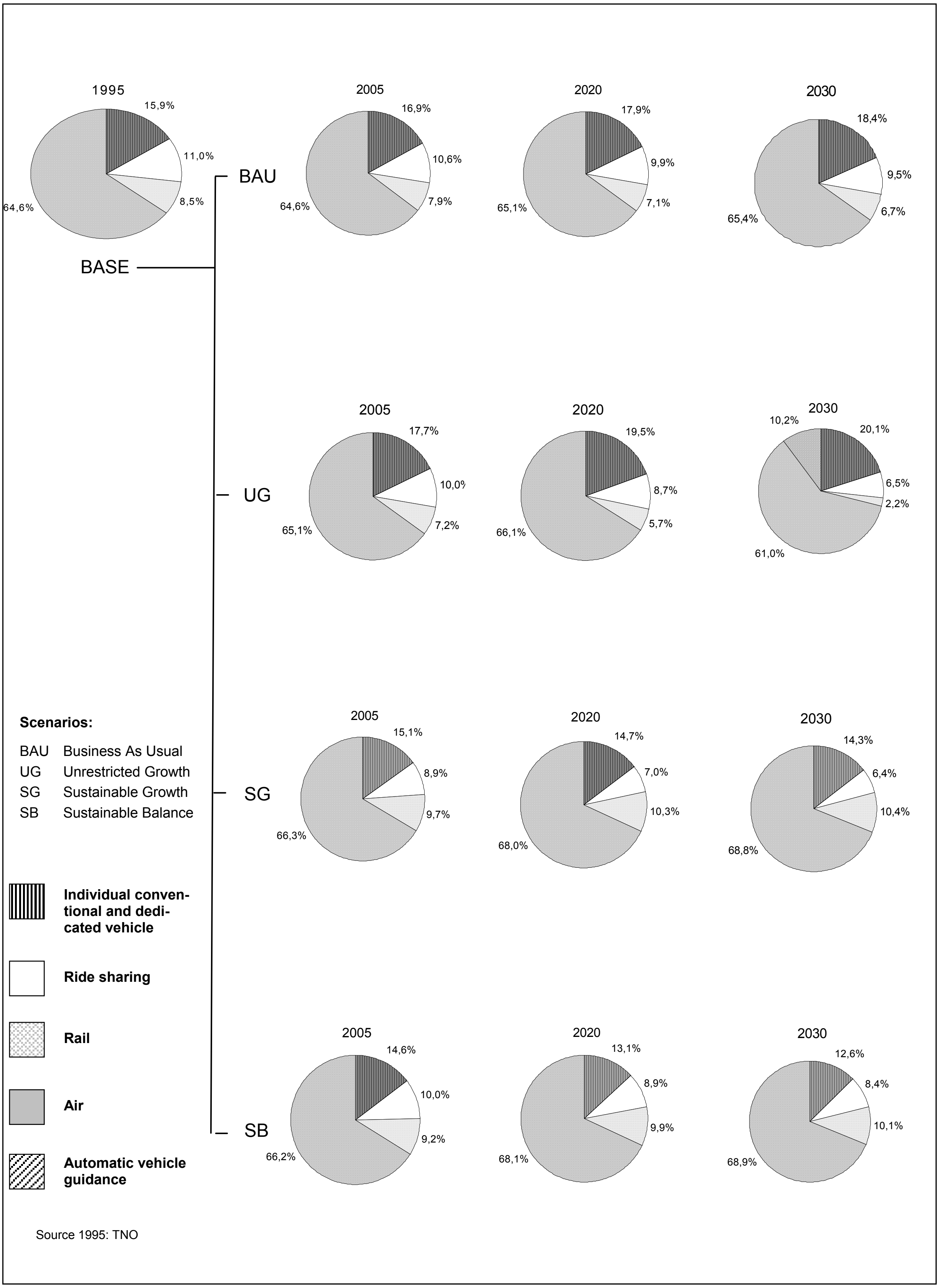

Figure 8.12: Expectations on market shares of EU interurban passenger trips: long-distance (>250 km)

The interurban freight area

Only the long-distance segment (>250 km) is considered.

The shippers consider cost the most important variable. Availability ranks second, reliability last but comparable to safety and time.

The interurban freight transport market shows in base year, in terms of tonne-km, road TCs with the highest shares, followed by waterborne TCs (second) and rail TCs (third). Air transport represents only a niche market for freight and is not considered here. Road TCs show the highest priority for reliability and availability. Highest priority for cost is shown by waterborne TCs. All variables have a comparable importance for rail.

The AVG TC is expected to enter the market in 2020 in UG and SG.

In BAU and UG changes in road transport cost are expected to decrease while in the sustainable scenarios it is expected that pricing policies will be largely implemented with dramatic effects on average costs. In the rail segment fares are expected to increase in UG and BAU since operators are expected to pay access cost to the network, slight decreases in SB only. No significant changes are foreseen for waterborne fares.

Travel time for road transport is expected to decrease in all scenarios due to the effects of decreasing congestion. Rail travel time is expected to decrease at different speed in all scenarios, due to improved rolling stock and the implementation of the freight freeways. Improvements are expected in waterborne travel time as consequence of congestion reduction in the move and at the ports due to improved traffic control.

Safety shows positive changes in all scenarios for all TCs. Road safety is increased through the adoption of anti-collision, driver monitoring and lane keeping systems; the increase is higher in UG, intermediate in SG, lower in BAU and SB. A higher safety level for railways derives from new infrastructures and more sophisticated rolling stock; it is foreseen that the change will be higher in UG, lower and equal in all remaining scenarios. The adoption of new traffic control systems and transhipment equipment will improve safety levels also for waterborne transport, particularly in ports; the trend will be higher in UG, lower and equal in all remaining scenarios.

Variations in reliability are linked to changes in the levels of congestion, investments, technological development, promotion of intermodality, efficiency of logistics. All modes show a differentiated increase in reliability in all scenarios, excluding BAU where road transport shows a decrease.

The availability of transport services strongly depends on production and demand. Since all scenarios present an increase in GDP, the availability of transport services will increase for all modes in all scenarios at the speed of GDP or related to it and to the policies specific of each scenario. In this way in UG the increase will be the same for all modes and the highest possible. The SG scenario follows in terms of increase in transport services; particularly intense for railways. The BAU and SB scenario are characterised by the lowest trends, differentiated among the various transport modes: since intermodality is promoted, railways have the highest variation in availability, road the lowest.

In the AVG case all the variables follow the trends determined for the road case in the period 2020-2030.

In terms of market shares, road travel maintains its dominance in the market in all scenarios, reinforced by the AVG in the period 2020-2030 which can be regarded as a particular segment of road transport. The BAU scenario, due to the hypotheses used in the forecasting model, presents a substantial steadiness of the market shares of the different modes. The specific policies adopted for the promotion of intermodality and the reduction of road congestion in the SB scenario, provoke a decrease in the road market share in advantage of all the other modes. The entry of the AVG system on the market in 2020 changes significantly the situation in the UG and SG scenarios: all the transport modes lose significant part of their market in advantage of the new system.

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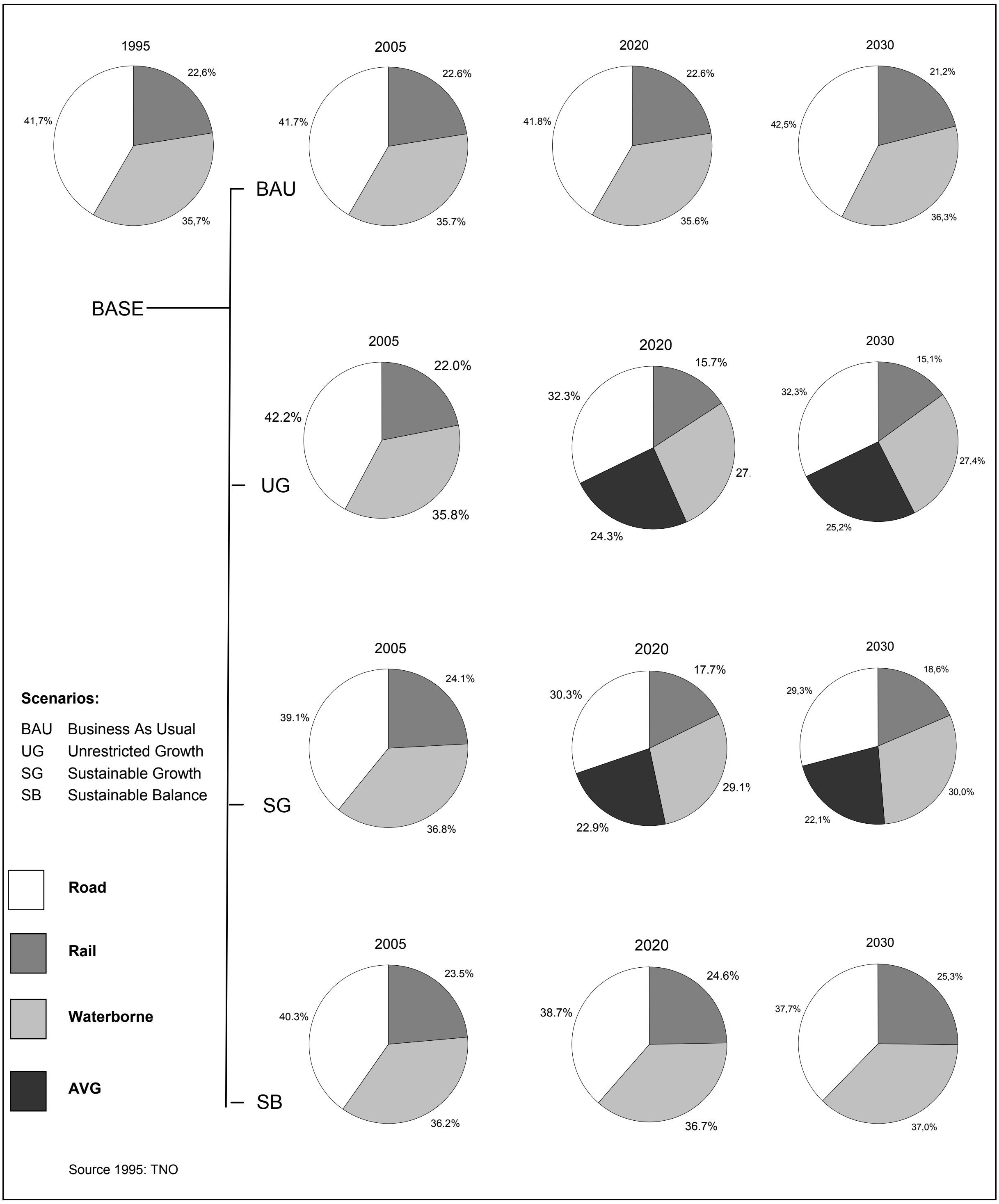

Figure 8.13: Expectations on market shares of EU interurban freight transport

9. POLICY OPTIONS

9.1 Technology selection for policy options

The bottom-up approach

The FANTASIE consortium has executed the technology search and assessment from bottom-up, starting at the concept level, followed by a study of the applications. The market potential of technologies has been analysed at the transport concept level. The assessment of technologies has been integrated at the transport system level, although the actual assessment had always to be done at the level of transport concept or even the application level.

Filtering the technologies and synthesising them to applications helps to get some structure in the virtual chaos in technological possibilities. Choices have to be made in that process, which means that certain technological options disappear, even though they might have potential applications. Completeness is an impossible requirement for a survey of a domain that is so large and so rapidly changing. The selection process that was followed to find the most promising technologies consisted of the assessment of the most important (in the sense of market share) transport concepts with respect to the objectives of the Common Transport Policy.

The 'intuitive' selection of relevant technologies

After the inventory of technologies and the assessment of the transport concepts, the FANTASIE consortium has held a workshop with the objective to generate a list of a few most important technologies and to identify the policy options that could be recommended to foster these technologies. The approach of these workshops is one of the *expert-guess*. It is meant to avoid that certain important technologies are missed because of a flaw in the surveying and selection process. Since the members of the FANTASIE consortium have acquired much knowledge that was not all integrated in the bottom-up assessment process, this separate search for promising technologies was conducted.

The following technologies and innovations were identified as most promising:

- fuel cell;
- tele-activities (teleworking, e-commerce, m-commerce, remote diagnostics etc.);
- authentication (technologies to identify a person, including electronic signature);
- information and payment telematics;
- freight telematics;
- multimodal passenger terminals; and
- airship.

The original list of relevant technologies was much longer, but in the workshop the participants had to focus on the most relevant technologies and only a limited selection was left over. Such workshop processes appear to provide a very efficient method to focus the attention and to place the emphasis on a few important items. The workshop process has in this respect advantages over the assessment process, which is more objective but gives less explicit choices of technologies.

Most technologies emerging from this workshop have been studied in the bottom up process too. 53 very promising technologies of both approaches have been used for the following policy options.

9.2 Specific roles and options for European policy

The key questions this chapter aims to address are:

- Which of the most promising technologies have not yet addressed by EU policy, and from a role that would be appropriate for the EU?
- Which specific measures could possibly be taken over the next few years to stimulate the innovation process from the European policy level?
- How could such measures be integrated in and connected to the current policies, programmes and key actions?

The discussion has been structured along lines of the 53 most promising technologies identified. Based on the analysis in earlier chapters, we can assume for each of the most promising technologies that

- they are contributing to the achievement of the CTP objectives; and
- they are likely to have a major impact.

Each technology has been analysed in terms of the *current and potential policy roles and options over the next few years* to complement the current or the next research and policy programmes ("policy packages"). In addition, emphasis was put on the identification of additional "needs for action" in relation to policies and key actions, not so much on identifying current policy actions that appear to be questionable from the perspective of the approach to transport innovation policy as outlined. For each action suggested, it will also be indicated to which of the current policies and key actions it would have the closest link.

With further progress of the individual technologies along the innovation process, it may become necessary for the Union to take over other roles and options than the ones that are currently advisable, but we are most interested in giving advice for the medium-term, i.e. for the preparation of the next generation of policy programmes, such as e.g. the next Framework Programme.

The detailed needs for action are presented in Annex A.

9.3 Generic policy conclusions

Three general observations can be made after reviewing current and possible transport technology policy actions. First, many of the most promising technologies identified in FANTASIE are only indirectly addressed in the current EU policy programmes by defining requirement profiles rather than specific technologies. This reflects the reluctance to adopt a "technology push" approach. While this is probably appropriate in the early phases of technology innovation, the stimulation of later phases of the innovation process could most likely be improved by a more specific approach. In later phases, issues of co-ordination, harmonisation, standardisation and regulation become more important; problems are difficult to resolve without specific reference to individual *types* of technologies.

A second general observation is that for most technologies a combination of targeted and framing policies is needed. Targeted technology policies can be specific R&D and pilot action, aiming not only to improve a technology that is of cross-European benefit, but also to provide a solid foundation for changes in transport and other transport-related policies. These latter framing policies (taxation, regulation, land-use planning, pricing, and liberalisation) are often needed to *enable* the uptake of new technologies. With many of the most promising technologies having left the R&D stage and being now close to market introduction, EU RTD policy has an important role to play to inform and trigger such enabling policies, e.g. through monitoring and assessment tasks that in many cases will require also R&D and pilot actions. Pilots/demos have thus a twofold function by contributing to advance the knowledge bases and transfer in the European transport industries, but also to inform and underpin policy.

A third general observation is that technology and industrial policy are increasingly overlapping. This is most obvious in the case of the key action aeronautics, but also in other key actions. In view of the growing importance of regulatory and standardisation issues for many of the technologies identified, especially in later phases of the innovation process, this does not come as a surprise. It is crucial to address such industrial issues early enough to have barriers to uptake removed once the technology is ready to move onto the market.

The generic recommendations developed in this business environment. European policy, therefore, should be based on monitoring developments and engaging in learning activities like pilots and assessment studies. Then – informed by monitoring and learning – policy action should be taken to enable the uptake of a new technology (or indeed to prevent it), to exploit the opportunities it creates with respect to policy objectives, and to mitigate or manage the threats.

When looking at the different technologies and policy options discussed in this chapter, a number of key "packages" can be identified as potential inroads to future RTD policy in the transport field:

1) Propulsion package: Progress in propulsion technology is mainly driven from the regulatory side. In general, there is only limited scope for direct research funding, because of the availability of major industrial and national funding. From a European perspective, soft actions seem to be more promising. They should help prepare regulations and adjustments of policy framework to enable and speed up the introduction of new propulsion systems. This would entail the setting up of networks of potentially relevant parties (e.g. for infrastructure, fuels, etc.), but also pilots and demos to dispose of the knowledge needed for a solid assessment and well-informed policy position. Pilots/demos might in addition be useful to disseminate findings more widely, and thus contribute to raising awareness.
2) Urban package: Several elements of the propulsion package apply also to urban transport. Additional problems that need to be addressed involve the interrelationship with land-use planning and public transport systems. The EU has a difficult role with respect to urban transport policy, because the implementation of key initiatives (e.g. in planning, investment, access restrictions, etc.) are clearly local competencies. Beyond the aforementioned policies on propulsion and vehicle technologies for the urban context, the exchange of experiences, awareness raising, and some framing regulations (safety, land-use planning) would be helpful to speed up the introduction of promising urban transport technologies. This may be underpinned by pilots and demos, but the scope for direct R&D on urban technology is rather limited.
3) Intermodality package: In order to foster the uptake of intermodal transport solution, both in passenger and freight transport, we are faced with the problem that there is no single key driver of innovation (such as environmental regulation for propulsion systems). An package of interdependent actions is needed, composed of regulatory changes, pilot actions/demos, R&D activities (especially in new rail systems), terminals, and – perhaps most important – stimuli for the establishment of intermodal service providers, that have an intrinsic interest in intermodal solutions. Finally, intermodality requires changes of user behaviour and awareness, as expressed e.g. in a wider acceptance of solutions such as ride sharing or car sharing.
4) Aeronautics package: There is a significant part of the current RTD actions of the Union dedicated to aeronautics. A large part of the activities in this area is motivated by industrial concerns. When focusing on transport related concerns, European RTD should concentrate less on the advancement of new aeroplane technology (though possibly justified for industrial reasons), but on ground based systems and air traffic management where the problems are most pressing. In parallel, safety-related R&D will continue to be a major issue of relevance to European policy. As an important facilitating measure for the uptake of new solutions the speeding up of certification and standardisation procedures should make part of an aeronautics package.

5) Rail package: Industrial development of new rail systems is under way on several of the most promising technologies. While high-speed and tilting trains have received a lot of attention over the last years, thus not necessarily requiring additional financial support from public funds, some other new technologies are still in an early development phase and could benefit from some kick-off funding. This holds in particular for urban rail technologies and other advanced people-mover-type technologies that are not supported by the main companies in the rail sector. A key element of an innovation-oriented strategy in the rail sector should also be seen in the opening up to competition. Direct research and pilot actions will continue to be needed to support and inform safety regulations.
6) Navigation and information package: This set of mostly ICT-based support technologies plays a crucial function for all modes, and in particular also for a better performance of future intermodal services. While much R&D in this area is driven by industrial interests, the introduction of these technologies will require sophisticated solutions for dealing with standards, interoperability, and data protection.
7) Traffic management, communication and payment package: This package addresses “interactive” technologies that have an impact on transport demand, either on absolute demand or on the distribution of demand over time. As far as traffic management and payment is concerned, it needs to be framed by a new pricing policy, but requires also further RTD to foster technology innovation. The EU should keep in mind that strong market forces exist that drive the innovation process for many interactive technologies and that policy measures should be used to control these forces and redirect them if necessary. The second main area to be addressed here would be concerned with tele-activities.

9.4 Specific policy conclusions

There are a number of technologies and policy measures that we would like to highlight as requiring the particular attention of European policy, either because the respective technologies from the list of most promising technologies have not yet been taken up in the programmes of the Commission, or because the initiative seems to be particularly important to help improve the European transport system.

- Financial support to advanced propulsion systems is only needed for those technologies that do not represent the mainstream of industrial research.
- A combined effort to provide multi-modal traveller information and to help set up the establishment of multi-modal service providers seems to be crucial for moving towards intermodality. The current market system will not bring intermodality about by itself. Particular attention to enabling conditions for multi-/intermodal services should be given in the new CTP framework.
- The co-ordination of modes is another key element for intermodal service operations. Especially for cross-European services, the setting up of network of relevant market actors that have an interest in intermodal operations (infrastructure opera-

tors, logistics companies, rail operators, manufacturers, etc.) could help improve the organisational set-up for intermodal services.

- The new generation of navigation systems is likely to bring about many follow-up or spin-off innovations in the transport field. These developments need to be monitored in order to identify promising development early on, and start initiatives to facilitate their uptake (e.g. by regulatory adjustments).
- Mobile access to internet and other enabling technologies for tele-activities have at least the potential to reduce or smoothen transport demand.
- Authentication technology is part of the EU's research programmes, but has not been considered closely with respect to transport. Due to its enabling function for new forms of transport service provision, payment, mobile access, etc. its implications should be monitored closely, and R&D in transport-relevant development be supported.
- Innovation in rail transport technology and services should be fostered by advancing the opening up of rail transport market. A competitive framework is likely to have a stronger impact on technology innovation that targeted RTD support.
- Information about travel behaviour underlies many technological choices, but the knowledge base is rather weak. A targeted effort to address both the quantitative and qualitative aspects of travel behaviour in Europe should be made.
- Promotion of a European network of car-sharing organisations to promote the professionalisation of car-sharing and integrating it with the use of other modes (rail, air).
- Re-consideration of the option of supersonic aeroplanes to explore whether a reliable and long-term consensus to advance this technology can be achieved.
- The issue of fuel taxation should be brought back onto the political agendas.

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10. LESSONS LEARNED AND OUTLOOK

10.1 Best practice guide

Technology Assessment (TA) studies have different purposes and take different forms. There is no general methodology, suitable for all cases. However, for certain classes of assessment study it is possible to find some guiding principles that increase the prospects for success.

This Best Practice Guide is mainly based on experience gained in the European 4th Framework project FANTASIE. It was extremely broad and complex, covering many aspects. The Guide is relevant to highly complex fields of study where the structure, system boundaries and dynamics are not well understood. The forming of a common understanding in these respects is, therefore, a very important task for such projects, and must have an impact on the choice of focus and data gathering as the project proceeds. This speaks for an iterative approach that allows learning and adaptation to new insights.

As for strategic aspects of project design, the Guide is mainly targeted for projects performed by ad hoc project teams with several partners from different organisations and possibly also different countries – such as EU Framework projects. However, the recommendations regarding technical issues are more generally applicable.

Hitherto, examples of technology assessments of such a high degree of complexity as in the FANTASIE case are rare. Most studies are more limited in scope and often focus on trend developments. This means that an essentially *linear project design* can be used such that the study is first planned in a relatively detailed manner and then executed – of course subject to minor revisions.

When the field of study is highly complex, and in particular if the interest is directed towards trend-break developments, the linear approach is less effective. Instead we propose what could be called an *iterative focusing approach*. This means that one tries to formulate a hypothesis on final results early on in the project, typically based on a broad but shallow survey of the problem area. A *pilot study* is a common format for achieving this. This first shot hypothesis then serves as focus for a first round of more detailed information collection and analyses in specific sub-areas. In all likelihood this will disclose flaws and weaknesses in the original hypothesis whence the focus will shift successively as the project team learns.

The project plan should be less detailed in a project applying an iterative focusing approach, but a number of strategic issues key to this kind of approach must be settled early on. In general terms, the project design must facilitate collective learning, successive iterations and adaptations. Strategic issues are:

- **Role of the customer.** Public sector customers often request independent input from technology assessment teams and, therefore, choose not to interfere with the process. If, however, the customer wants to ensure that the results will be of interest to him, he should consider taking an active part in the project. This is particularly important in the case of an iterative focusing project. Since it cannot be decided at the outset what will be the main focus of the study, the customer may want to have an impact on the successive choices made.

- **Utilisation of internal and external expertise.** In the kind of study considered here, the task is not just to fill in knowledge gaps in an already existing structure of the field. Instead, a structured picture will emerge only gradually as the project proceeds. It is important that this emerging picture will be reasonably shared among partners, otherwise it will be difficult to agree on the successive focusing that has to be done along the way. Hence, core methodology and knowledge accumulation should be handled by internal expertise in close co-operation, while external experts may be used to fill in gaps and for corroboration of ideas.
- **Project architecture and organisation of the consortium.** If the customer does not take part in the iterative focusing, then it is important to design the project and the project team in a way that facilitates the management of iteration and refocusing. It is essential to have a close co-operation and shared learning in the project. One possibility is to form a core team with the task to jointly handle such strategic issues as knowledge accumulation, development or adaptation of key methodologies and choice of a new focus when necessary. The core team model is intended to facilitate the emergence of a common understanding and agreement on change of direction, which is difficult to attain in a model with a fully performed division of tasks and responsibilities.

At a more technical level the following issues are of particular importance:

- **Information gathering.** Any technology assessment study must review state of the art as regards emerging technologies and assessment methodologies etc. One problem is how to acquire input that is both comprehensive and fully up-to-date. One way of coping with this problem is to first carry out a scoping study based on a limited number of the latest and most comprehensive review documents, and to summarise the findings in a report that is then circulated for external consultation.
- **Use of workshops.** If well prepared and competently facilitated, workshops can be a powerful tool for problem structuring and generation of ideas. However, brainstorming workshops demand much of the participants in terms of preparations and commitment. For external participants it is also often unclear what is in it for them. Therefore, it is difficult to get busy people from outside take part in such workshops, making it a bit risky to rely on external participation. Internally, though, workshops are strongly recommended.
- **Use of scenarios.** Scenarios describing different trend breaking developments are a useful means to stimulate creative thinking. However, it takes time to penetrate the logic of a set of scenarios and to learn to use them. One has to allow enough time for participants to accommodate to scenario thinking. The development (or adaptation) of scenarios should preferably belong to the core of the project work and involve the partners who are supposed to use them.
- **Knowledge accumulation and knowledge retrieval tools.** Traditionally knowledge accumulation has not been considered of importance in connection with iterative focusing studies. The FANTASIE experience and, more broadly the emerging ‘network economy’ indicate a need to develop this aspect and to develop supporting IT tools.

10.2 Potential for future activities

Based on the preceding forecasting stages and the identification of the relevant affecting conditions of the scenarios (e.g. energy prices, congestion levels), the methodology allows to open windows on the expected developments of a number of problem areas of relevance to the CTP. The effects on impact changes are assessed by taking either a vehicle concept (VC) or a transport concept (TC) view. TCs are deconstructed in terms of VCs composition and VCs are in turn deconstructed in terms of alternative specifications by relevant technology packages.

Examples of the assessments carried out in the FANTASIE project include:

- in the environment area, greenhouse gases and particulate emissions by TC in urban and interurban markets, based on market penetration of alternative propulsion technologies;
- in the efficiency area, vehicle purchase costs and energy efficiency of road VCs based on market penetration of alternative propulsion technologies;
- in the safety area, accidents by TC in urban and interurban markets based on market penetration of telematics packages.

The assessments cover a long-term time horizon (up to 2030), with trend breaks at 2005 and 2020, corresponding to the expected states in short- and medium-term, in the four scenarios (BAU, SG, SB, UG). Impact profiles and impact trees enable to trace impact developments over time and the relevant lower levels (down to technology applications) in the layered model. The assessments highlight the impact changes on base year together with the main determinants of these changes, as far as technology, policy and other scenario-related conditions are concerned.

The data and expert opinion structuring exercise presented here is a first development of a tool which is intended to provide valuable input to policy concertation actions. The structure devised fulfils the transparency requirement to allow for continuous refinement of the extensive range of hypotheses that are behind the forecasts. Beyond some analytical developments relating to, e.g., the measure of the uncertainties derived from the expert opinions, the main development potential lies in the design and application of tools for the interactive updating and validation of the results.

Further activities in the context of FANTASIE may comprise the following:

Refinement of FANTASIE Activities

- Updating and restructuring the FANTASIE database
- Utilisation of dissemination feedback
- Detailed assessment for most important technologies
  - technical issues
  - non-technical issues
- Detailed uncertainty analysis

Extended Scope Activities

- Time horizons beyond the year 2030
  - more focus on base technologies
  - more focus on transport system visions
  - more focus on non-technical issues
- Dynamic assessment of selected technologies and innovations
- Iterative focusing approach
- Continuous knowledge conservation
- “Lessons learned” survey of policy actions for introduction of new technologies
- Detailed policy analysis
- Advanced policy options
- EU level assessment modelling standards

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ANNEX A: Specific Roles and Options for European Policy

A.1 Multi-modal technologies

Technologies that support multi-modal transport are first of all the technologies that support the chaining of modes. Physical linking by multi-modal terminals, but also logical and temporal linking by co-ordination of arrivals, departures and transhipment. Since multi-modality requires more decisions to be made, support by information systems will facilitate the choice for multi-modality.

Multi-modal traveller information

Multi-modal traveller information is clearly an issue of European relevance. Technically, the necessary technologies are available. R&D has been followed by pilots, but the establishment of standards has until now hampered a wider uptake, e.g. regarding the establishment of interface standards, acceptable rules for disclosing travel information between service providers, needed to guarantee also competition in the provision of traveller information.

A second enabling factor is the establishment of complementary systems for multi-modal traveller information services. Especially the emergence of multi-modal travel service providers would be helpful to establish multi-modal traveller information, but is dependent on further progress in liberalisation of transport markets.

A policy choice needs to be made whether to favour the competitive provision of multi-modal traveller information, or whether an integrated European approach should be implemented. In view of the difficulties for multi-modal service providers to become established in our modal transport, new ways to favour the creation of multi-modal services will be crucial.

Needs for action:

- after pilots/demos the wider transfer uptake of and access to the information systems needs to become the focus of European policy (Key Action [KA] Systems and Services for the Citizen, KA Sustainable Mobility and Multimodality);
- critical problems for the wider uptake exist in information handling (including data protection, information exchange among competing parties) and interface standards between different systems, on-board devices, etc (KA Systems and Services for the Citizen);
- multi-modal traveller information would benefit from the fostering of multi-modal traveller services. They require a liberalised framework (under way), but possibly also targeted actions to support the establishment of Europe-wide service providers (CTP);
- policy choice to be made regarding how to foster multi-modal traveller information under either competitive or public-operated conditions (CTP).

Multi-modal travel information/trip planning (on board devices)

On board devices need to be useable anywhere in Europe, pointing to standardisation issues as being of high priority in the future. On-board or even portable devices not have been widely tested yet, but currently demos/pilots are planned. It needs to be made sure that the experiences made will be analysed properly in order to initiate enabling actions by firms and in particular also by policy making. Moreover, most of the arguments regarding multi-modal traveller information apply.

Needs for action:

- thorough assessment and analysis of the experiences made with current pilots to learn about necessary policy actions (KA Systems and Services for the Citizen);
- information handling (data protection, information exchange among competing parties) and interface standards for on-board devices (KA Systems and Services for the Citizen);
- future harmonisation and standardisation requirements (KA Systems and Services for the Citizen).

Multimodal passenger terminals

Until now, multimodal passenger terminals have been effectively implemented at airports, and at a reduced scale also for the interchange between main rail and bus stations. The key problem for their success is not technical, but organisation because there are still hardly any integrated carrier organisations for multimodal service operations. While such terminals may in many cases be an action at regional level, the exchange of experiences, as well as pilots/demos to improve practices could be of European benefit.

Needs for action:

- support for the creation of multimodal service operators (CTP);
- pilots/demos at regional level to improve and exchange practices (KA Sustainable Mobility and Mobility and Intermodality).

Multimodal transport service

The creation of multi-modal transport services and of operators of such services is a key enabling factor for several other technologies related to multimodality. We are still in the phase of niche creation in need of a targeted strategy. First, in order to show their potential and advantages and achieve cost reductions by organisational and other innovations, pilots/demos would be important tools to show their viability and learn about their implementation. Secondly, until now the regulatory frameworks in most Member States do not favour such services, pointing to the need for European policy action. Moreover, the harmonisation and co-ordination of such services for cross-border operations would call for EU-action. Finally, there may be technical standardisation issues to be addressed.

Needs for action:

- niche creation strategies through a combination of pilots/demos and regulatory changes (KA Sustainable Mobility and Mobility and Intermodality);
- appropriate multimodal transport policy framework (CTP);
- standardisation of information interfaces regarding multimodal services (CTP).

Reservation system for transport modes

As part of a unimodal as well as an inter-modal service provision, reservation systems play an important enabling function. Technically, they are available, but for a user-friendly direct-access service, they would have to be easy to use.

If offered by competitive service providers there may be conflicts of interest when it comes to disclose full and transparent information on services. This points to harmonisation and regulatory issues to be addressed by European policy in the coming years.

Moreover, the integration with mobile information devices needs to be ensured. While R&D may be done by industry anyway, the demonstration and assessment would be a relevant EU policy action.

Needs for action:

- regulatory framework needs to balance between competition principles and easy harmonised information access. (CTP);
- pilots/demos for integration with fixed and mobile information devices, e.g. WAP, internet (KA Services and Systems for the Citizen).

Information system for the co-ordination of modes

Similar arguments apply as for reservation system, though targeted to multimodal operations. Information systems are key to enable multimodal operation. Currently R&D activities on information systems are already under way, but will have to be complemented by measures to foster market introduction (e.g. pilots/demos) because it is unclear whether such systems would be introduced in a purely market-based framework (see arguments regarding intermodality raised before).

Standardisation issues will have to be addressed as well, as harmonisation/regulation regarding exchange and access to information between competitors. Network development and co-ordination between service providers and infrastructure operators may be facilitated by European policy initiatives. There is a clear interest in Europe-wide initiatives due to the cross-border character of many intermodal operations.

Needs for action:

- pilot actions and demos to bring information systems closer to the market and facilitate learning (KA Systems and Services for the Citizen);
- network development to establish co-operation between different market actors in infrastructure and service provision (KA Sustainable Mobility and Intermodality);
- framework conditions in liberalised markets need to be adjusted to facilitate intermodal services (CTP);
- standardisation and regulation to enable information exchange and access (KA Systems and Services for the Citizen).

Information system to identify preferences and habits of travellers

Such information systems would be a complementary element to underpin and inform several of the other policy actions to foster intermodal transport. This type of information is crucial to reduce uncertainty for several market actors, and to give them clearer incentives to engage in multi-modal service provision. There is clearly scope for European action in monitoring, assessment and dissemination of findings. In order to establish such a system, there may be scope for European R&D first, but in the longer term, this may be taken over by more continuous monitoring activities in the Member States. Harmonised standards and guidelines for monitoring and transferring of the data collected may then be needed.

Needs for action:

- R&D to establish and test an information system for monitoring (KA Sustainable Mobility and Intermodality);
- dissemination and transfer of knowledge on travel behaviour (KA Sustainable Mobility and Intermodality);
- once established, regulation to delegate monitoring tasks to member states (CTP).

Multi-modal transhipment terminals

Especially for long-distance freight, there is a role to play by the EU in supporting and planning the location of major transhipment terminals of Trans-European importance, e.g. from the side of industrial policy (see e.g. the former DG III Marpol programme). But also standards, e.g. for handling equipment or load units, will be needed to enable smooth and fast operation. Standardised labelling is another issue of importance for tracking, tracing and loading. Framing policies on pricing, organisation and liberalisation are also decisive enabling factors for making transhipment terminals viable because they depend on an important role of rail-based freight transport.

Needs for action:

- co-ordination in planning the major European terminal locations, related also with the planning of TENs (CTP);
- standardisation of key technologies for freight handling (KA Land Transport and Marine Technologies);
- framing policies to favour intermodality: pricing, organisational principles, liberalisation (CTP).

A.2 Information technology

This category contains the applications of information technology that are not directly linked to vehicles or infrastructure. The policy approach of information technology has to take into account that this domain is strongly market driven. The emerging network economy and its transport related consequences are not likely to be controllable by European policies. But this is not to say that they are impossible to affect. In fact the early, formative stages of a major societal transformation typically present many key decision points where the difference in outcome is particularly big between effective and ineffective policies.

Typically the relevance of the developments alluded to above is limited neither to the transport sector, nor to Europe. Therefore, European transport policy needs a partnership strategy to exploit shared interests with other actors. A case in point is the development of mobile Internet. Mobile communication in general requires development of a general-purpose information infrastructure, which could also be used for many transport telematic applications. Also with the foreseen broad market penetration of mobile Internet terminals (e.g. WAP telephones) these are likely to emerge as the affordable solution to receiving in-travel information on transport offerings and traffic situation, and for placing orders in near real time and paying for transport services.

Much of these developments are already under way at the hands of market actors. Use of generic platforms obviously has great advantages over dedicated solutions in terms of economies of scale and scope, and therefore has the potential to achieve commercial take-off for transport telematics. In addition to framing policies, which may be required to enable some of the new services, this development also creates novel opportunities for co-operating with mobile communication operators to achieve objectives in specific policy areas as traffic control, road pricing and emergency services.

Smart payment systems

The technology is basically available, driven by significant industrial interests and R&D. Standardisation, even beyond the European level, is a crucial issue to enable inter-operability across countries and modes and foster a wider uptake. Stakeholder network could be set up to facilitate standard-setting. From the consumer side, concerns about data protection may require new reliable regulations, similar to other IT-based areas. Demos and pilots with new payment technologies have a crucial role to play to identify early on problematic issues that require policy action in the future.

Needs for action:

- initiatives to achieve standard-setting (KA Systems and Services for the Citizen);
- agreements or regulation on data handling and protection (KA Systems and Services for the Citizen);
- demos and pilots during introduction to identify critical issues (KA Systems and Services for the Citizen).

Smart card (keyless)

There is much industrial interest in smart card technology. R&D has been done for some years already, and there is little scope for direct European research funding. Currently, smart card applications are mentioned frequently in FP 5, but integrated solutions have only reached the stage of pilots/demos. There are serious difficulties to agree on common standards which is why the EU should concentrate on this issue.

Also a niche management strategy to go beyond pilots/demos and standardisation initiatives would be most helpful, especially to consider user requirements and regulatory adjustments that may be needed to enable the uptake of smartcards. In particular, the handling of personal data and security issues are likely to become key concerns of users, and could turn into barriers.

As smart cards are a cross-cutting technology, spin-off opportunities should be monitored and assessed with respect to the need for complementary policy initiatives.

Needs for action:

- initiatives to establish common standards for multi-purpose applications (KA Systems and Services for the Citizen);
- upscaling of pilots and demos to achieve a wider diffusion (KA Systems and Services for the Citizen);
- monitoring progress and spin-offs (KA Systems and Services for the Citizen).

Authentication systems

Data protection and security is the key issue for this enabling technology. Therefore, there is also some justification for R&D and demos/pilots to improve the technology, but also to learn about user-related concerns. In general, European R&D should take into account that industry is already doing a lot of R&D on authentication systems.

Authentication systems are not a very explicit issue in current R&D programmes, but should be addressed more explicitly due to their general enabling function for many other services and technologies, not only in the transport area (c.f. smartcard, mobile access, payment systems, etc.).

Needs for action:

- more explicit consideration of authentication technology in transport in R&D programmes (KA Systems and Services for the Citizen).

Mobile access to internet

Both the interests of consumers and industry drive the progress in mobile access to internet. There is a need to ensure interoperability of systems, but due to the fast pace of change this should be done mainly by industry itself. Therefore support for network development, involving lead users and industry, could be a valuable initiative for the EU.

There is little explicit consideration of mobile access in relation to transport in the current programmes, in spite of the expected significant impacts on driving patterns. More research is needed on the assessment of impacts of mobile access on driving behaviour due to the fast pace of change in this area, also in terms of monitoring progress. Pilots and demos as testbeds for assessment and identification of needs for policy action would also be justified.

Furthermore, programmes to enable the exchange of experiences (“knowledge transfer”) could facilitate the uptake of advanced mobile access solutions.

Complementary policies would be helpful to speed up traffic replacement by mobile access, ranging from taxation and planning to working time regulations. While national governments might recur also to financial and tax incentives, the EU could complement this by awareness-oriented initiatives and dissemination of good practices.

Needs for action:

- network development to enable standardisation and interoperability (KA Systems and Services for the Citizen);
- monitoring progress and assessment (KA Systems and Services for the Citizen);
- pilots and demos to identify needs for enabling policy action (KA Systems and Services for the Citizen);
- exchange of experiences and knowledge transfer (KA Systems and Services for the Citizen);
- awareness building (KA Systems and Services for the Citizen).

Tele-activities

The benefits of tele-activities with respect to transport are still highly disputed. Monitoring and assessment should thus continue, building also on further pilots/demos. Technically, we are already in the introduction phase of tele-activities where awareness needs to be raised about their potential, and knowledge transferred about good practices. In both respects, the EU could play a facilitating function.

Furthermore, the EU, with its many activities in which people from different places in Europe are involved, would be an excellent place to apply tele-activities and to demonstrate innovative concept in this field.

Needs for action:

- raising awareness (KA Systems and Services for the Citizen);
- monitoring and assessment on the basis of new pilots and demos (KA Systems and Services for the Citizen);
- transfer of knowledge and experiences with tele-activities (KA Systems and Services for the Citizen).

A.3 Road transport technology

The most promising road transport technologies are differentiated into three groups:

- generic technologies;
- technologies for passenger transport; and
- technologies for freight transport.

In the area of road transport technologies, two main groups of policy measures can be distinguished. There are first of all technical R&D measures that are justified by the horizontal nature of the technologies in question (especially for generic technologies). Secondly, there are several technology-related activities that aim to support the advancement of policy in the transport field, e.g. in the sense of informing policy about regulatory or legislative changes required to make new technologies diffuse. Many demonstration and pilot projects fall under this latter category, even if they also have important benefit for directly improving and speeding up the uptake of new technologies.

Generic technologies

Advanced propulsion system

Research and development have shown the technical viability of new propulsion systems. The introduction of new fuels requires the co-operation and the distribution of costs among vehicle manufacturers and fuel/infrastructure providers, which can represent a critical barrier. A moderating, and if necessary enforcing, role of the EU may be needed soon, because most of the technical problems seem to be addressed already.

Current EU policy puts emphasis on emission and consumption regulations on the one hand, and on technical R&D on the other. Further European R&D funding is not likely to add much to what is already done by industry. Stronger emphasis could be put on technical R&D to support policy action, e.g. in relation to requirements for new safety regulations or to co-ordinate the activities of different industrial players.

Furthermore the potential of market mechanisms has not yet been fully used to stimulate the uptake of advanced propulsion systems, e.g. fuel taxes, and should be re-considered in a reliable way to foster advanced propulsion systems.

Needs for action:

- technical R&D could be oriented more towards policy-relevant issues, such as safety regulations, establishment of standards, assessment (KA Economic and efficient energy);
- moderation and co-ordination between manufacturers, fuel suppliers and infrastructure operators needed to overcome the current niche status of most advanced propulsion systems (KA Economic and efficient energy);
- fuel taxation strategy to provide predictable economic framework conditions (Common Energy Policy).

Electric and hybrid traction

Electric and hybrid traction are already a key target of European technology policy, both through the roles of regulator and R&D manager. Societal, mainly environmental, interests may justify targeted financial support for new traction, but given the substantive research efforts by industry and national governments, partly in response to announced regulations, the EU could probably spent its resources more efficiently than on direct technical research funding. A co-ordinating, monitoring and disseminating role would probably be more effective to overcome the barriers in the introduction phase.

Financial support should rather be targeted on non-technical and non-commercial barriers. Pilots and demonstration can help identify and subsequently address such barriers, and especially those that have a European dimension. These are especially compatibility problems, barriers and uncertainties related to safety regulations, infrastructure standards (e.g. for recharging). These are clearly border-crossing topics that could be addressed best by European research and co-ordination actions. In other words, making sure that new advanced propulsion systems can overcome “interoperability” problems could become a main target of future technical research actions.

A co-ordinating function and stimuli towards network development would also be helpful to establish co-ordination between vehicle manufacturers and electricity suppliers, especially in view of the changing context in the liberalised electricity market. The current “turbulent” phase in electricity supply markets is probably a good opportunity to attract their interest in new forms of business.

Electric and hybrid traction systems are good cases for a niche development strategy. The mobility behaviour with hybrid, and especially with electric, vehicles differs and requires a learning process of the vehicle users to find widespread acceptance. Moreover, new mobility services (e.g. self-drive public EV fleets) will most likely be central to such niche markets. Exchanging experiences with such schemes could be a promising inroad for EU policy. At national scale, several such schemes have already been set up, both in freight and passenger transport, but there are still hardly any international service schemes. Moreover, the lessons learnt from these experiences have not yet been translated into an adjustment of framework conditions to favour their uptake. In this respect, the EU could have a pace-making role.

Needs for action:

- network development and co-ordination to ensure “interoperable” new propulsion technologies (KA Economic and efficient energy);
- reducing uncertainty about safety regulation for advanced traction systems (KA Economic and efficient energy);
- stimulating networking and co-operation between electricity supply sector and vehicle manufacturing (KA Economic and efficient energy);
- support new types of electric/hybrid vehicle mobility schemes (KA Land Transport, KA Sustainable Mobility and Intermodality);

- trigger an adjustment of policy-dependent framework conditions (taxation, regulation) to favour the uptake of new traction systems (CTP, Common Energy Policy).

Fuel cells

Similar arguments as in the case of electric and hybrid traction apply. Due to the option of using hydrogen, safety standards are a critical barrier, but it is currently already addressed in FP5. Financial support for technical R&D does not appear to be important to advance the technology itself, as industrial research goes already very much into fuel cells. However, it would be worthwhile maintaining R&D work on those fuel cell technologies that are not of highest priority to industry in order to maintain future options in the broader fuel cell area.

If indeed fuel cells reveal to become the preferred propulsion option of the future, knowledge transfer and network development will be important in order to make sure that the wider support and infrastructure system for fuel cell technology is in place, including service stations, garages and competent mechanics.

Needs for action:

- in spite of remaining uncertainties, targeted R&D funding needed only in the non-dominant fuel cell trajectories (KA Economic and efficient energy);
- safety assessment and research should be continued to ensure that acceptance problems can be overcome (KA Economic and efficient energy);
- focus on standards in safety to provide a reliable application context for fuel cells (KA Economic and efficient energy);
- knowledge transfer and network development to establish a wider support system for fuel cell technology (KA Economic and efficient energy, KA Land Transport and Marine Technologies).

Electric urban car

Many arguments regarding electric traction apply also to electric urban cars. Electric urban cars are clearly driven by societal rather than commercial interests. The commercial barriers justify financial support in order to move beyond isolated experimental applications and into a development stage where economies of scale can be achieved. For the next years, the creation of a wider application niche will thus be decisive.

European and national financial support has already gone into demonstration and pilot projects in cities which, due to their specific situation (historic centres, high contamination, etc.), offered conducive conditions for electric urban cars, or that are willing to introduce traffic restrictions. However, this key driver is in the first place a matter of local policy; the EU should rather restrict itself to an encouraging function. Further direct financial support for the uptake of electric urban cars would only be justified for demonstration projects, to be financed from national rather than European sources.

European policy could support the niche creation process by facilitating knowledge transfer and the exchange of experiences, but also by raising awareness and promoting further the vision of clean cities among those that are still less conscious about the importance of clean urban transport.

Needs for action:

- facilitation of knowledge transfer among cities (KA City of Tomorrow); support to networking of key industrial actors and users (e.g. cities) to improve the learning process with urban Electric Vehicles (KA City of Tomorrow, KA Land Transport and Marine Technologies);
- raising awareness and creating visions regarding cleaner cities (KA City of Tomorrow).

Dynamic route planning

Integration with real time traffic data has not yet been fully achieved and tested. While this may not be directly a European task, standardisation issues to enable data exchange are involved.

Needs for action:

- standards for data exchange (KA Systems and Services for the Citizen, KA Sustainable Mobility and Intermodality).

In-vehicle traffic information

The need to ensure inter-operable devices in Europe justifies support and action by the EU. By monitoring current developments in industry, and by networking with industrial actors and users, standardisation issues could be addressed by the EU.

Needs for action:

- monitoring and assessment of current developments (KA Systems and Services for the Citizen);
- initiatives to establish standards or standardised interfaces that enable the Europe-wide use of in-vehicle devices (KA Systems and Services for the Citizen).

Electronic tolling

While being essentially implemented locally, there is scope for European policy to support the development of electronic tolling technology by direct research funding because it is key to achieving a fair pricing for infrastructure use in the future. While regulatory action needs to make sure that the pricing principles are applied across countries, the technical possibilities will have to be advanced in parallel. Currently, the technologies seem to be available, but stalled due to uncertainties about the future pricing framework. The new regulatory framework for infrastructure pricing is under way, but there is still much uncertainty about the timing of its implementation. In order to raise real interest in electronic tolling technology among industrial firms, the envisaged framework needs to be fixed and introduced in a predictable manner.

A second area that should be considered already in the next few years are standards to ensure inter-operability of on-board tolling devices on European roads.

Exchanging experiences in different Member States could foster the wider uptake of this electronic tolling.

Needs for action:

- regulatory principles to be implemented (CTP);
- standards for interoperability (KA Systems and Services for the Citizen);
- knowledge exchange to support standard-setting as well as technical research (KA Sustainable Mobility and Intermodality).

Navigation systems

A new generation of navigation systems at European level is under way. This is clearly a subject of European interest that justifies EU-financial support, even direct funding and operation (possibly in co-operation with Eurocontrol for air transport). It will be important to ensure compatibility with on-board devices and that open interface standards defined.

Moreover, the new satellite navigation system could become a platform that triggers and speeds up many follow-up innovations. Monitoring opportunities for transport-relevant innovations could thus be beneficial, because policy will have to be able to respond to new opportunities and innovations developed by industry on the basis of GNSS.

Needs for action:

- compatibility issues between navigation systems and on-board devices (KA Systems and Services for the Citizen, KA Sustainable Mobility and Intermodality);
- monitoring of spin-off innovations and needs for policy actions to enable and frame them (KA Sustainable Mobility and Intermodality).

Traffic control systems

This is typically a local measure in road transport, but the efficiency of current R&D-work for the European market could be improved through knowledge transfer and network development, possibly also by pilots/demos for innovative applications. Cross-boundaries co-ordinated traffic control will be beneficial to cities and regions. The outputs of such EU-wide initiatives could be to the benefit of many cities, especially those that until now have not engaged in targeted traffic control schemes. Economies of scale could result in major cost savings, thus justifying attempts for establishing key standards or platforms. However, the local context of each system will always require experimentation and adjustment.

Needs for action:

- transfer of experiences with traffic control systems through networks of operators and firms (KA Sustainable Mobility and Intermodality);
- key standards/platform initiatives to enable economies of scale (KA Systems and Services for the Citizen);
- research, development and pilots for cross-boundaries co-ordinated traffic control (KA City of Tomorrow).

Parking management systems

This is also essentially a local issue but some degree of harmonisation would be an advantage for the travellers. Knowledge transfer of experiences and pilots/demos could help improve systems and speed up their widespread application. Regulatory harmonisation measures would interfere quite heavily with the competencies of cities, and are less likely to be an appropriate EU policy inroad.

Needs for action:

- knowledge transfer and pilots/demos to improve practices widely (KA City of Tomorrow).

Automated guided vehicles

R&D is mainly driven by industrial interests. The technology is still in the R&D phase and will not be widely available in the next few years. Nevertheless, it is clear that it will throw up important standardisation issues, especially regarding interoperability both within and across MS, and regarding safety. For the moment mainly industrial research is carried out, but the EU could have an important role in monitoring progress to identify early on needs for regulatory actions, especially with respect to safety and interoperability. Due to secrecy issues, there is little scope for direct financial support to networks of manufacturers.

Needs for action:

- monitoring of progress of industrial research (KA Land Transport & Marine Technologies);
- targeted research on safety implications/standards and on requirements with respect to the interoperability of systems/standards (KA Land Transport & Marine Technologies, Industrial Policy);
- reliable safety regulations (KA Land Transport & Marine Technologies, Industrial Policy).

Driver support systems

As for automated guided vehicles, this technology is strongly determined by industrial interests. Safety regulations are an important area in need of EU policy action. Reliable regulations could enable a fast uptake. In order to make sure that users are not confronted with too many different systems, there may also be a need for harmonisation of driver support technologies once they are more advanced. Furthermore, the interface between these technologies and the environment in which they must operate should be suited for whole Europe. At the moment, the optimal application of driver support systems is still delayed by national and regional differences in institutions and regulations.

Currently, for most technologies the high level of secrecy does not make financial support for networks promising, but once the technologies come closer to commercialisation, the need for harmonisation may actually call for European initiatives along such lines, possibly based on pilots/demos to allow transparent assessment.

Needs for action:

- monitoring of progress of industrial research (KA Land Transport & Marine Technologies);
- reliable safety regulations (KA Land Transport & Marine Technologies, Industrial Policy);
- in a few years time, there will be need for harmonisation initiatives (KA Land Transport & Marine Technologies, Industrial Policy).

Drive by wire

R&D is strongly driven by industrial interests, but safety regulations and a reliable legal framework will be crucial to enable its uptake. This technology is not explicitly considered in the current EU R&D programmes, but would be a candidate for monitoring progress of industrial research, assessment of its safety implications, and emerging legal requirements to enable its introduction. For this purpose, pilots/demos might be useful, while direct technical R&D should be left to industry.

Needs for action:

- safety regulations (KA Land Transport & Marine Technologies, Industrial Policy);
- reliable legal framework (Industrial Policy);
- monitoring progress and assessment (KA Land Transport & Marine Technologies);
- pilots and demos as test cases to inform policy (KA Land Transport & Marine Technologies).

Technologies for passenger transport

Human-powered vehicles

The promotion of human powered vehicles has to rely mainly on local actions. The EU can only contribute through soft measures like awareness building and transfer of experiences. Support could also be given to pilots/demos that aim to integrate human powered transport with public transport.

Needs for action:

- awareness building and transfer of experiences/knowledge (KA City of Tomorrow);
- pilots/demos to integrate with public transport systems (KA City of Tomorrow).

New systems for personal rapid transit

Research on new systems for personal rapid transit has been done over the last years already. Now a wider uptake is needed. It could benefit from a better knowledge transfer, based also on the assessment of pilots and demos, but the main problem for new such systems must be seen in financial barriers and in a mismatch with the dominant public transport technologies. As these systems are implemented at local level, the possibilities for the EU to support their uptake are rather limited. In the implementation of the new regulatory frameworks for a liberalised transport system the specific conditions that would favour the uptake of such new personal rapid transit systems should be taken into account.

Needs for action:

- knowledge transfer and assessment/monitoring of selected pilots/demos (KA City of Tomorrow);
- advancement of the liberalised regulatory framework for competitive transport operation (CTP);
- awareness building (KA City of Tomorrow).

Ride sharing

Several smaller and experimental schemes are being implemented, often combined with reserved lanes. The technology is basically available to operate and co-ordinate ride sharing at a larger scale, but behavioural and organisational barriers still prevail, related e.g. to working times, reliability, etc. There is still scope for experimenting, but that should be essentially financed locally. The EU could have a function in exchanging experiences, networking of relevant actors, raising awareness and making initiatives to remove regulatory barriers. Pilots/demos could help to monitor and assess experiences.

Needs for action:

- raising awareness (CTP);
- networking and exchange of experiences (KA Sustainable Mobility & Intermodality, KA Land Transport & Marine Technologies);
- support for pilots/demos to monitor and assess experiments, leading to regulatory initiatives where appropriate to stimulate ride sharing (KA Sustainable Mobility & Intermodality, KA Land Transport & Marine Technologies).

Car sharing

There is still a need for further experimenting with new forms of car sharing schemes, to learn about and assess better practices and transfer the experiences. There are many different forms of car sharing schemes, by car manufacturers, car rental companies, public transport operators. The main remaining barriers for car sharing are not technological any more, but behavioural and organisational (even if some of the vehicles used may still be in need of further R&D). Network development at European level to enable car sharing beyond the local level could be of high interest to establish car sharing also in those countries where it has not been successful until now. Until now, at least, there are hardly any experiences with Trans-European car-sharing schemes (car-“roaming”). In addition, support could be given for pilots that involve co-operation between public transport operators and car-sharers to transfer the experiences made. Finally, awareness about the advantages and characteristics of car-sharing could be raised.

Needs for action:

- promoting a European network of car-sharing organisations (KA Sustainable Mobility & Intermodality);
- pilots/demos for new forms of co-operation in experimental car-sharing schemes (KA Sustainable Mobility & Intermodality);
- raising awareness about car-sharing (KA Sustainable Mobility & Intermodality).

Technologies for freight transport

Road trains

Currently road trains are not explicitly considered in European technology policy. The timely establishment of safety regulations could help speed up their introduction, i.e. assuming that in general the use of road trains, be they mechanically or electronically coupled, finds widespread support and acceptance. Monitoring experiences with road trains and their assessment would then be needed, especially to evaluate their benefits in comparison with rail transport.

Needs for action:

- regulation to enable the use of road trains (Industrial Policy, CTP);
- safety regulations (Industrial Policy, CTP);
- monitoring and assessment (KA Land Transport & Marine Technologies).

Freight telematics

Telematics applications in freight have a high potential to improve the situation in transport. For city freight distribution, some pilots/demos receive currently support, but long-distance freight transport telematics is only monitored and assessed by the EU. Given the European dimension of long-distance freight transport, there is thus scope for EU action. First of all, raising awareness among the many small freight forwarders could be helpful, even if they tend to operate for larger logistics firms that dispose of the necessary telematics technology. Secondly, pilots/demos and knowledge transfer could help overcome several of the user-sided barriers, but also financial incentives for small freight forwarders to participate in such systems should be considered, although this may be difficult to realise at EU-level. Third, “hard” regulatory measures to prevent empty freight trips or enforce intermodal freight transport would in principle be another option to favour the use of freight telematics, but such an approach would probably be faced with severe resistance.

Intermodal freight transport is dependent on the widespread availability of telematics technology, but as already mentioned frequently, there are not the right organisational structures and incentives in place to enable intermodal freight transport.

Needs for action:

- raising awareness and knowledge transfer about the benefits of freight telematics applications (KA Systems and Services for the Citizen, KA Sustainable Mobility and Intermodality);
- pilots and demos to support the use of freight telematics, especially by small firms (KA Systems and Services for the Citizen, KA Sustainable Mobility and Intermodality);
- financial incentives to use freight telematics schemes (not necessarily EU);
- regulatory actions to favour the use of freight telematics and intermodal integration (CTP).

Innovative systems to build underground freight infrastructure

There is still R&D needed to develop the technologies for underground freight infrastructures. Currently, only first assessments are under way. Given the rather small number of candidate firms that are engaged in this technology in Europe, an EU research action might be appropriate to improve the knowledge and practices, though taking into account already ongoing initiatives at Member States level (Switzerland, UK, Netherlands). Apart from direct research funding and setting up of competent networks, in later phases the EU could support first pilot applications as a basis for the transfer of experiences. Otherwise, most funding of schemes should rather come from the countries/regions that mainly benefit from the new schemes. Innovative financing schemes as part of the wider regulatory framework could benefit the uptake of underground freight systems in the longer term.

Needs for action:

- monitoring and in-depth assessment of first national experiences (KA Sustainable Mobility and Intermodality, KA Land Transport and Marine Systems);
- network development and direct R&D funding (KA Land Transport and Marine Systems);
- transfer of experiences and knowledge (KA Land Transport and Marine Systems);
- initiatives to facilitate financing of schemes in the longer term (KA Land Transport and Marine Systems).

A.4 Rail transport technology

Many rail technologies are not addressed directly in current EU programmes, but only indirectly through the definition of requirements for future technologies. The specific technologies would then have to be suggested by the respective research consortia.

Recycling and upgrading waste material (urban rail)

No targeted activities related to recycling in urban rail area could be identified in current EU programmes, but they may be covered by the platform strategy of the KA land transport and marine technologies. Similar to the recent directives on car recycling, the rail sector could be subjected to regulations regarding recycling. Demos/ pilots to trigger knowledge transfer are also possible, to complement regulatory action.

Needs for action:

- regulatory initiatives on recycling in the rail sector (CTP and Environment Policy);
- pilots/demos for knowledge transfer (KA Land Transport & Marine Technologies).

Fuel cell and battery technology (on-demand rail systems)

Fuel cell and battery technology are currently addressed in the KA Economic and Efficient Energy, though not in relation to rail transport. It is questionable whether there is scope for EU action beyond monitoring and assessment at the current stage, to explore the scope for rail applications of fuel cells. In the longer term, pilots/demos might become a relevant option if a potential for on-demand rail systems can be clearly identified.

Needs for action:

- monitoring and assessment (KA Economic and Efficient Energy);
- in the longer term also pilots and demos (KA Land Transport and Marine Technologies).

New rail infrastructure for new transport concepts, e.g. MagLev and Personal Rapid Transit

With MagLev being until now a German initiative only (at least in Europe), it should not be addressed directly by European policy. If indeed MagLev reveals to become a real option, its wider uptake could in the longer term be fostered by European policy; in the near future only monitoring and assessment appears to be necessary.

For MagLev as well as for PRT, interoperability issues are of crucial importance, as are intermodal terminals. New infrastructure projects are always related to land-use planning, to noise problems. In all these respects, European harmonisation could help speed up the uptake of new rail infrastructure solutions. Technical research will continue to be needed on noise and safety issues, and can be justified from a European view. PRT demos/pilots to learn about new requirements and transfer experiences could also be justified European actions.

Needs for action:

- monitoring and assessment of MagLev technology (KA Land Transport & Marine Technologies);
- harmonised land-use planning, noise regulations, safety regulations for new infrastructure systems needed to speed up introduction: for PRT already now, for MagLev possibly in the longer term (CTP, Industrial Policy);
- R&D on safety and noise (KA Land Transport & Marine Technologies);
- demos and pilots with new PRT systems to learn about new policy implications and transfer experiences (KA Land Transport & Marine Technologies, KA City of Tomorrow).

Traffic management systems and integration of information technologies with GNSS (Global Navigation Satellite Systems); Wireless Communication Systems and Computer Communications Networks (Internet, LAN, WAN) for long distance passenger and interurban rail)

With GNSS currently being launched, including R&D, piloting and full-scale implementation, most ground-laying work is already driven by European policy. However, in the follow-up of introduction there are additional issues to be addressed. In order for ground-based traffic management technologies to operate together with GNSS, new standards will have to be introduced. GNSS will also most likely throw up new questions regarding data protection, information access, and regulation. In particular, to exploit its full potential, the harmonisation of traffic management systems will have to be achieved, i.e. they should use the GNSS platform as widely as possible all over Europe.

Needs for action:

- implementation of the currently launched R&D, pilot and full-scale system (CTP, KA Sustainable Mobility and Intermodality);
- new standards for ground-based technology using GNSS (various programmes);
- legislation and regulation regarding data protection and information access (KA Systems and Services for the Citizen);
- harmonisation of traffic management systems in Europe (CTP).

Weight and drag reduction

This is a typical permanent research task to improve performance. However, it is questionable whether the EU should deal with it directly, apart from monitoring and assessing progress. More effective will be the introduction of competition, and thus of incentives for innovation in the rail sector. To integrate the (still) national markets, harmonising regulations may be required with respect to safety, weight and drag issues.

Needs for action:

- liberalisation and competition in the rail sector (CTP);
- harmonisation to help open up markets (CTP).

Tilting high speed rail

Tilting high-speed trains are increasingly preferred to dedicated track trains that require massive infrastructure investment and impact the environment quite heavily. Research on tilting high-speed trains is in principle already addressed in the current EU programmes. However, it is questionable whether the rather limited EU funding will really make a difference. A lot of industrial research is already going on in this area. The opening up and liberalisation of national markets should be addressed before further targeted research or pilot funding in the rail sector is offered. Monitoring and assessing safety performance seems to be the only concrete technical research area for the coming years for the EU.

Needs for action:

- liberalisation and competition in the rail sector (CTP);
- harmonisation to help open up markets (CTP);
- monitoring and assessment of safety (KA Land Transport & Marine Technologies).

Technologies for coping with different voltages

Different voltages are an example where harmonisation of different national standards can not be easily achieved. The issue is at least indirectly addressed in the current FP5 task descriptions. As a bridging technology between national markets, European R&D is fully justified. Another argument is the need to reduce the time losses at border crossings

Needs for action:
- direct R&D funding (KA Land Transport & Marine Technologies);
- pilots/demos (KA Land Transport & Marine Technologies);
- standardisation and regulation to ensure their fast introduction (Industrial Policy).

Light rail and people movers
As urban technologies light rail and people movers are already considered in the current research actions. Safety issues continue to be important concerns, but most attention should now be paid to market introduction. Safety regulations need to be updated and harmonised to facilitate introduction and remove often unnecessary barriers. Furthermore, the transfer of experiences could speed up introduction, based on pilots/demos.

Needs for action:
- harmonisation and updating of safety regulations (Industrial Policy);
- knowledge transfer (KA City of Tomorrow);
- pilots/demos (KA City of Tomorrow).

A.5 Air transport technology

In general, RD&D done under the key action aeronautics is very close to the commercialisation stage. Even specific cost reduction targets are given as research objectives. A large part of the programme seems to be motivated by concerns of industrial rather than technology policy. A second key characteristic is the emphasis put on quite generic issues such as design tools, air traffic management system, safety related research, etc.

R&D at European level should be preferred to national R&D initiatives because the aircraft industry is the model case of a Europeanised industry.

A more general issue for aircraft are the cumbersome procedures for certification of new core components, structures or new materials (e.g. propulsion systems or fibre reinforced structure). Also the certification of complete vehicles, e.g. airships, take a too long time.

Megaliner
Megaliner predevelopment is under way in industry, but for being fully efficient also the ground-based technologies need to be adapted. Safety and efficiency issues will also be of major importance for this new class of aeroplanes. As these are mostly beyond European single control, a key role of European policy lies in a constructive role in international organisations to facilitate the uptake of new generation European aeroplane concepts.

Needs for action:

- standards for ground based technology/terminals (KA Aeronautics, CTP);
- augmented safety standards to be introduced soon in international regulations (Industrial Policy, CTP).

Tiltrotor

Niche markets for tilt rotor aircraft will primarily depend on conducive regulations, e.g. regarding access to urban areas. In all these respects, a harmonised European regulation would be desirable to facilitate the establishment of a niche market in Europe. During the niche development process, monitoring and assessment of the progress made and possible problems should be maintained, based also on pilots/demos. Technical research as well as regulation are necessary on noise and safety issues.

Needs for action:

- harmonised regulation on noise, safety and access to urban areas (CTP, Industrial Policy);
- monitoring and assessment of emerging problems during the niche market creation process (KA Aeronautics);
- R&D on noise-reduction and safety (KA Aeronautics).

Improved propfan propulsion

New propulsion systems are mainly driven by new regulations. R&D is done in response to this by industry. A reliable regulatory framework would help facilitate innovation. Pilots and demos could further complement a European innovation strategy in this area to learn about problems with new propulsion, and enable the monitoring of progress.

Needs for action:

- reliable regulatory framework for safety, emissions, fuel consumption, noise (Industrial Policy, Environmental Policy, Global interaction);
- pilots and complementary demos to allow monitoring progress (KA Aeronautics).

Supersonic commercial transport

As a long-term option, the planning requirements for such aeroplanes would benefit from reliable long-term policy goals (~20 years). Innovative, possibly public-private, financing schemes would have to be explored to guarantee the implementation of this large-scale technology.

Needs for action:

- establishment of a policy consensus regarding supersonic commercial transport should be attempted before any further measures are taken (CTP).

Airship

First assessments indicate a number of unique transport capabilities and promising niche applications for airships. First serious developments are on their way. Further studies are needed for a more widespread application potential. Certification is mandatory to speed up their introduction and could be supported by the EU. As airships need a new type of ground infrastructure and support system, network development of associated activities could be helpful. There are different interested manufacturers in Europe that could benefit from such joint activities, not least in relation to safety and operational standards for airships in Europe. Indirect effects of airship operation are estimated to be significantly beneficial (congestion reduction of roads).

Needs for action:

- certification to speed up introduction, (KA Aeronautics);
- network development to develop complementary activities to enable widespread airship operation (KA Aeronautics);
- standards and regulation regarding safety and operation (Industrial Policy);
- studies for a more widespread application potential and transport system integration (KA Land Transport & Marine Technologies);
- development of a long term perspective to replace heavy and bulky freight transport on roads (regulation) (KA Sustainable Mobility & Intermodality).

Subsonic aeroplanes

Subsonic aeroplanes are the main vehicles of a significant growth market and, therefore, they need further improvements in efficiency, safety and environmental impact. Many aspects are already tackled in the Fifth Framework Key Action Aeronautics.

Needs for action:

- continue R&D (KA Aeronautics);
- prepare in time new aircraft/hybrid concepts for a possible next generation (KA Aeronautics);
- emission reduction, lightweight structures, improved aerodynamics and noise reduction (KA Aeronautics).

Defrosting/de-icing systems

Defrosting and de-icing systems are an important safety matter of pan-European interest, but also matter for reducing congestion problems under problematic weather conditions. R&D, networking and knowledge transfer should thus be given financial support. In parallel, the findings from research should lead to adjustment of safety regulations in line with latest technology.

Needs for action:

- R&D funding (KA Aeronautics);
- knowledge transfer and networking to diffuse technology (KA Aeronautics);
- adjustment of safety regulations (KA Aeronautics/CTP).

Air traffic management

New air traffic management systems are currently under development. All phases of the innovation process need to be addressed quite fast. Financial support for R&D is already given, as well as for pilot/demo application. The key issue for the coming years is a harmonisation of the European ATMS based on a unique standard. This will require knowledge transfer to all relevant partners in air operations, network development, adjustment of safety regulations, and finally also a central control/supervision of air operations in Europe.

Needs for action:

- R&D and pilots to test new ATMS (KA Sustainable Mobility and Intermodality);
- harmonisation of standards in all European countries requires European policy initiative (CTP);
- knowledge transfer and networking (KA Sustainable Mobility and Intermodality);
- adjustment of safety regulations (CTP);
- strengthening of supervision of air operations (CTP).

A.6 Waterborne transport technology

In general, the marine part of the KA Land Transport & Marine Technologies does not specify individual technologies, but performance requirements. Whether the four promising technologies will in the end be selected depends on the implementation of the key action, and the selection of proposals.

The KA focuses primarily on an R&D role, not so much on an innovation manager's role. However, pilot projects (typical for innovation management) fit also in the platform strategy of the key action.

All-electric ship

Currently still in an experimental phase, support for R&D would be justified on the basis of its promised environmental advantages. The EU role might be less in direct funding but in monitoring and preparing the regulatory frameworks for enabling its uptake in a later phase of development.

Needs for action:

- monitoring and assessment (KA Land Transport & Marine Technologies);
- preparatory action for setting harmonised regulations (KA Land Transport & Marine Technologies).

Fast sea-going passenger ferries

These ferries will only be successful if they are fully integrated into intermodal transport operations (operation as well as ticketing and intermodal services).

Needs for action:

- regulatory framework to support intermodal transport chains (CTP).

Fast inland passenger ferries

These ferries will only be successful if they are fully integrated into intermodal transport operations (operation as well as ticketing and intermodal services).

Needs for action:

- regulatory framework to support intermodal transport chains (CTP).

Whale tail inland ship

Currently still in an experimental phase, support for R&D would be justified on the basis of its promised environmental advantages. The EU role might be less in direct funding but in monitoring and preparing the regulatory frameworks for enabling its up-take in a later phase of development.

Needs for action:

- monitoring and assessment (KA Land Transport & Marine Technologies);
- preparatory action for setting harmonised regulations (KA Land Transport & Marine Technologies).

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ANNEX C: List of Deliverables

The FANTASIE project has produced the following documents:

Number and title of deliverable	*Status/ availability*	*Responsible partner*
D1 Requirements survey – workshop results	restricted	IPTS
D2 Integrated view of user and policy requirements	restricted	IPTS
D3 Technology watch tools	restricted	IABG
D4 Assessment framework and methodological guidelines	restricted	ETSU
D5 Workshop processes for technology forecasting & assessment	restricted	WS
D6 Appraisal of impact evaluation methods	restricted	ETSU
D7 Conceptual framework for market penetration	restricted	FOA
D8 A structured state-of-the-art survey and review	public	ETSU
D9 Forecast of new technologies with major impacts	public	ETSU
D10 Workshop design	restricted	TNO
D11 Definition of European transport systems – workshop results	restricted	TNO
D12 Characterisation of technologies for impact assessment	public	ETSU
D13 Definition of European transport systems	public	TNO
D14 Scenarios	public	CSST
D15 Adapted methods and time horizons for assessment	restricted	DITS
D16 Safety impacts and benefits of new transport systems	restricted	CSST
D17 Efficiency impacts and benefits of new transport systems	restricted	PFT
D18 Update of policy and user requirements	restricted	IPTS
D19 Environmental impacts and benefits of new transport systems	restricted	ETSU
D20 Socio-economic and other impacts of new transport systems	restricted	IABG
D21 Best practise guide for assessment methods	restricted	FOA
D22 Synthesis of impact assessment and potentials	public	IABG
D23 Options to support the introduction of new technologies and their implications on transport policy	restricted	AVV

GLOSSARY OF TERMS AND ABBREVIATIONS

ADT	Automated Driverless Transport
AHS	Automated Highway Systems
(A)ICC	(Autonomous) Intelligent Cruise Control
APCAR	All-Purpose Car
ATC / ATM	Air Traffic Control / Air Traffic Management
ATP / ATC / ATO	Automatic Train Protection / ... Control / ... Operation
AVG / ...P / ...F	Automated Vehicle Guidance (passenger / freight)
BAU	Business As Usual scenario
CBA	Cost-Benefit Analysis
CHRAIL	Conventional Heavy Rail – passenger and freight
CNG	Compressed Natural Gas
CNS	Communication, Navigation and Surveillance
Cordis	(EC's) Community Research and Development Information Service
CRISP	Counter Rotating Integrated Shrouded Propfan for airplanes; an advanced combination of fan jet and turboprop engine
CRYO	Cryoplane; subsonic aircraft using "green" fuel such as LH_2 or LNG
CTP	Common Transport Policy of the EU
CVT	Continuously Variable Transmission
D	Deliverable; output document, as cited in this report
DG TREN	European Commission's Directorate General for Energy and Transport (formerly DG VII)
DISC engine	Direct Injection, Stratified Charge engine (often includes variable valve timing)
EATMS	European Air Traffic Management System
ELESHIP	All-Electric Ship
ERTMS	European Rail Traffic Management System
ESTO	European Science and Technology Observatory (network)
EV	Electric Vehicle
FFERRY	Fast sea-going passenger Ferry
FIFERRY	Fast Inland Ferry
FRP / FRM	Fibre Reinforced Plastics / Fibre Reinforced Metals
GPS	(satellite based) Global Positioning System
GHG(s)	Green House Gas(es); comprise naturally occurring gases, such as water vapor, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (NO_X), and man-made gases, such as chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), carbon monoxide (CO), sulfur dioxide (SO_2), etc.
GSINNO	Rail and Guided System Innovations
GSM	Global System of Mobile communications
HDV / HGV	Heavy Duty Vehicle / Heavy Goods Vehicle
HEV	Hybrid Electric Vehicle
HOV	High Occupancy Vehicle
HPVE	Human-Powered Vehicle

HSRAIL	High Speed Rail
ICC / ACC	Intelligent Cruise Control / Adaptive Cruise Control
ICE	Internal Combustion Engine
IPT	Individual Public Transport
KA	Key Action in the context of the EC's R&D programme(s)
LDBUS	Long-Distance Bus
LDHDV	Long-Distance Heavy Duty Vehicle
LDV / LGV	Light Duty Vehicle / Light Goods Vehicle
LEV	Low Emission Vehicle
LH_2 / LNG	Liquid Hydrogen / Liquid Natural Gas
LPG	Liquid Petroleum Gas
LRTPM	Light Rail and People-Movers
MagLev	Magnetic Levitation (railway) system
MCA	Multi-Criteria Analysis
MEGAAIR	Megaliner (high capacity, long range) Aircraft
OECD	Organization for Economic Cooperation and Development
PRT	Personal Rapid Transit
PTW	Powered Two-Wheeler
RME	Rape Methyl Ester
ROTOR	Rotorcraft Vehicles; i.e. helicopters, tilt-rotor/-wing aircraft
RTD / R&D	Research and Technological Development / Research and Development
SB	Sustainable Balance scenario
SCT	Supersonic Commercial Transport
SG	Sustainable Growth scenario
SME	Small and Medium-sized Enterprise
SMVE	Slow-Moving Vehicle
Socio-economic	in the FANTASIE context five main socio-economic (impact) areas have been assessed, namely: economic development, completion of the European single market, social cohesion and quality of life, public acceptance, and EC enlargement
SUBAIR	(advanced) Subsonic Aircraft
TA	Technology Assessment
TC	Transport Concept
TCS / ETCS	Train Control System / European Train Control System
TF	Technology Forecasting
TW	Technology Watch
UBUS	Urban Bus
UCAR	Urban Car
UG	Unrestricted Growth scenario
VC	Vehicle Concept
VTOL	Vertical Take-Off and Landing (aircraft)
ZEV	Zero Emission Vehicle