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PLanning and Urban Mobility in Europe

DELIVERABLE 10: Third Annual State-of-the-Art Review

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TABLE OF CONTENTS

TABLES

Overview of Key Findings for Politicians

This State of the Art Report has reviewed the implications of recent research for the pursuit of sustainability through urban transport and land-use strategies in European cities. It has considered the challenges of sustainability in the widest sense, including considerations of environmental, economic and social sustainability.

Problems and Challenges

While vehicle technology improvements have led to a reduction in many local pollutants, cities still face serious environmental challenges. Local air pollution remains a problem, and its health impacts are now more widely understood. Noise has been overlooked as a problem in many European countries, but is likely to attract increasing emphasis as its implications for health and quality of life are more fully appreciated. Other local environmental impacts on visual amenity and historical monuments are less well understood, though research in ISHTAR has documented the scale of the risk to monuments. Transport in cities is also a major contributor to global warming, and needs to be fully integrated into strategies for achieving targets for reducing greenhouse gases.

Congestion is a major challenge to economic sustainability, and is expected to continue to increase rapidly unless remedial action is taken. The costs of congestion, and the direct costs of provision and use of the transport system, are well understood. Considerable work has also been undertaken in connection with the external costs of travel on the environment, but the implementation of solutions to internalise such costs as a mechanism to manage travel demand has been limited. Behavioural solutions offer an alternative to fiscal policies but are equally complex to implement.

Social sustainability challenges include the impacts of accessibility, congestion and the environment on quality of life; the social costs of accidents and lack of personal security; and the distribution of costs and benefits across society. Of these, the costs of accidents are best understood and quantified. Accident rates are falling in most cities, but further action is needed to reduce their impact further, particularly on the most vulnerable users of the road system. Most cities are giving greater emphasis to distributional issues and the reduction of social exclusion, but the scale of the problem remains less well understood and policy is largely driven at a political level rather than by transport issues. Quality of life remains a relatively ill-defined concept in urban planning.

Policies

In tackling the problems outlined here, cities have an increasingly wide range of policy instruments available to them. This range offers the potential for a much richer policy mix, but at the same time presents a challenge, in that cities need to understand better the contribution of each policy instrument. Several Land-Use and Transport Research projects have contributed to this improved understanding.

A key message from several projects is that an integrated strategy will be more effective than one which focuses on a limited set of measures. Successful integrated strategies use combinations of policy instruments to achieve synergy and to reduce the barriers to their implementation. The five principal elements of a successful integrated strategy are enhancements to public transport, walking, cycling, pricing of car use, and land-use policies designed to reinforce these measures.

Public transport services can be improved most effectively by increasing service levels, improving reliability and operating speeds, reducing and simplifying fares, and enhancing the quality of the vehicles, supporting infrastructure, interchange options and information systems. Such moves must be underpinned by marketing initiatives to ensure that habitual car users are aware of improvements in service quality.

Controlling the growth of car use is essential if sustainability is to be increased. While some success can be gained through regulatory measures, and controls on vehicle speeds, pricing is likely to be the most effective means of control. Ideally this should be through a form of road pricing, though parking charges imposed on all forms of parking can provide an effective alternative. Such pricing policies remain politically unpopular, but public antipathy can be reduced by packaging of pricing with public transport improvements in an integrated strategy.

While land-use measures on their own may have a limited impact on current travel patterns, they do enable public transport improvements to be more effective, and can avoid relocation in response to road pricing. The principal elements in an effective land-use strategy are to focus development in centres and on public transport corridors, to maintain sufficiently high densities to support public transport, walking and cycling, and to reduce the provision of parking space. Where transport investment leads to an increase in land value, notably in urban metro investment corridors, land value taxation may provide a mechanism by which transport costs can be recouped.

Road space needs to be managed more effectively, by allocating appropriate priority between general traffic, public transport, walking and cycling, frontage access and public space. While most urban streets will be multi-functional, a balance should be determined for each street between its link status and its place status. A range of cost effective measures is available to enhance link and place status as appropriate.

Walking and cycling are important modes in most European cities, and can provide for a significant proportion of journeys. They offer an effective alternative for many car journeys, provide access to public transport, and may also help relieve congestion on more heavily used public transport corridors. They need to be fully integrated into the overall strategy by providing for them effectively in land-use plans and in the reallocation of road space.

Attitudinal and behavioural measures, including individualised marketing and company travel plans, are attracting increasing interest. They can prompt individuals to consider alternatives to car use, promote specific public transport services, and stimulate walking and cycling. They have the added attraction of being a positive, rather than negative, means of controlling car use. However, the scale of their impact remains uncertain, and it is unlikely that they will ever remove the need for effective pricing of car use.

With this range of lower cost policy measures available, infrastructure investment, in roads or in public transport, will often prove to be a less cost-effective solution. Moreover, it can stimulate growth in journey lengths, which may jeopardise the pursuit of sustainability. Any such investment should be designed to be fully integrated into an overall strategy, so that it can focus on bottlenecks and gaps in the network, while avoiding the generation of additional travel.

New technology will have a continuing role in making vehicles safer and less polluting, and in reducing the emission of greenhouse gases. New modes such as personalised rapid transit

and cybercars may offer effective alternatives to the car and conventional public transport in the longer term, but their potential remains to be demonstrated.

While most of the above conclusions relate principally to passenger travel, freight movements are a significant element in urban travel, and are predominantly road based. Freight is often overlooked in urban transport planning, but has important contributions to both environmental and economic sustainability. An integrated strategy of the kind outlined above can assist in more efficient freight movement. Within that context, freight planning needs to focus on the promotion of efficient access, removal of heavy vehicles from sensitive areas, and transhipment facilities to support more environmentally sensitive modes.

Processes

The essential starting point for an effective land-use and transport strategy is a clear set of policy objectives. Such objectives are specified through a series of processes, including, setting targets, strategy development, strategy impacts forecasting, strategy appraisal, public participation, and strategy implementation. Additionally, there are a range of processes, regulations, and issues associated with financing, and institutional issues that affect all of the processes outlined here.

Policy objectives can be identified in the context of the three elements of sustainability: environmental, economic and social, but need also to address the impact of transport on other areas of public policy, such as health and social inclusion. Once the objectives have been identified, outcome indicators should be specified, which measure performance against these objectives. These in turn can be used to identify problems, to suggest solutions, and to monitor progress in overcoming those problems. Targets can be a valuable stimulus to strategy development and implementation, but need to relate to the agreed outcome indicators, and to be internally consistent. They may best be specified once the overall strategy has been agreed, and then used to monitor the achievement of the strategy.

Strategy development should be based on the agreed objectives and focus on the identified problems. Option generation remains an art rather than a science, and has become more challenging as the range of policy instruments has widened. Several Land-Use and Transport Research projects have identified good practice in strategy development, including the importance of considering the full range of policy instruments, and formulating integrated strategies based on them. Such integrated strategies need to focus on achieving synergy, or at least complementarity, between the measures, and in helping to overcome the barriers of acceptability and finance. Optimisation techniques are now available to help in the design of such strategies.

A wide range of techniques is available for strategy forecasting. However, urban transport systems are complex, and for most applications predictive models are essential in understanding the impacts of proposed strategies. Several Land-Use and Transport Research projects have demonstrated the application of such models, and provided advice on modelling practice. The main barriers to progress are the availability of skilled staff in cities; cities' own unfamiliarity with models, and the availability of good databases for model construction, calibration and validation.

Strategy appraisal needs to be based on the agreed set of objectives. The principal methods are cost-benefit analysis and multi-criteria appraisal. The former relies on the ability to place money values on all objectives and impacts. As the range of objectives widens, this becomes

more difficult. Multi-criteria appraisal is more flexible, in that it can use money values, quantified impacts or qualitative impacts as appropriate, and can reflect differing weights between objectives. Neither method is particularly well designed to reflect distributional impacts or to appraise aspects of social justice.

Public participation can contribute positively to all the above elements of strategy development, including agreement on objectives, problems, indicators and targets; input to option generation; checking forecasts; and appraising options. A range of methods is available; those which promote more active involvement are more expensive but more effective. While such participation may add to the time taken for strategy development, it is likely to simplify the subsequent process of implementation.

Good practice in implementation is less well understood, and has attracted less research, than other elements of the strategy development process. However, research in TRANSPLUS has demonstrated that pursuit of integrated strategies, effective collaboration between disciplines, agencies and tiers of government, and active public participation all help to streamline implementation. A staged implementation process may also help, provided that a balance is maintained between pull and push measures, and between infrastructure management, pricing and public transport measures, and attitudinal and behavioural policies.

Urban transport systems are often subject to operational financial deficits and lack of capital to finance investment. Public budgets are the traditional sources of funding, but are under increasing pressure. For operational costs the other sources are user charges and cross-subsidy. Two broad approaches to obtaining capital for investment may be identified: outright privatisation, and public-private partnership.

For some time there has been a division of responsibilities between local, regional, national and multi-national authorities in relation to transport policy in urban areas, with different levels of authorities having different responsibilities in different countries. Industry reforms have sought to increase competition and promote greater involvement of the private sector in service delivery. Different areas of government have recognised the need to work more closely with one another, leading interest groups from related spheres of public policy to seek a greater input into transport policy. The assessment of good practice in these increasingly complex institutional arrangements is still in its early stages.

Policy Implications

Integrated land-use and transport strategies are more successful than isolated individual policies in either field. The following findings are important to the design of such strategies:

- Land-use and transport policies are only successful in reducing travel distances, travel time and the share of car travel if they make car travel less attractive (i.e., more expensive or slower) and provide attractive land-use alternatives to suburban living.

- Land-use policies to increase urban density or mixed land-use without accompanying measures to make car travel more expensive or slower have little effect as people will continue to make long trips to maximise opportunities within their travel cost and travel time budgets. However, these policies are important in the long run as they provide the preconditions for less car-dependent lifestyles in the future.

- Transport policies making car travel less attractive are very effective in achieving the goal of reducing travel distances and the share of car travel. However, they depend on a spatial organisation that is not too dispersed. In addition, highly diversified labour markets and different work places of workers in multiple-worker households set limits to an optimum coordination of work places and residences.

- Large retail and leisure facilities that are not spatially integrated increase the distances travelled by car and the share of car travel. Land-use policies to prevent the development of such facilities ('push') are more effective than land-use policies aimed to promote high-density, mixed-use development ('pull').

- Transport policies to improve the attractiveness of public transport have in general not led to a major reduction of car travel, attracted only limited development at public transport stations, but contributed to further suburbanisation of the population.

In general, the impacts of 'pull' measures, e.g., of land-use measures, or of improvements in public transport, are much weaker than the impacts of 'push' measures, i.e., of increases in travel time, or travel cost, or other constraints on mobility. In summary, if land-use and transport policies are compared, transport policies are far more direct and efficient in achieving sustainable urban transport. However, accompanying and supporting land-use policies are essential for creating less car-dependent cities in the long run.

Vision

We have illustrated many of these findings, and their possible impacts, through a sketch of a typical European city, Futuresville, as it might appear in 2030. The city's transport strategy has focused on improvements to the light rail network, gradual replacement of the bus service by automated personal transport, charging for car use based on distance travelled, and redevelopment of Brownfield sites and of the low density late 20th century developments. This core strategy has been reinforced by rejuvenated support for walking and cycling, and the development of freight distribution and transhipment centres on the old out-of-town superstore sites.

Car use continues to rise, but at a lower rate, and urban sprawl remains a problem, with people and freight making longer journeys. However, local pollution and noise are far less serious than they were, thanks to the improvement of public transport and the reuse of roads as public space. Congestion is also a much less severe problem, as a result of the change in the costs of car use and the improvements in public transport.

This successful strategy has been developed through a process of deciding together, in which residents, businesses and interest groups have all contributed to an understanding of the problems and possible solutions. They in turn have been aided by a clear and consistent approach to setting agreed targets and monitoring performance against them; Futuresville knows precisely how it performs by comparison with similar cities across Europe. The transport planners, who now work in close cooperation with land-use planners and architects, have provided interactive forecasting tools, which enable everyone to see the likely impacts of new strategies before they are approved. This has helped considerably to increase acceptability of controls on car use, because they are seen as directly benefiting the city and helping meet its targets. All policies are appraised in a consistent way, with money values on all impacts reflecting public concerns, and helping to ensure that the city obtains value for money from all that it does.

Research Needs

While the Land-Use and Transport Research programme has substantially increased our understanding of the requirements for sustainable urban land-use and transport strategies, several research needs remain. These have been categorised into seven domains. The first three: human behaviour, technical performance and new trends, all help to increase our understanding of the fourth: land-use – transport relationships. The last three deal with ways of conducting, disseminating and applying that research: research methods, political aspirations and professional applications. All of these seven domains are interdependent, and each draws on a distinct set of disciplinary approaches. Any future research programme needs to integrate the contributions of these different disciplines into a truly interdisciplinary approach if it is to be successful.

Better communication of key findings from researchers to professionals, politicians and the public will be essential if the lessons for sustainable mobility are to be learnt. Equally importantly, cities need to learn from one another both by example and by testing the transferability of successful initiatives. The sustainability paradigm may serve not just as a basis for evaluating the success of different policy options, but as a means of airing societal aspirations for the future of cities. To this end, the public needs to be more fully engaged, by adopting a clearer and more tangible expression of the concept of sustainability.

1 Introduction

1.1 Background

Across Europe there is a common challenge to improve the quality of life in urban communities, and to ensure the competitiveness of cities, whilst promoting sustainable development. All cities face common challenges relating to air quality, noise, urban sprawl, traffic congestion, waste, economic competitiveness, job creation, security, social inclusion, and maintaining the built environment, cultural heritage, and a deteriorating infrastructure. At the heart of these issues is the fundamental question of how to improve urban planning, in particular the planning of land-use linked to more sustainable urban transport. The question for urban policy-makers and planners is how to integrate these distinct disciplines at the policy level and operationally, given the different actors involved. The discussion has been ongoing for many years, but the question has remained unsolved, mainly due to inadequate channels of communication between researchers, planning officials and policy-makers.

A number of national and international research activities exist that deal with the question of how to implement integrated land-use and transport strategies for sustainable development and sustainable urban mobility. There is now a major challenge to ensure that the results of these projects are exploited to the full in the next few years by matching research outputs to user needs, enabling the means of information exchange, seeking agreement on best practice, and promoting the early introduction of new policies, measures and tools into urban and regional planning.

1.2 Scientific Objectives of PLUME and Approach Taken in this Review

The objective of PLUME, which began in 2003, is to facilitate the transfer of innovation in the field of planning and urban mobility from the research community to end-users. PLUME itself does not generate its own new results; it instead conveys novel research findings previously dispersed around multiple Land-Use and Transport Research projects through a single outlet. A central mechanism for achieving this objective is the provision of three annual State of the Art Reviews, of which this review is the final one.

Each State of The Art Report is intended to provide a synthesis of European research findings from the FP5 Land-Use and Transport Research cluster[1] of projects supplemented by pertinent information from other national and international research. However, it is worth emphasising here, that the content of this State of The Art report is primarily constrained to match the content of the Land-Use and Transport Research cluster projects. In turn the content of these projects was dictated by briefs including specific research questions from the European Commission; thus, there may well be issues that readers feel are relevant that by definition, it has not been possible to include in this State of The Art Report. The State of The Art Reports make recommendations as to which policies, measures and tools are best able to meet the need for sustainable development, taking account of user needs and barriers to implementation. This work was undertaken by a group of experts involved in many of the projects under consideration.

A State of The Art Report is structured according to a number of "themes" as listed in Section 3. Each theme is addressed in a separate document called a "Synthesis Report", which

[1] The Land-Use and Transport Research cluster and PLUME website is: http://www.lutr.net

summarises relevant research from the projects described in Section 2. In order to spread resources efficiently over the lifetime of the project, some Synthesis Reports were prepared for the 2003 State of The Art Report, some for the 2004 Report, and some for the first time for this final report. All Synthesis Reports have been peer-reviewed, including an international review, and the early reports have been updated. Summaries for all of the Synthesis Reports can be found in this final State of The Art Report.

Section 2 of this State of The Art Report identifies the information sources (Land-Use and Transport Research cluster projects) used in compiling the material reported here, and the associated Synthesis Reports. Section 3 goes on to provide an introduction to the themes addressed in the Synthesis Reports, and relates these themes to the relevant Land-Use and Transport Research projects. Overlaps and synergies between themes are considered in this section. Section 4 presents more detailed summaries of the themes, which are categorised by problems, policies and processes, as they are throughout this report. Section 5 considers the policy conclusions from the PLUME work, particularly interactions between urban processes, impacts of policies and measures, and policy conclusions. The report then concludes with a vision of the future for European cities if themes are addressed as the research reported here suggests they should be (Section 6), a summary of research gaps, and future research needs (Section 7), and overall conclusions (Section 8).

2 Sources of Information

The principal source for PLUME has been the Land-Use and Transport cluster of research projects commissioned by DG Research within FP5. The research activities of this cluster focused on land-transport, and its interaction with land-use, as per the common brief that the projects responded to. Consequently, air and water transport receive little attention in this report; but this is not a criticism, it is merely the focus of the research reviewed. The projects were all undertaken and completed between January 2000 and December 2004. In addition, we have drawn on other international and European research as appropriate. For example, ASTRAL (Matthews, 2003) identified a large number of national projects and international networks, which were potentially relevant to PLUME. Another source has been KonSULT[2], a web-based knowledgebase maintained by ITS Leeds. It is regularly updated and covers a broad range of transport related topics and forms an important information source for PLUME, as well as a means of disseminating PLUME outputs, as new material identified through PLUME can be used to keep KonSULT up to date.

2.1 The Land-Use and Transport Research Cluster

The objectives of the Land-Use and Transport Research projects were to develop strategic approaches and methodologies in urban planning that contribute to the promotion of sustainable urban development. These included issues of transport demand and related land-use planning, the design and provision of efficient and innovative transport services including alternative means of transport, and the minimisation of negative environmental and socio-economic impacts.

The cluster includes 12 research projects and covers a wide range of different topics. Short summaries of the objectives of these projects are as follows:

[2] The KonSULT website is currently: http://www.env.leeds.ac.uk/its transferring to http://www.konsult.leeds.ac.uk in the near future.

ARTISTS (Arterial Streets Towards Sustainability)	To improve decision-making regarding the re-construction of arterial streets, taking into account a broad set of social, economic and environmental factors. This should enable European city authorities to re-design arterial streets in to improve the physical environment of corridors while contributing to the implementation of more sustainable transport systems.
ASI (Assess Implementations in the frame of the Cities-of-tomorrow Programme)	To improve assessment of quality of life and to make appropriate consideration of, quality of life assessment results in connection with urban transport and mobility policies. The focus of the project is on the subjective part of quality of life.
CITYFREIGHT (Inter – and Intra – City Freight Distribution Networks)	To identify innovations in freight transport that could contribute to a more sustainable development in European cities; to set up assessment methods; to build sustainable freight transport options for seven cities, assess these options with the proposed assessment tools, and finally propose best practices and initiate implementation in the seven cities.
ECOCITY (Urban Development Towards Appropriate Structures for Sustainable Transport)	To develop settlement patterns giving priority to the requirements of sustainable transport. Necessary conditions are compactness and a balanced mix of land-uses at suitable sites. The aim is to design model settlements in seven participating countries and to derive general guidelines for planning.
ISHTAR (Integrated Software for Health, Transport Efficiency and Artistic Heritage Recovery)	To build an advanced software suite for the analysis of the effects of short-term actions and long-term policies to improve the quality of the environment, citizens' health, conservation of monuments.
PROMPT (New Means to Promote Pedestrian Traffic in Cities)	To promote non-motorised transport in cities with particular focus on pedestrian traffic. The project seeks to identify, discover and disseminate innovative new tools and solutions for problem identification, problem solving, and implementation of measures in order to promote walking in cities.
PROPOLIS (Planning and Research for Land-Use and Transport for Increasing Urban Sustainability)	To research, develop and test integrated land-use and transport policies, tools and comprehensive assessment methodologies in order to define sustainable long-term urban strategies and to demonstrate their effects in European cities.
PROSPECTS Procedures for Recommending Optimal Sustainable Planning of European City Transport Systems)	To provide cities with guidance to generate optimal land-use and transport strategies to meet the challenge of sustainability in their particular circumstances.
SCATTER (Sprawling Cities and Transport: from Evaluation to Recommendations)	To study the causes and consequences of urban sprawl in order to design and to assess the efficiency of measures aiming to prevent, mitigate or control this trend that threatens most European cities.
SUTRA (Sustainable Urban Transportation)	To develop a consistent and comprehensive approach and planning methodology for the analysis of urban transportation problems, that helps to design strategies for sustainable cities.
TRANSPLUS (Transport Planning, Land-Use and Transport Planning, Land-Use and Sustainability)	To identify best practice in the organisation of land-use and transport measures in order to reduce car dependency in European cities and regions and promote economic, social and environmental improvement.
VELOINFO (The European Network for Cycling Expertise)	To support local authorities and sustainable urban planning experts by establishing a web-based expertise centre on bicycle planning policies and bicycle use. European cities and transport planners represent supply/demand for expertise; VeloInfo is sustained by these users, ensuring optimal distribution of expertise.

3 Themes

The 23 themes covered in this State of The Art Report were identified through discussions at the first PLUME end user workshop held in Brussels in early 2003, and were checked again in the second workshop in March 2004. In addition to this, user requirements as identified in PLUME Deliverable 5 were also taken into account. The themes are structured hierarchically into three main groups - Problems, Policies, and Processes - which reflect typical decision-making processes in practice. The current problems with integrated land-use and transport planning and practice identified by the Land-Use and Transport Research cluster of projects create the challenges that land-use and transport professionals are currently grappling with. It is intended that the policies and processes identified and disseminated through PLUME will spread good practice that will help land-use and transport professionals to successfully tackle the challenges they face. Within the structure set out here, the themes are presented in a logical order that also reflects decision-making processes:

A) Problems
1. Environmental Problems
2. Social Problems
3. Economic Problems

B) Policies
4. Land-Use Planning Measures
5. Infrastructure Provision
6. Infrastructure Management
7. Public Transport
8. Travel Demand Management
9. Information Measures
10. Pricing Measures
11. Walking and Cycling Measures
12. Urban Freight Transport Measures
13. Vehicle Technology Measures
14. Innovative Modes
15. Integrated Strategies

C) Processes
16. Setting Targets
17. Strategy Development
18. Strategy Impacts Forecasting
19. Strategy Appraisal
20. Public Participation
21. Strategy Implementation
22. Financing
23. Institutional Issues

All topics are included in this report.

As noted previously, each theme is addressed specifically in a Synthesis Report that follows a common structure: introduction; overview of key findings for politicians; what the theory tells us; what modelling results tell us; what empirical evidence and case studies tell us; tech-

nical summary and implications, and references for further reading. However, because the themes are strongly interlinked, all Synthesis Reports also cover related topics belonging to other themes. In this section the 23 Synthesis Reports of PLUME are introduced in greater detail, and reviewed with respect to overlaps among them. Overlaps highlight the interconnectedness of the themes addressed in the Land-Use and Transport Research cluster, as well as revealing any differences in the perception of problems and the assessment of solutions.

3.1 Land-Use and Transport Research Project Themes Addressed in Synthesis Reports

Table 3.1 identifies the coverage of themes, and indicates where a theme is addressed in more than one Synthesis Report. Table 3.1 can be used to check the consistency with which specific issues are treated in different Synthesis Reports. It might of course be the case that inconsistencies reflect a real divergence of views about particular topics (such as the relative superiority of cost-benefit analysis compared to multi-criteria analysis).

An assessment of how far the projects of the Land-Use and Transport Research cluster cover the range of themes deemed relevant for the analysis of urban land-use and transport, as well as the urban environment is also considered. It should be stressed that the twelve projects were generated independently to a common brief. The omission or limited coverage of certain topics is a result of this process rather than a criticism of the projects themselves.

Table 3.2 indicates which themes are addressed in the twelve Land-Use and Transport Research projects. In Table 3.2 the 23 themes presented previously are further subdivided into sub-themes based on the content of respective Synthesis Reports. The most useful of these sub-themes are picked up in the summaries in Section 4. An inspection of the table shows that the 12 Land-Use and Transport Research projects cover the field of urban land-use, transport and environment quite thoroughly, although there are, different levels of emphasis. Environmental, social and economic problems are not evenly covered:

Problems

A look at the list above shows that the three Synthesis Reports on *problems* are very coherent, although environmental, social and economic problems are not evenly covered by the Land-Use and Transport Research projects. As expected, all three Synthesis Reports emphasise the interconnectedness of environmental, social and economic aspects as the three dimensions of sustainability:

- *Environmental problems*. Virtually all Land-Use and Transport Research projects mention central environmental problems, such as atmospheric pollution, noise, land capture and greenhouse gas emission, as principal targets of their research. ISHTAR and PROPOLIS have paid some of the most detailed attention to environmental issues. Adverse visual impacts, loss of cultural heritage and negative health impacts are addressed less frequently. Environmental problems of cities are the consequence of the increase in economic activity and mobility caused by economic growth and therefore cannot be discussed without addressing the goal conflict between economic growth and environmental sustainability. However, there are also links between environmental and social problems because many solutions to environmental problems have equity implications.

- *Social problems*. The social dimension of urban sustainability is less frequently addressed by the Land-Use and Transport Research projects. Only, ARTISTS, PROMPT, PROPOLIS, PROSPECTS, TRANSPLUS, indicate that equal access, social exclusion and equity

are important items on their agenda. The close relationship between social and economic problems is obvious. However, there are also relationships between social and environmental problems as in many cities environmental problems are highest in low-income neighbourhoods.

Table 3.1 Themes Addressed in Synthesis Reports

		... addresses issues of theme																						
		Problems			Policies												Processes							
Synthesis Report ...		Environmental problems	Social problems	Economic problems	Land-use planning	Infrastructure provision	Infrastructure management	Public transport	Travel demand management	Information measures	Pricing measures	Walking/cycling measures	Urban freight measures	Vehicle technology measures	Innovative modes	Integrated strategies	Setting targets	Strategy development	Strategy impact forecasting	Strategy appraisal	Strategy implementation	Public participation	Financing	Institutional issues
Problems	Environmental problems	■	○	○																				
	Social problems	○	■	○																				
	Economic problems	○	○	■																			○	
Policies	Land-use planning	○	○	○	■	○			○			○											○	
	Infrastructure provision	○	○	○	○	■			○		○	○	○										○	
	Infrastructure management					○	■	○				○					○						○	
	Public transport	○				○	○	■	○	○	○				○								○	
	Travel demand management	○	○	○	○				■		○	○												
	Information measures									■														
	Pricing measures	○	○	○	○	○			○		■	○	○										○	
	Walking/cycling measures	○	○	○	○	○			○		○	■												
	Urban freight measures	○	○	○	○	○							■											
	Vehicle technology measures	○		○							○			■										
	Innovative modes	○				○	○	○	○	○	○			○	■								○	
	Integrated strategies	○	○	○	○	○	○	○	○	○	○	○	○	○	○	■	○	○	○	○	○	○	○	○
Processes	Setting targets																■	○	○	○	○			
	Strategy development	○	○	○														■		○		○		
	Strategy impact forecasting																		■					
	Strategy appraisal	○	○	○														○		■		○		
	Strategy implementation	○	○	○														○			■	○		
	Public participation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	■		
	Financing			○	○	○					○							○		○	○	○	■	
	Institutional issues			○	○			○			○					○		○				○	○	■

■ Full overlap ○ Partial overlap

- *Economic problems*. Traffic congestion and traffic accidents are the most frequently addressed economic problems in the Land-Use and Transport Research projects. Economic problems in general have a strong social or distributional (equity) component. In many cases solutions to economic problems are in conflict with the achievement of social and environmental objectives.

Policies

Among the policies identified in the Land-Use and Transport Research cluster, the individual projects are more specialised. Each of them addresses a certain group of policies. The Synthesis Reports dealing with policies are equally coherent among each other and, in addition, tend to refer to all three dimensions of sustainability:

- *Land-use planning measure*s. Land-use measures are addressed mainly in ECOCITY, PROPOLIS, SCATTER and TRANSPLUS. It is recognised that land-use measures strongly interact with the provision of transport infrastructure, such as roads or public transport lines as well as with travel demand management policies.

- *Infrastructure provision*. Infrastructure provision measures are dealt with in ARTISTS, ECOCITY, PROMPT, PROPOLIS, PROSPECTS, SUTRA and TRANSPLUS. With respect to transport policies, PROSPECTS is similarly comprehensive as TRANSPLUS. VELOINFO, not surprisingly focuses on measures related to cycling. The Synthesis Report on infrastructure provision emphasises the need to co-ordinate infrastructure provision with appropriate land-use planning measures and also refers to travel demand management, transport pricing and urban freight measures, as necessary accompanying measures.

- *Infrastructure management*. Issues of road and public transport infrastructure management were considered in ARTISTS, ECOCITY, PROPOLIS, PROSPECTS and TRANSPLUS. For reasons explained in Section 4.2.3, the Synthesis Report on infrastructure management focuses on road space management, but relates to other management measures, including public transport service provision, walking and cycling facilities, and travel demand management.

- *Public transport*. Public transport was addressed in virtually all Land-Use and Transport Research cluster projects. However, public transport strategies are explicitly addressed in ISHTAR, PROPOLIS, PROSPECTS, SCATTER and TRANSPLUS. SCATTER in particular analyses the effects of implementing regional public transport (e.g., regional railways) on the spatial structure of urban areas, and spatial distribution of population (sprawl) and economic activities. Improving public transport is one of the main policy fields of sustainable urban planning and is to become even more important with the prospect of rising energy prices and increasing car costs. Such measures are closely linked to infrastructure provision, pricing and travel demand management.

- *Travel demand management - attitudinal and behavioural measures*. Only a few projects looked into the potential of attitudinal and behavioural transport measures. PROSPECTS and TRANSPLUS are the most comprehensive in this respect; VELOINFO suggests marketing as a means to promote cycling. It is stressed that successful travel demand management depends on a not too dispersed land-use system and needs to be accompanied by appropriate transport pricing policies, and a well developed network of public transport, walkways and cycling lanes.

- *Information measures*. Information measures, such as traffic information systems or public transport passenger information systems were treated in ARTISTS, ECOCITY, ISHTAR, PROSPECTS and TRANSPLUS. Providing relevant and timely information on travel opportunities to travellers before starting a trip and en-route is important for mitigating road congestion and attracting new passengers to public transport.

- *Pricing measures*. Only PROPOLIS, PROSPECTS, SCATTER, SUTRA and TRANSPLUS looked into the impacts of pricing polices, such as fuel or car taxes, different schemes of road pricing, parking charges or changing public transport fares, impacts on mobility and environment, and in some cases, impacts on land-use, and the spatial distribution of the population and economic activities. This is surprising as these policies have been found to be by far the most effective in reducing car travel and the related environmental impacts. More than other policies, pricing measures depend on supporting measures in the field of land-use planning, infrastructure provision, travel demand, walking and cycling and urban freight.

- *Walking and cycling measures*. Walking and cycling measures were dealt with in infrastructure provision and in this separate group of policies. Measures promoting walking were considered in ARTISTS, ECOCITY, PROSPECTS and TRANSPLUS. Cycling was dealt with in PROPOLIS, PROSPECTS, TRANSPLUS and of course, in VELOINFO. Successful promotion of the slow modes walking and cycling cannot be done in isolation but requires a high-density mixed-used land-use system, supporting travel demand measures, taxation of car travel and a well developed network of walkways and cycling lanes.

- *Urban freight measures*. Only four projects explicitly dealt with urban freight transport. CITYFREIGHT dealt exclusively with urban freight transport. In ARTISTS loading and unloading was considered as a function to be accommodated in the street space. ECOCITY considers city logistics, and PROSPECTS discussed various freight-related policies. Sustainable urban freight transport is connected to land-use planning, as well as infrastructure provision and management.

- *Vehicle technology measures*. ECOCITY, PROPOLIS, SUTRA and TRANSPLUS took account of the impact of cleaner cars on air quality or of more energy-efficient cars on greenhouse gas emissions and air quality. However, as these developments cannot be influenced by local government decisions, they were not generally considered in the projects. More energy-efficient cars become economically feasible only if fuel becomes more expensive.

- *Innovative modes*. Innovative modes were addressed in the NETMOBIL cluster which is a sister-cluster to the Land-Use and Transport Research cluster. The EDICT, CYBERCARS, CYBERMOVE and STARDUST projects were devoted to these themes although they addressed some of the issues of interaction of new modes and land-use planning. New forms of using and combining travel modes are becoming more and more important to achieve synergies between modes and to maintain quality of access in low-density areas.

- *Integrated strategies.* Only a few projects studied integrated land-use and transport policies: ECOCITY, PROPOLIS, PROSPECTS and SCATTER. However, in PROPOLIS

and PROSPECTS integrated strategies were a major concern. Not surprisingly, the Synthesis Report on integrated strategies addresses all themes addressed in PLUME.

Processes

The last part of Table 3.2 showing processes clearly reveals the distinction between 'What' projects and 'How' projects. 'What' projects are mainly interested in finding solutions to problems, i.e., to find out 'what' should be done. 'How' projects, on the other hand, are predominantly interested in 'how' policies can be implemented. In this respect, ARTISTS, CITY-FREIGHT and ISHTAR are clearly 'What' projects, whereas ASI and TRANSPLUS are clearly 'How' projects, with the other projects somewhere in between. It is also apparent that the different phases in the planning process have received different attention.

The Synthesis Reports dealing with planning processes start from the problems representing the three dimensions of urban sustainability. These Synthesis Reports discuss how policies are developed, assessed and implemented and applied to all sorts of problems. Therefore these Synthesis Reports mostly cross-reference each other:

- *Setting targets*. Little attention was paid to the process of goal setting as a political and participatory process. However, PROPOLIS and PROSPECTS developed their own goal systems, partly in co-operation with their client partners in their case study cities. Setting targets is closely linked to the subsequent steps of strategy development, strategy impact forecasting and strategy appraisal.

- *Strategy development*. In a certain sense all twelve projects developed strategies. But only ASI, ECOCITY, PROMPT, PROPOLIS, PROSPECTS, TRANSPLUS and SCATTER have paid attention to the process and methodology of how strategies are developed. Only PROMPT, PROPOLIS and PROSPECTS explicitly addressed the potential of combinations of policies, or policy packages. Strategy development is intrinsically linked to strategy appraisal and in many cases involves public participation.

- *Strategy impact forecasting*. It is surprising that only a few projects addressed issues of forecasting the impacts of land-use and transport policies, as this is a task of extreme complexity and, because of the many factors and interactions to be considered, great methodological difficulty. ECOCITY, PROPOLIS, PROSPECTS, TRANSPLUS and SCATTER reviewed the state of the art and developed innovative methods in this field, whilst ISHTAR developed a tool for forecasting strategy impacts. With the prospect of imminent energy shortages and climate change, long-range forecasting of economic, social and environmental impacts of planning policies becomes more important, in particular for integrated strategies.

- *Strategy appraisal*. ASI, ECOCITY, PROPOLIS, PROSPECTS, ISHTAR, SCATTER and SUTRA explored different types of strategy appraisal, such as cost-benefit analysis or multi-criteria analysis or, as in ISHTAR and PROPOLIS, combinations of both. Only ASI, PROPOLIS and PROSPECTS addressed issues of measuring social and/or spatial equity. Strategy appraisal is intrinsically linked to strategy development.

- *Strategy implementation*. Implementation issues were clearly underrepresented in the projects of the Land-Use and Transport Research cluster. Barriers to implementation were addressed in SCATTER and TRANSPLUS. The presentation of planning alternatives was

considered in PROSPECTS and SCATTER. There is a strong link between strategy implementation and public participation.

- *Public participation*. Similarly, public participation was treated by only a few projects. Only ASI, ECOCITY, PROSPECTS and TRANSPLUS dealt extensively with public participation. Public participation addresses all aspects of urban planning. Because strategy implementation is strongly linked with public participation, it is also treated in this Synthesis Reports.

- *Financing*. Financing problems and methods were addressed only in a few of the projects. PPOPOLIS and PROSPECTS addressed methods of cost analysis and TRANSPLUS looked into different financing methods. Financing of policies applies equally to land-use planning and infrastructure provision, and pervades all phases of the planning process.

- *Institutional issues*. Institutional issues of policy implementation were addressed in many Land-Use and Transport Research projects, most notably in PROSPECTS and TRANSPLUS. Urban problems have long exceeded the jurisdictions of individual local governments. Therefore issues of centralisation/decentralisation and the role of public and private actors have to be reviewed.

In summary, the projects of the Land-Use and Transport Research cluster addressed an impressive range of themes related to land-use and transport planning. The coverage of planning problems was quite comprehensive. Among the policies, more conventional engineering, regulatory and management policies, such as infrastructure and pricing, received more attention than attitudinal and behavioural policies, or information. Integrated strategies were analysed in only a few projects. Among the different phases in the planning process, the early stages, such as strategy development and appraisal, were treated more extensively than the latter phases, such as implementation, public participation and financing.

Table 3.2 Themes Addressed in the Land-Use and Transport Research Projects

Theme/sub-theme ...			*... is addressed in project*											
			ARTISTS	ASI	CITYFREIGHT	ECOCITY	ISHTAR	PROMPT	PROPOLIS	PROSPECTS	SCATTER	SUTRA	TRANSPLUS	VELOINFO
Problems	Environmental	Air pollution	●	●	●	●	●		●	●	●	●	●	●
		Noise	●	●	○	○	●		●	●			●	
		Land				●	●		●	●	●		○	
		Greenhouse gases			●	●	●		●	●	●	●	●	●
		Visual impact	●	●				●						
		Cultural heritage		○		○	○							
		Health		●		○	●	○	○				○	
	Social	Access	●	○	○	○		○	●	●	●		●	○
		Social exclusion							○	●	●			○
		Mobility handicaps						○						
		Equity		○				○	●	●	●		○	
		Health		●		○	●	○	●				○	○
	Economic	Congestion	●		●	●	●		●	●	●	●	○	
		Accidents	●				●	●	●	●	●	●	○	○
		Financial barriers								○			○	
		Economic activity			○	○			●			●		
		External costs					●		○	○	○			
		Equity							●	●	●		○	
		Health		●		○	●						○	○

● Major theme ○ Minor theme

Table 3.2 Themes Addressed in the Land-Use and Transport Research Projects (cont)

		Theme/sub-theme ...	*... is addressed in project*											
			ARTISTS	ASI	CITYFREIGHT	ECOCITY	ISHTAR	PROMPT	PROPOLIS	PROSPECTS	SCATTER	SUTRA	TRANSPLUS	VELOINFO
Policies	Land-use planning	Settlement planning				●			●		●		○	
		Settlement size/containment				●			●		●		●	
		Concentration/densification				●			●	○	●		●	
		Urban structure			○	●			●		●		●	
		Location by accessibility			●	○			●	○	●		●	
		PT-oriented development				●			●	○	●		●	
		Car-free development				●			○				●	
		Urban design	●			●			○		●		○	
	Infrastructure provision	Motorways					●		●	○		●	○	
		Local roads	●						●	○		●	○	
		Walkways	○			●		●		○			●	
		Cycling lanes	○			●		●	○	○			●	●
		Public transport				●	●	●	●	○		●	●	
		Freight infrastructure			●	○								
		Parking				●	●		●	○		●	○	
	Infrastructure management	Better public transport				○			●	○	●		○	
		Park and ride												
		Parking management				○				○				
		Road space management	●		●	○				○			○	
		Traffic control systems								○			○	
	Public transport	New infrastructure					●		●	○	○		○	
		Better service							●	○	○		○	
		Fares							●	○	○		○	
		Travel information								○			○	
		Mixed-mode travel						○		○			○	●
	Travel demand management	Marketing				○				○			○	●
		Company travel plans								○			○	
		Ride sharing							○	○			○	
		Car sharing							○	○			○	
		Flexible work hours							○	○			○	
		Teleworking							●	○				
		Teleshopping			○									
	Information	Radio/TV. based services	●							○			●	
		Internet-based services			●					○				●
		PT passenger information								○				
		Navigation systems			●					○				
		Mobility centres	●		●	●							●	

● Major theme ○ Minor theme

Table 3.2 Themes Addressed in the Land-Use and Transport Research Projects (cont)

		Theme/sub-theme ...	*... is addressed in project*											
			ARTISTS	ASI	CITYFREIGHT	ECOCITY	ISHTAR	PROMPT	PROPOLIS	PROSPECTS	SCATTER	SUTRA	TRANSPLUS	VELOINFO
Policies	Pricing	Fuel taxes							●	○		○	○	
		Car taxes							○				○	
		Road pricing, motorways							●				○	
		Road pricing, all roads							●	●	●	○	○	
		Parking charges							●	●	●	○	○	
		Rail network charges							●					
		Public transport fares							●	●	●	○	○	
	Walking cycling	Walkways	○			●				○			○	
		Pedestrianisation	○			○							○	
		Safe crossings	○			○								
		Cycling lanes				●			○	○			○	●
		Bicycle service stations				●								●
	Urban freight transport	Access constraints			●	○								
		Loading zones			●									
		Freight terminals			●									
		City logistics			●	●								
		Parcel delivery points			●	○								
	Vehicle technology	Cleaner cars				○	●		●			○	○	
		More energy-efficient cars				○			●			○	○	
		Safer cars												
		Hybrid cars												
		Natural gas vehicles												
		Alternative fuels												
	Innovative modes	Personal rapid transit												
		Advanced driver assistance												
		Automated vehicle guidance												
		Bus/taxi on demand								○			○	
		Car/bike sharing							○	○			○	○
	Integrated strategies	Infrastructure			○				●					
		Infrastructure and pricing							●	○	●			
		Infrastructure and land-use				○			●		●			
		Pricing and land use							●	○	●			
		Infrastructure and TDM							●	○				
		TDM and information							●					
		Integrated programmes				○			●	●	●			

● Major theme ○ Minor theme TDM Travel Demand Management

Table 3.2 Themes Addressed in the Land-Use and Transport Research Projects (cont)

Theme/sub-theme ...			... is addressed in project											
			ARTISTS	ASI	CITYFREIGHT	ECOCITY	ISHTAR	PROMPT	PROPOLIS	PROSPECTS	SCATTER	SUTRA	TRANSPLUS	VELOINFO
Processes	Setting targets	Defining objectives			●	●			○	●	●			
		Defining indicators			○	●			●	●	●			
		Soliciting preferences							○	○				
		Updating targets							○	○				
	Strategy development	Decision making	●	●		●				●			○	
		Public participation	●	●		●				○			●	
		Specification of objectives			●				●	●	●		○	
		Defining indicators	●	●	○				●	●	●		●	
		Understanding barriers			●					●	●		●	
		Combining policies			●			●	●	●	●		●	
	Strategy impact forecasting	Theoretical foundations			●				●	●			○	
		Forecasting techniques				●	●		●	●	●		●	
		Scenario building			●				●	○	●		●	
		Simulation			●		●		●	○	●		○	
		Policy optimisation			●				○	●			○	
	Strategy appraisal	Definition of sustainability	●	●		●			●	●	●			
		Cost benefit analysis			●		●		●	●				
		Multicriteria analysis		●	●		●		●	●	●	●		
		Equity		●					●	○				
	Strategy implementation	Presentation of strategies			●				●		●			
		Barriers to implementation			●					○	●		●	
		Overcoming barriers			●					○	●		●	
		Implementation			●	○				○			●	
		Monitoring			○					○	●			
	Public participation	Stages of participation	●	●						○			●	
		Levels of participation	●	●		●				○			●	
		Organisational aspects	●	●		●							●	
		Participants	●	●									●	
		Current practice	●	●									●	
	Financing	Cost analysis			●				●	●				
		Sources of funding			○					○				
		Financing techniques											○	
		Overcoming barriers												
	Institutional issues	Levels of government								○	○		○	
		Vertical co-operation								○	○		○	
		Horizontal co-operation								○	○		○	
		Public-private partnerships								○			○	
		Privatisation								○			○	

● Major theme ○ Minor theme

4 Theme Summaries

This section of the State of The Art Report provides more detailed summaries of themes set out above. Each synopsis is taken from the political summaries included in the individual Synthesis Reports. For examples of the issues and solutions outlined in the following summaries, readers should turn to the individual Synthesis Reports, which can be found on the PLUME website (http://www.lutr.net)[3].

4.1 Problems

4.1.1 Environmental Problems

The principal environmental impacts of transport and land-use considered here are atmospheric pollutants, including greenhouse gases, and noise. Visual amenity, severance and intimidation are also negatively affected by land-use and transport activities, but are less easily quantified, and thus less frequently studied.

There is a clear causal link between traffic and environmental problems. However, the link with urban sprawl, though theoretically realistic, is much more difficult to establish because of the lack of available data. In principle, increased sprawl will affect land consumption, energy consumption, pollution, noise and visual amenity. The net impacts on energy consumption and pollution are particularly difficult to estimate.

Transport emits a range of local pollutants, including Oxides of Nitrogen, Carbon Monoxide, Volatile Organic Compounds and Particulates. Many of these have been dramatically reduced by improvements in vehicle technology, triggered by European and international regulations. However, Oxides of Nitrogen and Particulates remain serious problems. There is no threshold under which air pollution is harmless. Following the Directive 1999/30/EC, the concentration of PM_{10} in the air in 2005 should not exceed 40µg/m³ (annual average). Overall, each 10µg/m^3 of PM_{10} increases the risks of mortality by around 3%, illness linked to respiratory ailments including asthma and respiratory diseases by 1% to 3%, and illness related to acute bronchitis in children by as much as 30%.

Air pollution has an impact on cultural heritage too. Pollution accelerates the natural ageing of stone. In the most polluted cities, pollution can cause the loss of more than one millimetre of stone thickness in 10 years. The nature of the stone is of course an important factor, as is local climate. Reduction of sulphur oxides emissions has improved in the past, but nitrogen oxides can also be a source of corrosion.

The principal regional pollutant is Ozone, which results from the photochemical reactions of primary pollutants such as Oxides of Nitrogen and Volatile Organic Compounds. Ozone is distributed widely in certain meteorological conditions, and can have serious ecological impacts.

Global warming is generated by the excess production of certain “greenhouse” gases, of which Carbon Dioxide is the most prevalent. Transport accounts for around a quarter of all Carbon Dioxide emissions, and its share is growing. Transport and land-use also contribute to

[3] Please note that as with all EU research project reports, the synthesis reports (and this state-of-the-art report) must be approved by the Commission before they are released into the public domain, thus, there may be a small delay in uploading this and the most recent synthesis reports to the website.

other greenhouse gases, including Methane which, while produced in much smaller quantities, have a proportionally greater impact on climate change.

There are a number of potential effects of noise on health, in domains such as annoyance, speech interference, concentration on tasks, mental health, hearing loss, stress or sleep disturbance. However, according to ISHTAR, there is no evidence of effects other than those based on sleep disturbance and annoyance. For noise, scientific evidence suggests thresholds below which it is unlikely that there is an impact on health, though this is not yet firmly established. Uncertainties remain large in this field.

European Directives have been introduced to limit the emission of most pollutants and of noise, and these have a significant influence on the development of transport policies to protect the environment. Several studies have assigned values to the emission of a unit of local pollutants, noise and, more recently, greenhouse gases. As these valuations become more robust, they will enable policies designed to reduce such emissions to be more effectively appraised.

4.1.2 Social Problems

It is stated in the "European Transport Policy for 2010: time to decide" White Paper (European Commission, 2001, p6) that "a modern transport system must be sustainable from an economic and social as well as an environmental viewpoint". Currently, there are a range of transport and land-use related social sustainability problems resulting in social exclusion for certain groups (i.e., the inability to participate fully in society, in this case primarily due to the location of activities and the nature of transport supply, although factors such as income are also important in many cases), and inequitable distribution of benefits and disbenefits arising from land-use and transport decisions. These problems include:

- Urban land-use planning resulting in increased need for mobility as a result of urban sprawl, at the same time as inequitable transport supply, e.g., lack of provision of public transport, or facilities for pedestrians and cyclists resulting in exclusion for those without a car.
- Social, education and health policies having little regard for wider transport and mobility consequences of decisions in the context of inequitable transport supply, an example from the UK is, parental choice of schools resulting in increased school escort trips by private car.
- National and regional transport policies that do not tackle, and potentially create, local problems especially severance, loss of community cohesion, and distortion/disruption of social networks, and therefore supply of social capital.
- Fiscal reforms to internalise external costs, and allocation of budgets to complete trans-European networks raise a range of equity questions concerned with; who benefits, who does not, and how those who do not are compensated.
- Moves to open up the transport market, especially in rail, being negated by almost monopolistic positions of some operators, resulting in uncompetitive pricing, higher costs for consumers, gaps in provision, and thus inequitable opportunity to travel.

It is also worth observing here, that many of the social sustainability problems are directly linked to environmental and economic sustainability problems outlined elsewhere in Section 4.1. For example, decisions and systems that generate demand for mobility, but do not supply public transport will have negative environmental consequences, whilst monopolies in an open market are economically inefficient.

Given the range of issues identified above, it is clear that those with responsibility for decision making in land-use and transport, and other policy areas have to provide the preconditions for social sustainability. Indeed the PROSPECTS project cites equity and social inclusion as one of seven key objectives for sustainability, and describes the objective as follows:

"Under equity the principal concerns are the need for reasonably equal opportunities to travel, costs of travel and environmental and safety impacts of travel. Within social inclusion we include accessibility for those without a car and accessibility for those with impaired mobility. True equality of opportunity will never be feasible, but consideration needs to be given to compensating those with the fewest opportunities or the greatest costs" (May et al, 2003).

Thus, location decisions, and transport supply decisions need to be considered in terms of equity and distribution impacts for different sectors of society to ensure accessibility and usability for all. By accessibility we mean ensuring that everybody can access jobs, education, health, leisure facilities, and a healthy diet. This means more than building a link road between a new business development site and the urban ring road, to provide access to the road network for example, it means ensuring public transport services (that are usable by those with disabilities, the elderly, those travelling with children, or luggage, and those traveling after dark, as well as your average commuter) link residential areas to the new development, and that services operate when employees need to travel, not when convention or the operator decides they should.

Further, land-use and transport policy instruments that are traditionally associated with environmental sustainability, can also have positive social sustainability impacts. For example, measures to reduce negative environmental impacts such as noise and pollution, and measures to reduce car use through increased walking and cycling, or public transport use can all have positive quality of life benefits in terms of reduced anxiety and respiratory diseases, increased fitness, less stress arising from driving in congested conditions, and helping to sustain social networks. These all have positive health consequences that contribute to social sustainability. However, measures to promote environmental sustainability are often only communicated to the general public in those terms, if they are communicated at all, quality of life, health and wider social sustainability issues are often neglected. To achieve the necessary public acceptability to implement the more challenging policy instruments, such as pricing to internalise external costs and create a more level playing field between modes, communication of the full range of benefits is needed. Social marketing could be one way to achieve this.

4.1.3 Economic Problems

The following economic challenges in the transport field have been identified:

- Real and perceived connections between economic growth and transport growth;
- Internal costs and resulting financial barriers to transport strategy implementation;
- External costs (those not inherently borne by the user), including environmental & noise impacts (see Section 4.1.1), accident impacts, loss of time and land consumption.

In the EU, economic growth is currently coupled with an increase in demand for both freight and personal transport: between 1990 and 2000, the EU's GDP increased by 22%, goods transport (in tonne kilometres) increased by 32% and passenger travel (in person kilometres) by 20%. The negative side-effects of these trends create considerable costs to society and

have negative effects on people's quality of life, especially in urban areas and it is increasingly important to work towards a decoupling of mobility and economic growth.

Planning, implementing, maintaining and monitoring transport infrastructure and services gives rise to significant costs but the people travelling often do not bear the costs of the infrastructure they use. Other than in some cities with road user charging schemes and on toll motorways, car users pay no direct costs for using the roads and people travelling by rail or air only cover some of the infrastructure costs through the ticket price. People in Germany, for example, underpay for use of the roads by about €1.80 per 100 person km (pkm) and for use of rail infrastructure by €0.20 per 100 pkm (Vestner, 2004). This can lead to significant difficulties in financing (see the Financing Synthesis Report), and a survey for PROSPECTS (Deliverable 15; May et al, 2003) indeed found that road building and public transport infrastructure are the two transport policy areas most commonly subject to financial constraints (in 80 % of cities surveyed) with bus and rail operation following in third place.

Increasing – though still insufficient - consideration is being given to the external costs of transport: those costs that are caused by satisfying the mobility needs of goods and people but which are not actually paid for within the transport system, including environmental pollution, noise, accident and other health costs, land-use and loss of time through congestion. Questions exist concerning how best to calculate their true value and how to predict the effect different policy instruments will have on these costs in the short, medium and long term. A recent study in Germany puts external costs of personal travel at €11.00 per 100 pkm travelled by car and €2.50 per 100 pkm of rail travel (Vestner, 2004).

Tackling these challenges through measures that increase the direct costs of the undesired modes (such as road tolls or fuel prices) is politically difficult. An alternative is to decrease the relative (financial or time) costs of other modes by increasing their speed or frequency, and to focus on access rather than mobility through integrating land-use and transport policies. Achieving better air quality, noise reduction, time savings, and new uses of urban open space can positively influence economic development, so extending the notion of quality in the management of urban systems to include transport and all its effects is the best strategy to sustain economic development in the future.

It is clear that if current trends continue, both internal and external costs of transport will rise even further in absolute terms and people will be faced with spending increasing proportions of their income on satisfying their mobility needs. However, projects within the PLUME network are showing (through both case studies and the development and application of models), that the problems of financial barriers and of external costs can both be tackled with some success if the right combination of instruments is chosen.

4.2 Policies

4.2.1 Land-Use Planning Measures

Land-use and transport are interlinked. To have an efficient and effective transport system implies getting the land-use planning right, and planning urban development implies getting the transport access right. In other words, the different policy spheres and disciplines have to work together to deliver the best results for the functioning of a town or city.

A range of policy measures is available to influence travel demand. Of these, land-use planning measures can contribute, but these may take a long time to take effect. The conversion of existing building stock and neighbourhoods takes place at a slow rate of change – a typical figure for the rate of turnover of the urban fabric is 1% per year. Therefore, the switch from, say, a policy of minimum housing density and maximum parking standards to a policy of maximum housing density and minimum parking standards will take some years to have an effect, since a large proportion of the existing urban development will already be laid out to previous standards.

On the other hand, this long-term nature means that land-use planning measures can set the physical pattern upon which mobility patterns are based for generations. Put another way, once good practice has been invested in, it is less easily undone. The suburbs of the early 20th century – built to low density but before mass car ownership – have meant that car-orientation has been 'built in' to those localities for decades. This also implies that if we can 'build in' sustainability-oriented (e.g. travel-minimising) features to new development, we could expect these to be a worthwhile investment prevailing over decades to come.

There is a variety of land-use planning measures available for influencing mobility. These range from the large scale planning of whole settlements down to the detailed design of urban design features such as buildings and 'streetscape' features. The Synthesis Report has considered these under the following nine themes:

1. Settlement Planning
2. Settlement Size and Containment
3. Urban Concentration / Densification
4. Urban Structure
5. Location Policy linked to Accessibility
6. Transit Oriented Development
7. Car Free Developments
8. Development Control
9. Urban Design

There have been a great variety of studies into the effect of land-use planning measures on travel. The general themes are well known, but the robustness of results is not necessarily consistent, and the exact extent of cause and effect is not conclusive. Even where results appear to show clear correspondence between indicators, this clarity does not necessarily prove a straightforward underlying relationship. Often there is a complexity of factors relating to particular people and localities involved. Nevertheless, the general impression of the planning policy contribution – that denser, more compact, mixed use settlements, and medium-large settlements tend to exhibit a greater propensity for travel by public transport and on foot, and to generate shorter journeys – is one often supported by evidence, and rarely if ever contradicted (Hall and Marshall, 2002).

While land-use distribution and the design of development do not necessarily themselves cause shifts towards more sustainable travel behaviour, they can provide a supportive context for those transport polices which are able to stimulate such responses. Moreover, a combination of complementary land-use planning measures can provide an integrated package where each element reinforces the others towards a more sustainable outcome.

4.2.2 Infrastructure Provision

Major works of engineering are among the most high profile elements of any city. Bridges, metro systems, street systems, highway interchanges, and multi-storey car parks are particularly visible investments that can significantly influence the form and function of cities. Underground rail systems also significantly affect the function of cities, but these were not a focus of any of the Land-Use and Transport Research projects considered in this report. Infrastructure is one of the major costs that any public authority may have to invest in, so getting it right is important. In particular, infrastructure can be a very long-term investment, and care has to be taken to balance short-terms needs and long-term needs. Ways of phasing infrastructure provision to optimise operational performance must take account of the need for a system to be viable and efficient at any particular time, and not forever building for the future. Yet, decisions taken now will affect the long-term viability and efficiency, and getting it right to start with will pay dividends, i.e., avoiding the need for retrofitting.

Infrastructure represents supply side investment in transport. Supply is directed towards meeting demand – or it may be used to deliberately constrain, or generate demand. It is therefore an important influence. In any particular circumstance, infrastructure is likely to be a necessary prerequisite for an effective transport system, even if it is not always sufficient, without provision of accompanying measures. Tailoring infrastructure to demand and other transport and public policy packages is an important task for any city decision-maker.

Infrastructure provision can affect demand for the different modes of transport, the origins and destinations and hence the accessibility of different locations, and the distribution and volume of flows on different parts of the network. Major transport networks can be a powerful influence on the dispersal of both residential and employment development. The proximity to major transport networks may lead to travel patterns characterised by long travel distances and high transport energy consumption. Overall, infrastructure provision is a significant influence in directing locations for growth, for favouring certain modes, toward objectives of spatial equity, economic performance and sustainability.

The provision of infrastructure is likely to increase demand for travel, and therefore should be considered alongside other policy measures, such as those acting to restrain demand or encourage the use of more sustainable modes. The provision of high speed infrastructure, whether road or rail, may encourage more decentralised patterns of land-use and longer distance travel, e.g., long distance commuting.

The relative investment in infrastructure for different modes should be considered. For example, dedicated public transport infrastructure can significantly boost the attractiveness of using public transport. However, if users of a new service are drawn from existing public transport services (e.g., existing bus users switch to use a new light rail service) then the benefits in terms of policy objectives such as equity and sustainability may be minimal. Alternatively, where public transport systems are able to encourage some car users to switch, there may be second order effects where any reduction in car use frees up more road space for new car users, unless traffic restraint measures are applied. Good interchange can encourage efficient use of the transport system as a whole, and especially can promote trips comprising use of both public transport and access modes such as walking and cycling. Need for provision of space for these modes is covered under Walking and Cycling Measures.

4.2.3 Infrastructure Management: reallocation and design of road space

Once constructed, transport infrastructure can be managed in a range of ways to enable it to contribute more effectively to transport policy. Among these, the principal elements are the management of road space and its allocation among competing users; the management of parking space; the management of public transport; and the maintenance of all transport facilities. The Synthesis Report on Infrastructure Management focuses specifically on the management of road space, and draws heavily on the Land-Use and Transport Research project ARTISTS. Public transport management is covered in the Synthesis Report on Public Transport (Section 4.2.4 below). Land-Use and Transport Research projects gave little consideration to the management of off-street parking or to maintenance.

To enable the effective design and management of street-space, the function of the street has to be determined. Conventional street classification systems have a tendency to focus only on motorised traffic and the main function of motorised traffic i.e., efficient and safe movement along the street. Very seldom are other activities in the street that are so vital to the city considered, such as the street being a public place for people to meet and for other road users like pedestrians and cyclists.

The multifunctional street must be recognised. It must be accepted and included in the planning process that most urban streets have several types of road users who have different interests in, and demands of the street. It is suggested that a street should be described in two dimensions: link status and place status. Link status describes the significance of the street as a link in the overall road network, and place status describes the significance of the same street as an urban place relative to the overall urban system. When determining the function and thereby the design of the specific street-space the significance of link status is balanced with place status and local attributes are balanced with the wider city context.

Empirical studies and predictive models indicate that measures like priority for buses at signals and in bus lanes can enhance public transport speed and reliability and thereby increase patronage. This may result in a shift of travellers from car traffic to public transport, but it is more likely to attract patronage from walking and cycling. Similarly, improved provision for walking and cycling can increase their use, but the impacts on choice of mode are less clear. Other models indicate that it is generally worth using low cost measures like traffic management, signal control and information to increase capacity of the road network, and hence increase the efficiency with which it is used, provided that cordon charging is in place to limit the resulting additional demand for road use.

The Synthesis Report presents a number of urban redesign cases where the foremost aim has been to recognise different user groups' demands and interests in the street. The case studies show how this can be tackled in different ways. However, the common denominator in these case studies is the reallocation of space and time from general traffic to walking, cycling and public transport. If the reallocation of space is combined with speed reducing measures, considerable improvements in crossing conditions for pedestrians and cyclists are achieved. For motorised traffic this type of measure seems to generally reduce efficiency of movement. As a consequence the flow of motorised traffic is reduced on the redesigned street. The migration of motorised traffic to other routes will be a side effect which needs to be managed carefully. However, empirical studies suggest that total traffic levels are typically reduced by such measures.

4.2.4 Public Transport

This Synthesis Report has set out to define, as far as is possible, the nature of public transport and the roles that it plays. Conventional public transport modes include heavy rail, buses and light rail. In the past, water based transport also had a greater role, and in the light of modern policy objectives relating to sustainability there is a renewed interest in such modes. In London, for example, river services have been re-introduced in recent years. However, published evidence is thin on the ground. Similarly, internal flights also compete with rail and in that respect parts of the air market at least should be considered a form of public transport, but again explicit evidence is scarce, and as noted previously, air transport was not a focus of the Land-Use and Transport Research cluster projects.

Public transport has a number of roles within the transport arena. At the simplest level it is a means of getting from A to B. However, the context within which public transport operates makes its roles more complex. Public transport is often perceived as a second class option after car use, and only to be used when travelling by car is impossible. Within this, bus travel is often perceived as inferior to rail. However, pricing, marketing and travellers' needs and wants combine to ensure that public transport retains a share of the total travel market. Further, public transport, especially bus services with their ability to operate over selected routes, rather than routes pre-defined by fixed infrastructure, has an important role in ensuring equity of accessibility to goods and services. Over recent decades, public transport has also acquired a role as an alternative to car use to be promoted in attempts to achieve voluntary reductions in car use, and help achieve environmental sustainability objectives.

Evidence provided by public transport investment case studies suggests that the contribution to achieving transport policy objectives can be minimal when considered from a city wide perspective. However, one has to ask whether this is the right perspective to be taking. It seems reasonably obvious that the impacts public transport investment has will be concentrated in the corridors directly affected, and the areas at either end of said corridors. Thus, one should be looking at the sum of impacts from all public transport investments across a city when considering contribution to objectives on a city wide basis.

A further issue is the time scale over which evidence is collated and reported. Long-term monitoring is undertaken by many transport authorities in the form of annual surveys, but results often go unpublished. Instead, published reports are often monitoring studies carried out shortly after implementation of new infrastructure or services. Thus, long-term impacts of investment can easily be overlooked when interpreting the evidence available. For example, investment in transport infrastructure is known to attract economic development in an area, but it can take decades to come to fruition.

The evidence presented here suggests that the right public transport investment can achieve modal switch from cars, potentially as much as 20% of new patronage, and generate new trips, again as much as 20% of new patronage, contributing positively to the economy. Thus, notable benefits can be achieved in the areas directly affected by public transport investment. However, other new patronage is often extractions from other modes that may not be desirable. This may be inevitable, and in transport terms can be mitigated through accessibility studies to identify any negative equity of supply impacts, and devise appropriate measures to ensure accessibility is maintained. However, this would not mitigate against the negative health impacts of extraction from walking and cycling. Health benefits will be achieved through reductions in atmospheric and noise pollution arising from lower levels of car use though. Again though, mitigating measures are needed to guard against induced traffic, or

existing drivers merely changing route eroding such benefits. A variety of traffic restraint measures can be implemented in conjunction with public transport improvements to guard against induced traffic.

4.2.5 Travel Demand Management: Attitudinal and Behavioural Measures

In the past, solutions to transport problems were usually considered in terms of conventional measures, such as building new infrastructure, providing new services, or regulating traffic flows. However, such measures are not always appropriate for solving the problems of increasing car use, which require reductions in car use. This is because car use has become the cultural norm, and continues despite policy measures to change travel habits for a variety of reasons, including our individual perceptions of mobility, environment and way of living, our social status, our level of knowledge and information about transport, wider public opinion and social norms, and the history of transport policies and plans in the area.

Car use is considered prestigious, as a symbol of richness and power, while other modes are stigmatised; more and more people prefer living far from the urban centres, which increases the use of the car; many people are not well informed of the alternative choices that they could make; in some areas, some alternative modes like cycling have not been integrated in the community culture; public opinion often assumes, incorrectly, that automobile dependency contributes to economic development. All these examples show us that attitudes and behaviour are a key component to be considered in transport policies. However, traditional transport planning measures do not, by themselves, tackle the political, social or psychological influences on travel habits, or challenge the cultural values and attitudes that favour the car. In response to this, a new field of travel demand management instruments – attitudinal and behavioural measures – has developed over the past decade. Some measures are not traditional land-use and transport instruments, and have been in existence for many years, e.g., flexitime for employees, but have now been adopted to tackle excess car use problems.

Attitudinal and behavioural measures aim to change users' understanding of transport problems, or provide alternatives outside the transport sector, and hence induce changes in travel patterns. As these measures directly tackle people's attitudes and behaviour, they are more concerned with demand than supply. This means that they aim to manage and influence transport demand without explicitly changing the existing infrastructure facilities or supply of public transport services. This concept and the associated attitudinal and behavioural measures are often referred to as Mobility Management.

The objectives of attitudinal and behavioural measures include:

- Raising people's awareness, to make them change their values, their perceptions, their attitudes, and their travel habits,
- Improving transport information and publicity to influence people's travel behaviour,
- Helping people change their behaviour by offering them tailor-made solutions, which take into account their needs, their expectations and their habits,
- Influencing people's habits (their way of living, their rhythm of working, the 'relation' they have with their cars…) to reduce their need to travel.

The principal attitudinal and behavioural measures are:

- Communication campaigns, e.g., advertising campaigns designed to increase peoples' awareness of the need to reduce car use, and personalised travel planning to provide targeted information on alternative modes;

- Company and school travel plans in which organisations set out ways in which they can reduce their demand for car based transport, often focusing on employee (or pupil) commuter travel, but also include business travel, freight etc;
- Ridesharing that offers alternative solutions to solo car use;
- Car clubs that offer alternative solutions to car ownership, and therefore reduces car use;
- Flexible working hours to influence when people travel to and from work;
- Telecommunications as an alternative to travel.

4.2.6 Information Provision

This Synthesis Report has set out to review the discussion of information provision within the Land-Use and Transport Research cluster projects, outline the nature of information provision, and the roles that it plays. All the project outputs available were reviewed, however the majority of relevant information was contained within the ARTISTS, CITYFREIGHT and PROSPECTS reports.

Information provided by transport system managers may come from a number of sources and can be of great use to travellers if they are able to gain access to it, understand it and to trust it. Even when only a small, and/or imperfect amount of information is provided, it is likely that travellers will use this information as the basis of their decisions (E. Van Berkum, P. Van der Mede, 1990).

Travellers base their predictions of transport system conditions on various sources of information including personal experience, second-hand experience received from friends or colleagues, or the media and information provided by transport system operators. Their interpretation of the information will depend on their understanding of how the transport system works, and this in turn is likely to depend on the amount of experience they have with the transport system, as well as the amount of information at their disposal, and their intellectual curiosity/ability.

Information provision is likely to increase efficiency, by enabling individuals and operators to make journeys at lower cost. Information measures which assist public transport users, pedestrians and cyclists are likely to have positive equity implications. Route guidance systems may have an adverse impact if those without guidance suffer greater congestion. Safety benefits appear to be most likely to arise with variable message signs, but other guidance to road users may assist. With the possible exception of parking guidance and fleet management systems, there is likely to be little impact on economic activity (PROSPECTS).

The PROSPECTS project is designed to provide cities with the guidance needed in order to generate optimal land-use and transport strategies. In Deliverable 1, the results of surveys suggest that few legal, financial or political barriers arise with the implementation of any of the proposed information systems.

An exception may exist where the private sector is involved in implementation and operation, as with freight management systems, public transport information systems and route and parking guidance. All involve implementation and operation costs, but these are only high in the case of ITS-based information.

4.2.7 Pricing

Among the various policies assessed in the 12 research projects of the Land-Use and Transport Research cluster, pricing policies look to be the most efficient ones, in particular where transport is concerned. These policies may imply significant price increases and impact for some users in some places (such as +50% of travelling costs in the case of road pricing in London) and lower prices (and impact) for other users and/or in other cities. Although the same principle applies to pricing policies applied to land-use, examples of such policies are rarer and effects on mobility much more long-term, but it should be noted that altering transport prices will impact on land values. It is thus more difficult to draw conclusions on the effectiveness of pricing policies applied in the field of land-use than on the effectiveness of transport pricing measures.

The Synthesis Report focuses mainly on pricing policies in an urban environment. However, given the close relationship between urban transport and inter-urban travel, it was also pertinent to comment on this area (for example, the heavy vehicle fee in Switzerland, and the LKW Maut in Germany).

Economic theory shows that pricing policies can lead to the economic optimum (first best solutions), when each user has to pay the marginal social cost. This can be implemented through road pricing or land taxes for example. In practice, it is usually not possible to implement perfectly, for various reasons: technical, political, equity, complexity. Alternative solutions (second best solutions such as cordon or zone pricing, or a parking charge) can often bring about a significant share of the benefit a first best system would provide. Different congestion charging schemes with different areas affected, and different pricing strategies can have different effects. Experiences from Singapore, Oslo, and London show that responsiveness to price will depend critically on the context.

Long-term impacts of pricing are the results of the combined changes in behaviour of a large number of actors on a market. These impacts can range from a change in land-use or transport consumption behaviour (people moving to the suburbs and generating urban sprawl, modal choice) to raising revenues for tax collectors, or minimising pollution thanks to a decrease in private car use.

Packages of policies must in general be used, to improve the impacts of the better performing policies, reduce their negative side effect and improve acceptability. Pricing policies can for example be combined with measures to reduce the losses experienced by groups that have no possibility to adapt to the new schemes.

When road pricing at marginal cost is applied, the reactions are first a change in the timing of the trips or a change in route, and therefore a less significant impact than expected on modal split shift.

One key issue is acceptability of pricing. Policies must be transparent, have clear long-term objectives and address equity concerns. Hypothecation of revenues helps acceptability, as does consistent participation of the public at all stages. There are also experiences of road pricing that show that public acceptance tends to increase once the system is implemented.

4.2.8 Walking and Cycling

Walking can significantly contribute to improving quality of life and promoting sustainable development, since nearly all EU cities and their structures have evolved according to this mode of transport. Cycling represents a quick, efficient, healthy and sustainable mode of transport that can improve accessibility, especially in urban areas. Both modes are non-polluting, space-efficient and can help to counter congestion and increase air quality. In addition walking, and to a lesser extent cycling, are available to almost everyone and therefore can help to promote social inclusion as well.

Short walking and cycling trips are not always considered in the statistical data of travel surveys, which has severe consequences in nearly all related aspects, but most fundamentally in our perception and approaches. In spite of this shortcoming, most trips are short, especially in urban areas with for example some 69% of all trips in the UK being less than 8 km, and 43% of all trips being under 3.2 km. The figures also confirm that some 24% of car trips were under 3.2 km in 2001 (DTLR, 2001), showing a clear potential to replace a proportion of these by walking and cycling. The city context in Europe is very important with some 80.1% of the EU15 countries' populations living in urban areas (European Commission, 2002). This proportion has been increasing, and while providing safe and accessible mobility for 303 million people, this represents a challenge. It is also a real opportunity to redefine transport options in a positive way that will also ensure lasting quality of life.

City administrations across Europe are not only increasingly understanding the positive role that both modes can offer in providing alternatives to motorised trips, but are also putting in place policies, programmes and funding to increase their use. There still exist disincentives to walking and cycling, including the perceived danger, inadequate pavement and road space and cultural perceptions, but people, especially children, would like to walk and cycle more if the conditions for doing so were improved.

In order to support current levels, let alone increase the amount of walking and cycling in cities, it will be necessary for city administrations to actively provide the space and invest in these modes. This investment can be very cost-effective when compared to the costs of investment in public transport. In seeking to make cities sustainable and increase quality of life, it will be necessary to support all alternatives to motorised vehicle use. In this respect it is important to recognise that both walking and cycling are an ally and a useful adjunct to public transport rather than the competitors that they are sometimes perceived as. Indeed, walking and cycling can help to make a public transport system much more effective and efficient. Many walking and cycling trips are short, and if use of these modes is increased, it can help to relieve pressure on public transport systems. Walking and cycling trips can help to provide accessibility on non-radial routes where public transport systems are often poorly provided. In addition, providing good intermodality with easy access for pedestrians and parking for cyclists, especially in suburban areas, can help to provide a more efficient use of the public transport system. But one key element will be the exchange of on-street car parking space for walking and cycling space, which would make a significant impact on the many problems that exist.

However, in order for both modes to fulfil their potential, there have to be a number of conditions in place. These include having a coordinated set of policies and targets from the national, through to the city and local level that support their use. These will include transport, environmental, land-use and other policies. In addition there need to be the right structures and trained staff in place to ensure that the planning and support can take place. Funding also

has to be made available on an ongoing basis for any sustained progress to be achieved. Lastly, in order to ensure that levels of walking and cycling can increase; a wide range of complementary measures on the physical side as well as attitudinal and promotional measures will be required. This wide range of measures can be more successful than one large landmark project.

4.2.9 Urban Freight Transport

The aim of a sustainable distribution strategy must be to ensure that future development of the distribution industry does not compromise future needs of our society, economy and environment. A sustainable distribution strategy has therefore to consider more than just the transport of goods from A to B. Therefore strategies have to encompass supply chain management or "logistics" as well as all modes of transport (DfT, 1998).

Road freight transport has increased dramatically in the past decades within urban conglomerations, and prognoses for the future indicate that growth has not come to an end. For example the White Paper (European Commission, 2001) estimates a growth of 50% for long distance road freight over the period 1998 to 2010 if nothing is done. By pushing intermodal transport and non road modes this growth can be reduced to 38%.

The negative aspects of urban freight growth are most visible in all European urban areas: congestion to which lorries and small delivery vehicles contribute; noise emissions, emission of pollutants and accidents are problems that decrease the quality of the urban environment substantially.

Driving factors for freight growth are the liberalisation of the transport market and the progressive harmonisation of the regulatory framework created by the European Union; the internationalisation and globalisation of manufacturing, trade and logistics; and the consumers' increasing demand for customised products. The resulting economy of scale effects in production and retail (e.g., shopping centres) increase on one hand the demand for freight transport and on the other hand the number of commuting and shopping trips by private car, hence reinforcing the urban and suburban transport problems.

To mitigate the negative impacts of urban freight transport a series of instruments are suggested: time windows and weight restrictions for deliveries; urban freight distribution centres; congestion charging; environmentally friendly vehicles; improvement of information and communication technologies, etc. Although most of these developments have started in the last decade, first results can already be identified. Moreover, some first results seem very counterintuitive: instead of reducing congestion, some Urban Distribution Centres generate more freight vehicle movements than before. Therefore a successful implementation of instruments to deliver the desired effects has to be accompanied by appropriate adaptations of regulatory frameworks. For example, when local authorities impose time frames and weight restrictions they must also prevent the relocation of retail shops to the outskirts.

A major obstacle which hinders developing strategies to reduce negative impacts of freight transport is the lack of data. EU-wide there exists no common scheme to collect data on urban freight transport (BESTUFS, 2001). And without adequate monitoring it is not possible to assess the impacts of freight related policies. There exist some local attempts to collect data (ECMT, 1997) but these data collection exercises are not sufficient and are therefore only of limited use for EU and nation wide decision making processes. This lack of informa-

tion is also reflected in the lack of common policy and strategy documents at the regional, national and EU level (LT Consultants LTD and Buck Consultants International BV, 2002).

Finally it must be noted that today the overall purpose of logistics and freight transport seems to be the satisfaction of the global transport demand. The question of how much freight transport is necessary for a sustainable quality of life and how to reduce the global freight transport demand is not asked at all.

4.2.10 Vehicle Technology

The effectiveness of transport systems is a vital element in economic and social development. Nevertheless transportation activities are responsible for a number of negative social and environmental effects. In this report, conventional and innovative transport systems are proposed as solutions to three major problems: air pollution, noise and accidents.

All transportation modes consume energy and at present this is mostly derived from the combustion of oil-derived fuels. Combustion produces carbon dioxide and a range of other harmful substances. Most noxious emissions stay close to the source. Some such as Carbon Dioxide, Nitrous Oxides and Sulphur Dioxide, spread further, with effects at regional or even global level. Exhaust emissions for regulated pollutants are, however, decreasing due to EC legislation. Successes obtained are mostly due to technological improvements in the road sector, such as reductions in Sulphur levels in fuel, or Nitrous Oxide reduction using catalysts. New technologies like hybrid electric and fuel cell powered vehicles mean it will in the future be possible to achieve urban vehicles with zero-emissions (at point of use). Rail transport is more energy efficient due to the low friction of steel wheels running on steel rails; higher loading factors and the reduced levels of stop-start motion complemented by regenerative breaking to recoup energy lost.

Vehicles are also responsible for acoustic emissions. Although these have a negative impact on quality of life, they occur at a very local level so that effective mitigation devices can be adopted. Nevertheless, measures can be taken to reduce acoustic emissions at source, particularly from road traffic in urban areas. The EC has regulated noise produced from road vehicles but noise from urban traffic is very often higher than acceptable thresholds. Electrical traction (battery vehicles, fuel cell vehicles and hybrid-electric vehicles) and a better consciousness of noise, vibration and harshness design for vehicle bodies and mechanical parts will hopefully contribute to reducing these harmful effects.

Currently, more than 40,000 persons are killed every year on EU roads and less than 1,000 from using other modes of transport. The short-term strategic objective of the Community is to halve the number of fatalities by 2010. The medium-term objective is to cut by around 75% the number of persons killed or severely injured by 2025, while the long-term vision is to render road transport as safe as all other modes. The European Road Safety Action Programme identifies three areas for action: the behaviour of road users, vehicle safety, and improvement of road infrastructure. Improvements in vehicle and infrastructure safety require greater lead times, whereas measures on enforcement aimed at improving road user behaviour are most appropriate to achieve a rapid reduction in road deaths and injuries. Artificial aids based on electronic and information and communication technologies (warning, semi-active or active systems) that interact with human controllers to reduce or avoid consequences from mistakes, will become more important. Studies on their interaction with human factors will also represent a critical path for safety.

4.2.11 Innovative Modes

A range of innovative urban transport systems and concepts are reviewed in this report. They include personal rapid transit, advanced driver assistance and automated vehicle guidance systems. The theoretical points and conclusions made about these systems are taken from the evaluation and demonstration work carried out in the following European projects;

- EDICT (Evaluation and Demonstration of Innovative City Transport): assessment and demonstration of the concept of Personal rapid transit; work has been undertaken in 4 European cities: Cardiff, Eindhoven, Huddinge, and Ciampino.
- CYBERCARS: project experiments and demonstrations carried out in two test sites, a public and a private site, to test technology, impacts on mobility and user satisfaction.
- CYBERMOVE: feasibility studies and field trials of cybernetic transport systems at 16 European (and one Israeli) sites. The field trials are in Rivium near Rotterdam and Antibes. The feasibility studies are in Werfenweng, at the EPFL university campus in Lausanne, in Nancy and in Lausanne-Crissier.
- STARDUST: a series of site-specific case studies in Brussels, Oslo, Paris and Southampton. These cities differ by the size, the urban pattern, the supply of public transport services, the average congestion level, and Advanced Driver Assistance Systems and Automated Vehicle Guidance systems already in operation.

The ability to undertake personal travel is regarded as an important indicator of the quality of life. However, rapid growth of personal car travel and associated costs to our health, society, environment and economy, have put transport high on both public and political agendas. There is an urgent need across Europe for sustainable forms of transport that address the problems of congestion, poor air quality and social exclusion in cities. The ideal solution will offer an alternative to the car and complement existing forms of public transport. The kind of solutions identified at the EU level includes a range of innovative urban transport systems: automated driving systems with on-demand and door-to-door capabilities, personal rapid transit, advanced driver assistance systems and automated vehicle guidance systems. These technologies offer the potential for both better and safer transport and an improved environment, providing the opportunity to improve the quality of life for the whole urban community (as discussed in further detail below). High quality public transport services also offer benefits in terms of increasing accessibility and reducing social exclusion.

Personal rapid transit is a new class of urban transport. Personal rapid transit is a type of innovative public transport which takes advantage of current technology initially developed for the automobile industry. Research shows personal rapid transit to offer:

- a new, sustainable, alternative to the car;
- a popular choice for car drivers and public transport users;
- benefits to existing public transport networks;
- a low capital cost compared to other options; and
- A system matched to transport needs of cities today (in terms of sustainability, accessibility and social inclusion).

Personal rapid transit vehicles provide the benefits of a private car, capacity of mass transport, little or no waiting time, and no pollution or noise. A personal rapid transit guideway is small in scale, modular for low cost quick construction, and flexible which allows for extension, and it is readily integrated. The potential risks of having an elevated track include visual intrusion, safety concerns and disabled access.

Advanced driver assistance systems and automated vehicle guidance systems can be used to improve the efficiency and safety of buses and private vehicles. The two systems were first designed to be used in an inter-urban context, i.e., on motorways. Now, progressively, they are considered for urban contexts and systems manufacturers are designing new prototypes adapted to urban contexts. For example, first adaptive cruise control systems were designed to be used on motorways, at speeds higher than 50km/h. Meanwhile, other systems aiming at adaptive longitudinal control of the vehicle have been developed (to a prototype stage) for use on urban networks. Other systems include intelligent speed adaptation, which can play an advisory or active role i.e., warn the driver if the speed limit is exceeded, or allow the driver to maintain the maximum allowed speed without looking at the speedometer with the possibility for drivers to go above the speed limit by pressing the accelerator above the threshold given by the system. There is also the lane keeping system, which allows a driver to maintain the vehicle within the driving lane. This may be particularly valuable when lanes are narrower than usual.

4.2.12 Integrated Land-Use and Transport Strategies

Integrated strategies are combinations of individual policies for achieving cumulative positive effects, or mitigating the negative side effects of individual policies. Examples of integrated strategies are combinations of land-use and transport policies.

One reason for applying integrated strategies is to achieve synergies between policies. Synergies exist if the total benefit is more than the sum of its parts. There are significant synergies between individual urban land-use and transport policies if they are combined in policy packages. A second reason is to overcome the barriers to strategy implementation. One policy instrument can help make another more acceptable to the public, or can provide financial support for another policy instrument. The combination of public transport improvements and road pricing illustrate both of these principles.

Integration is only successful if it is applied to policies, planning methodologies and planning processes and structures – it is a multidimensional task. Most cities in Europe have initiated integrated policies like public transport oriented development. However, integration of the supporting models, monitoring indicators and institutional structures is much less developed.

Integrated land-use transport models are the only method to identify synergies between individual land-use and transport policies. However, only few cities apply and regularly update integrated land-use transport models. Extra effort is needed to make current advances in modelling techniques applicable by local practitioners. Besides better dissemination, there is also a need for technical improvement. Efforts should be concentrated on making integrated land-use transport models more disaggregate, simpler to use and more flexible in the range of issues addressed.

The projects in the Land-Use and Transport Research cluster produced rich evidence that integrated strategies combining land-use and transport policies have stronger effects on urban sustainability than individual policies implemented alone. The results of the different projects are in many cases congruent with each other.

Several Land-Use and Transport Research projects have demonstrated that a combination of transport pricing policies, involving making car transport more expensive while enhancing

public transport and implementing supportive land-use policies, can contribute significantly to achieving a better urban environment.

Land-use policies alone do not produce significant positive effects on travel behaviour because land-use adapts to the transport system and vice versa. However, such policies can be used to support changes in travel demand caused by the car pricing and public transport policies and may have significant local effects.

Optimisation techniques taking account of financial and other constraints can be used to identify optimal policy combinations meeting city-specific requirements. Good results can be achieved even under financial constraints by careful planning of integrated strategies.

A good urban strategy consists of co-ordinated policies that work together to produce cumulative long-term effects that attain a balance of environmental, social and economic goals.

4.3 Processes

4.3.1 Setting Targets

Targets are used to determine policy directions and to assess the success of selected strategies or measures. Setting targets can thus be an important part of the policy making process. Targets are specified in terms of selected quantifiable indicators, and represent a level of achievement of those indicators that is potentially achievable and which, if achieved, should reflect an acceptable strategy. Such targets can be used as part of a monitoring process to determine whether the strategy as implemented is having the desired effect, or predictively, in conjunction with forecasting models, to assess whether a proposed strategy is likely to achieve the targets set.

The underlying indicators can be specified in terms of input (the measures adopted), output (the change in overall travel or modal shares), or outcome (achievement against defined objectives). Outcome indicators and targets are the most useful basis for determining the performance of the strategy. This requires a process in which objectives, such as environmental enhancement or greater social inclusion are first specified. Indicators are then chosen to measure movement towards (or away from) these goals. Targets are then set to determine the values of these variables that are to be aimed for in implementation. Thus both indicators (with baseline values as starting points) and targets are necessary to help in evaluating the impact of any policy or policy package and determine levels of achievement.

Outcome indicators need to be defined for each of the agreed policy objectives, and targets for each need to be selected so that they are mutually consistent and compatible. It is also possible to specify indicators for modal shares, which are more readily measured, and can contribute to the achievement of the underlying objectives. However, it is important to note that a change in modal shares is not an objective in its own right, but solely a means of achieving other objectives (e.g., environmental sustainability). Targets can also be set for the measures to be implemented or the resources to be used in implementation. Such targets are usually related to budgetary objectives and are measured through resource or input indicators.

There is no single standard method of choosing indicators and setting targets - however, a number of PLUME projects have produced lists of indicators to help describe and measure aspects of urban sustainability in the land-use and transportation context and these can be a useful starting point for decision makers. Setting targets for these indicators, though, will de-

pend at least as much on local circumstances as on global policy objectives. At the local level, it is best to first determine outcome indicators and associated targets, and then decide on any input or process indicators and targets to be consistent with them. Though this might lead to an initial apparent deficit in terms of resources needed versus resources available, outcome targets are a very effective means of encouraging action and monitoring performance and can help to stimulate efforts to mobilise new resources.

4.3.2 Strategy Development

Traditionally, transport and land-use decisions have been made by elected politicians, advised by expert professionals. However, life is now much more complicated. On the one hand, there is an increasing demand for public participation, in particular concerning social groups who have traditionally been excluded from the policy formulation process. On the other hand, very few cities are "islands", so policies are influenced by neighbouring towns and cities. This influence may also be determined by regional policies, national government and, increasingly, European policy. Furthermore, fewer policy decisions can now be taken solely by government, even if influenced by public participation. The private sector and semi-private agencies are increasingly responsible for public transport, road construction and land-use decisions.

When considering the process of strategy development, it is useful to think in terms of three main approaches to decision-making. Vision-led approaches usually involve an individual politician having a clear view of the future form of city they want, and the policy instruments needed to achieve that vision. Plan-led approaches involve specifying objectives and problems, adopting an ordered procedure identifying possible solutions to those problems and, by using mathematical techniques, selecting those which perform best. Consensus-led approaches involve discussions between stakeholders and different social groups to try to reach agreement on each of the stages in formulating strategy.

Underpinning a plan-led approach, we can define an "ideal strategy development process". This process includes the stages of: definition of objectives, performance indicators and targets; the identification of barriers to implementation and how to overcome them; the formation of packages of measures; and the use of appraisal and modelling methods to predict the extent to which any package of measures meets the defined policy objectives.

All strategy development should take place within an ongoing context of public participation, which can be classified according to the following levels (ranging from the less active to the more active): information provision; consultation; deciding together; acting together, and supporting independent stakeholder groups. A distinction can be made between formal statutory consultation methods and informal participation methods. A large number of the latter have been implemented in various European cities and, in general, a successful public participation strategy will combine a wide range of such methods.

4.3.3 Strategy Impacts Forecasting

The ability to make reliable forecasts of possible actions is one of the key preconditions for rational behaviour. This is particularly valid in the case of urban land-use and transport planning because in these fields decisions are particularly long lasting and to a large part irreversible - a land-use plan is a fundamental roadmap for the spatial development of a community or a region for several decades, and major transport infrastructure projects are likely to be in place for several hundred years or more.

There is a range of methodological approaches to forecasting the impacts of possible land-use and transport policies. They can be classified as follows:

- Stated preference methods: to ask people how they would react if a certain policy were to be implemented.
- Revealed preference methods: to derive information about the likely response to policies under consideration from observation of past behaviour.
- Best practice methods: to learn from the experience of others based on the belief that what worked in other contexts will work also in one's own city or region.
- Expert judgement methods: to exploit the experience of experts for anticipating the likely impacts of policies.
- Forecasting models: to use mathematical models as simplified representations of cities and regions for forecasting the impacts of planning policies.

Each of these forecasting methods has its advantages and limitations. Stated preference methods are good at revealing tacit knowledge about unobserved or unobservable behaviour; their limitations are that people are rarely able to imagine how they would behave in still unknown situations. Revealed preference methods, in particular if they are based on behaviourally rich data sets, can feed powerful multivariate statistical techniques, but it is unclear how far the relationships identified are valid under different circumstances. Best practice methods are easy to understand and pragmatic, but their problem is that it is rarely possible to clearly identify cause and effect in urban and regional contexts that are influenced by a multitude of concurrent socio-economic and political developments. Expert judgement techniques are powerful when it comes to imagining novel, unknown situations but are weak with respect to the necessary quantification of the envisaged effects.

Compared with these other methods, planning models have many advantages. They are the only method that allows the analysis of the impacts of one single policy, while all other developments are kept fixed. They also enable the synergies between individual policies if they are combined with policy packages or strategies to be assessed. They facilitate the experimental examination of hypotheses about changes in technology, political framework, economic trends or lifestyles. On the other hand, planning models of urban and regional systems are complex, difficult to build and expensive with respect to data and maintenance, and not easy to communicate to non-experts.

Several Land-Use and Transport Research projects have developed and applied mathematical planning models to assess the impacts of land-use transport strategies, with ISHTAR and PROPOLIS being particular examples of realisation of quantitative tools. The results of these projects have in general been more concrete, tangible and accountable than those of other more qualitative projects. The policy conclusions derived from the differing modelling projects are in general in good agreement with one another indicating a high degree of maturity and reliability of the methodology. However, given the increasing importance of long-term decisions for urban sustainability, and the acquisition of new knowledge and modelling skills in this area over time, there is a continual need for the development and application of land-use, transport and environmental planning models for sustainable cities, to be an area of high priority for future research and technology development.

4.3.4 Strategy Appraisal

The notion of each generation's duty to its successors is at the heart of the concept of sustainable development and was captured by the Brundtland Commission (World Commission on Environment and Development, 1987) in its report Our Common Future. The report defined sustainable development as "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs". Since the publication of the Brundtland report, a large number of other definitions of sustainability have been devised and are currently in use. In general, definitions distinguish between three different aspects of sustainability: environmental (or ecological); economic and social.

Appraisal is the ex-ante process of deciding how well a scheme or strategy will perform and is a means of assisting the decision-maker with the following tasks:

- Deciding how serious the current or future problems (environmental, social, economic) are,
- Helping to identify possible strategies to solve these problems,
- Identifying gainers and losers from any proposed strategy,
- Determining whether the design for a proposed strategy could be improved,
- Choosing between alternative strategies and schemes.

In the appraisal process, the likely impacts of a scheme or strategy are considered against a set of policy objectives. For a sustainable transport and land-use system, these objectives will be based upon the type of sustainability concepts mentioned above. Two widely used techniques are available to help with this process: Cost-benefit analysis, and Multi-criteria analysis.

Cost-benefit analysis uses money as the comparator. Changes in amounts of travel, travel time, accidents and environmental factors are assigned money values, based on observation of the choices that people make. The net value of the expenditure less the benefits is calculated for each future year, and discounted to the present day to reflect the fact that expenditure in ten years' time will cost less now than the same expenditure tomorrow. These are then summed over the appraisal period to give, as a single indicator of performance, a net present value of the benefits. The main weaknesses in this approach are the assumptions required to value attributes like noise and accidents, and the difficulty of distinguishing gainers and losers.

Multi-criteria analysis overcomes some of these problems by allowing the decision-maker to assess the weights to be assigned to different indicators, objectives and impact groups. In this way, differing views on the relative importance of, say, noise and accidents can be reflected.

Social justice and equity are issues that are not currently well addressed in formal appraisal processes. An important reason for this is that there is a lack of clarity about what these concepts actually mean in practical day-to-day terms and how these often subjective concepts are measured. More research is needed on the definition of operational concepts of social justice and equity, and how these might be included in an appraisal process.

4.3.5 Public Participation

Participation can be defined as the involvement of stakeholders in the decision making/planning process with the purpose of influencing decisions. Stakeholders are any person, group or institution that is affected by, or can influence any decision or action. Public participation concentrates on stakeholders representing the citizens (residents/transport users/the public).

Key purposes of participation are to improve the quality and efficiency of planning, and to raise awareness and empower the actors involved. Public participation can take place at different levels and in different ways. These "stances" are:

- Information provision (a one-way process to keep those interested informed about plans, e.g., posters, leaflets and information sheets, websites, media coverage, unstaffed exhibitions),
- Consultation (where the views of stakeholders are sought and the results form inputs into the strategy formulation, e.g., public meetings, staffed exhibitions, mail back leaflets or surveys, focus groups, websites, public inquiries),
- Deciding together (where the stakeholders become decision-makers and work with decision-makers and professionals in formulating the strategy, e.g., citizen's forums),
- Acting together (where the stakeholders also become active in the implementation, e.g., the development of partnership bodies), and
- Supporting independent community interests (where the city enables community interests to develop their own strategies, e.g., advice, support, funding) (PROSPECTS D15; May et al, 2003).

The legal status of participation depends on the country and the type of the project, but the three last stances are usually not legally binding. Typically a participation process is built up of different participation methods (tools) adapted for the objectives of participation, the stakeholders and the stage of the involvement. Participation can contribute when determining objectives, assessing problems, identifying solutions, appraising alternatives, choosing a strategy and when implementing strategies etc.

Case studies show that the benefits of promoting participation mostly overcome the drawbacks. The main advantages are obtaining citizens' ideas, the greater transparency of the processes and the contribution to building ownership; disadvantages are delays, higher costs, leadership problems, fatigue in actors, decreasing credibility of authorities in case of failure and increased inequity if only some groups participate. Thus, it is very important to consider why the public should be involved and to determine what is negotiable before starting a process.

Thus, participation should aim at identifying and involving all stakeholders. Groups that risk exclusion (e.g., ethnic minorities, women, low income groups, older, younger and disabled people) need special treatment. Stakeholder analysis is valuable to identify all groups and their interests.

Today there is increasing emphasis on public participation in land-use and transport planning. There has been a shift from beneficiaries to citizens, from project to policy, from consultation to decision making, from appraisal to implementation and lastly from micro to macro. How-

ever, no method can be applied everywhere. Tradition, culture (and sub-cultures) and the legal and institutional structures have to be considered as well as the scale, and time horizons.

However, generally it is important to focus on the "right subjects", have a good comprehension of why participation is used, to communicate this inside and outside the authority, to identify what resources are needed to carry it out, to build capacity (i.e., prepare those who are less skilled and equipped for involvement), and strengthening the connection between participation and decisions and implementation, i.e., to see to it that the output is used.

4.3.6 Strategy Implementation

An essential step in achieving the aims of land-use and transport policies and strategies is their implementation. The PLUME projects have between them analysed the implementation experiences in a large number of different cities from all over Europe relating to a wide variety of land-use and transportation policies and measures.

With regard to implementation, these investigations aimed at answering the following four questions:

- What are potential barriers to implementation?
- How can such barriers be overcome?
- How can implementation results be monitored?
- What has worked elsewhere?

Barriers were identified and classified at various different levels, the key practical distinction being that between barriers which are:

- Legal (e.g., competencies, problematic legislation),
- Financial (mainly availability and distribution of funding),
- Institutional (e.g., territorial conflicts, conflicts between or within organisations, operational organisation),
- Political & cultural (e.g., problems with perception, acceptability, awareness or professional traditions),
- Practical & technological (including physical barriers or lack of the right technology).

The projects identified a variety of strategies for overcoming such barriers, which were also illustrated with practical examples in the relevant deliverables. The main strategies for overcoming implementation barriers can be summarised as follows:

1. Integrated strategic concepts (such as an urban transport plan for all modes and types of transport but also overall visions for a city's future),
2. Integrated sectoral policies (to co-ordinate e.g., public transport measures with land-use developments),
3. Innovative forms of interdisciplinary collaboration (e.g., interdisciplinary working groups from different administrative departments),
4. Regional co-operation (e.g., through regional planning bodies),
5. Step-by-step implementation processes (can be useful in some cases, if fully synchronised implementation is not possible),
6. Participation, communication, information (involving the citizens as early as possible),

7. Combining infrastructure (management and provision), pricing and public transport, and attitudinal and behavioural policies (e.g., combining infrastructure with awareness campaigns), and;
8. Innovative and early efforts to secure resources.

One important issue in the context of implementation is monitoring and evaluation – both of which need the selection of appropriate indicators, which do not require an unrealistic investment of time and money for data collection and analysis. Particularly the TRANSPLUS project dealt with these in some detail and developed sets of such indicators at different levels in the areas of public transport oriented development, short distance structure development and car space restriction (TRANSPLUS, 2002).

4.3.7 Financing Land-Use and Transport Projects

Current transport pricing mechanisms mean that urban transport systems are often subject to on-going financial deficits and that it is often difficult to generate sufficient capital funds to finance investment needs. The traditional, and in many places the prevailing, means of financing these on-going deficits and investment needs is through public budgets. However, this is increasingly subject to criticism as other sectors of public concern place competing demands on public budgets. These criticisms have created a pressure to identify alternative means of generating project finance, both to cover capital investment needs and to cover current costs, including the costs of servicing the capital.

Private finance is often advocated as a way of relieving pressure on public budgets and increasing available funding, as well as introducing private sector enterprise and incentives for efficiency. But there is a conflict between private profitability and allocative efficiency, not only because unprofitable projects may be socially worthwhile or vice versa, but also because members of private consortia may stand to gain for instance from over specifying (or 'gold-plating') the project. Key factors are the extent of competition and the sharing of risk.

Whilst capital may be provided by either the public or the private sector, private finance is not in general an option for covering current costs. For this the options are user charges, public budgets (be it in the form of transfers from central government, local borrowing or local taxation), and cross subsidy. This immediately illustrates the importance of looking at funding packages rather than individual instruments, as private finance always needs to be associated with other sources of funding to service the capital.

Two broad approaches to the introduction of private capital into urban public transport may be identified, each with its problems. Outright privatisation will lead to key decisions being taken on a commercial rather than a social basis. Therefore some form of public-private partnership, in which the public authority specifies the outputs and invites bids from the private sector to provide it, for instance under a franchising arrangement, looks the most promising approach. Within this approach a complicated range of options is available.

The reform of transport prices, in order that a greater share of costs can be collected through direct user charges, is a vital component of a more effective and efficient transport financing regime for the future. The failure to charge users for the costs they impose at the times and places where they impose those costs is probably the most significant single factor underlying current transport financing problems in urban areas. Studies have shown that for several urban areas, setting charges for road use and public transport use based on short run marginal cost principles would be likely to turn existing deficits into 'an embarrassment of riches' (Roy, 2002).

The separation of roads infrastructure from operations and the multiple objectives generally being pursued by urban transport authorities help to make the financing of urban transport complex and difficult. Furthermore, whilst finances for urban transport can come from a number of different public and private sources (which may serve to provide some flexibility in the availability of funds), the multiplicity of agencies involved can also add to complexity and create problems. Common frameworks for appraising transport spending and institutional arrangements that facilitate integrated decision-making are key factors in minimising such problems. With these, and with reform of transport prices, there is a real prospect of greater availability and better use of finance in transport.

4.3.8 Institutional Issues

Institutional analysis in transport has arisen out of a recognition of the apparently increasing number of 'actors' influencing, or seeking to influence, transport policy. For some time now there has been a division of responsibilities between local, regional, national and multi-national authorities in relation to transport policy in urban areas, with different levels of authorities having different responsibilities in different countries. Furthermore, industry reforms have sought to increase competition and promote greater involvement of the private sector in service delivery, often combined with industrial restructuring, the introduction or enhancement of regulation and a continued role for government agencies in overall planning. At the same time, the way in which transport affects and is affected by other spheres of public policy – economy, environment, community planning etc – is ever more apparent, leading different areas of government to recognise the need to work more closely with one another and leading interest groups from those related spheres of public policy to seek a greater input to transport policy. Somewhat separately, there has in a number of places been a trend towards greater involvement of the public in transport policy through public consultation and participation mechanisms.

The web of responsibilities for and influences on transport policy can, therefore, become quite complex and the organisational relationships which emerge have come to be viewed as important issues for investigation. This is, in large part, due to their impact on the capacity to implement effective policy. The ECMT highlighted institutional and organisational barriers - defined as inefficient co-ordination and co-operation among different branches and levels of government, and inefficient consultation and communication between government and the public - as "one of the biggest challenges to implementing sustainable urban travel strategies" (ECMT, 2001). The PROSPECTS project identified legal and institutional barriers, including lack of legal powers to implement a particular instrument, and legal responsibilities that are split between agencies, limiting the ability of the city authority to implement the affected instrument, as one of four types of barrier to the implementation of integrated urban transport policy (May et al, 2003). In particular, legal and institutional barriers were a major constraint for land-use, road building, pricing and public transport measures.

Concepts from game theory and economics, which set out to understand incentives, pay-offs and the costs of particular institutional arrangements, have been proposed as useful theoretical frameworks for institutional analysis. However, the most interesting work in relation to transport institutions has tended to be more applied in nature, for example, that undertaken within the PROSPECTS, TRANSPLUS and TIPP projects.

It is clear that institutional structures need to be designed to provide appropriate devolution of powers, finance and skills to regional and local government, with an integrated approach to

the management of transport and land-use within local authorities and between authorities within a given travel to work area. National governments have a key role in providing these effective institutional structures, in facilitating an integrated approach to transport and land-use policy, and in providing an appropriate legislative and regulatory framework. Private sector involvement in public transport operation, to achieve greater efficiency of operation and more innovative services, should be based on a franchising model in which fare and service levels remain the remit of the transport planning authority. Finally, while there may be a case for changing institutional structures in order to improve them, it is important to bear in mind that such changes can cause disruption and lack of focus, and such costs need to be assessed carefully, against the benefits of change.

5 Policy Conclusions from Land-Use and Transport Research Projects

Policy makers are interested in knowing which policies or measures are most effective for achieving the objectives of land-use and transport planning, i.e., to provide attractive living conditions and high accessibility to all groups of society, to enhance the competitiveness of urban economies and to protect the natural environment.

In this section the results of the Land-Use and Transport Research projects set out in the Synthesis Reports are further synthesised to draw policy conclusions. These policy conclusions are derived by looking into two kinds of interdependencies: the interactions between urban processes and the impacts of policies on problems.

5.1 Interactions between urban processes

First the results of the Land-Use and Transport Research projects are summarised to establish some common understanding about the manifold interactions and feedbacks occurring within urban systems. Understanding these interactions and feedbacks is necessary to assess the secondary and indirect effects of policy measures, which in some cases reinforce the effect expected from a policy measure but sometimes also act as negative, undesirable side effects.

Table 5.1 is an attempt to visualise the interactions between urban processes that need to be taken into account when long-range impacts of planning policies are considered. In the table both rows and columns contain the most important change processes occurring in urban systems over time, where the rows represent causes and the columns effects – each process can be both cause and effect. The processes are ordered by speed of change:

- *Transport networks* are the most permanent element of cities; they change only very slowly and have a lifetime of decades or centuries (although policy instruments applied to influence the way networks are used can have more immediate impacts).
- *Buildings* are the second most permanent element of cities; their lifetime can be hundreds of years, but they can be adapted to changing user needs through refurbishment,
- *Agents*, such as firms, households and individuals have their life cycles counted in decades but their needs change through events such as growth or decline, or through birth, marriage or death,
- *Location* decisions of the firms, workers and households occur more frequently, such as every few years,
- *Transport* decisions are much faster, they are made from every few years (vehicles) to daily (trips),
- *Environmental* impacts are the most rapid, but some have long-term irreversible consequences.

Each circle in the table represents an impact (from row to column), i.e., a cause-effect relationship. To keep the table simple, only direct impacts are indicated. However, secondary and indirect impacts can be deduced by following the circular structure of the table, as every effect (column) is also a potential cause (row):

- *Transport supply* represented by the road and public transport networks affects location and travel decisions but also the environment,

- *Buildings*, i.e., the existing building stock, affect location decisions about new development and are the origins of environmental impacts,
- *Agents*, i.e., firms and households, affect each other and generate the need for vehicles, goods transport and travel,
- *Location* decisions affect the location of buildings, work places and households, and influence other location decisions,
- *Transport* decisions about vehicles, freight transport and travel affect each other and the environment but also have impacts on transport supply in the form of congestion,
- *Environmental* impacts affect location decisions of firms and households but have little impact on freight transport and travel decisions.

The secondary or indirect effects implied by Table 5.1 are sometimes more important than the direct effects shown. For instance, extensions of the road network permitting faster access to the countryside may initially lead only to more car trips into the city from rural locations at the expense of rail or bus. In the medium and long term, however, they will make the countryside more accessible and attractive for households as a place to live and so accelerate suburban housing development and urban sprawl, and lead to more energy consumption, greenhouse gas emissions and loss of open space. This will attract new retail developments on suburban Greenfield sites at the expense of inner-city locations, which will in turn generate more traffic, mostly by car.

Table 5.1 Interactions between Urban Processes

Change of …		… causes change of …																				
		Net-work		Buildings				Agents			Location					Transport			Environ-ment			
		Road network	Public transport	Industrial buildings	Retail buildings	Office buildings	Housing	Firm lifecycles	Household lifecycles	Person lifecycles	Industrial location	Retail location	Office location	Labour mobility	Housing mobility	Vehicles	Freight transport	Travel	Energy, CO_2	Air quality	Noise	Land
Net-work	Road network	■									○	○	○			●	●	●	●	●	●	●
	Public transport		■													●		●	●	●	●	
Buildings	Industrial buildings			■							○					●	●	●	●	●	●	●
	Retail buildings				■							○				●	●	●	●	●		●
	Office buildings					■							○			●	●	●	●	●		●
	Housing						■					○	○	●	○	●	●	●	●	●		●
Agents	Firm lifecycles							■	○	○	○	○	○	○		○	○					
	Household lifecycles						○		■	○					○	○		○				
	Person lifecycles						○		○	■					○	○		○				
Location	Industrial location			●							■		○	○	○							
	Retail location				●							■	○	○	○							
	Office location					●							■	○	○							
	Labour mobility													■		○		○				
	Housing mobility						●					●	●	●	■	○		○				
Transport	Vehicles	●														■	●	●				
	Freight transport	●									●	●				●	■	●	●	●	●	
	Travel	●	●										●	●	●	●		■	●	●	●	
Environ-ment	Energy, CO_2										●	●	●	●	●				■			
	Air quality											●	●		●					■		
	Noise											●	●		●						■	
	Land														●							■

■ Full overlap ●/○ Direct impacts ● Faster interactions ○ Slower interactions

5.2 Impacts of Policies

Finally, Table 5.2 shows the relevance of particular policies for particular problems. In Table 5.2 both problems and policies are subdivided as in Table 3.2. Table 5.2 is as much as possible based on information in the Synthesis Reports; however if no material was available, other relevant sources of information were used.

The symbols used in the table indicate a strong or weak impact of a policy on a problem. It would have been desirable to indicate also the direction of impact, i.e., whether the impact is positive or negative with respect to urban sustainability. That would have required an even finer differentiation of policies. For instance building new roads relieves congestion but also induces more traffic and so in the long run increases congestion. However, because of the

selection of policies in the list, it can be assumed that in most cases the impact is positive with respect to urban sustainability.

It is important to note that only direct impacts are indicated in Table 5.2. To also include indirect impacts would imply impacts in almost all cells of the matrix, as in a sense all elements of the urban system are connected. However, this would be of little value. Therefore, when using Table 5.2 the interactions between urban processes shown in Table 5.1 should be considered. If a policy has an impact on one problem in Table 5.2, it can be expected that it will produce indirect desirable or undesirable side effects as indicated in Table 5.1.

The first impression from looking at Table 5.2 is that land-use planning, infrastructure provision and management, pricing, vehicle technology and integrated strategies stand out as the most efficient measures to improve urban sustainability.

- *Land-use planning*: land-use planning in general affects all three dimensions of urban sustainability, i.e., addresses environmental, social and economic problems, such as atmospheric pollution, noise, land capture, greenhouse gas emissions, equal access to all groups of society and congestion. Specific land-use policies, such as allocating development at locations with high accessibility, at commuter rail stations, or car-free residential areas, have much lesser impact but are efficient with respect to noise protection and providing equal access. Neighbourhood-scale urban design can be important for a pleasant and safe urban environment as well as for the mobility of physically impaired people.

- *Infrastructure provision*: infrastructure provision has in many cases ambiguous effects. To build new roads may relieve congestion but may also induce more traffic and so in the long run increases congestion, pollution and noise. Building new public transport lines may attract riders, but many of these may be former pedestrians and cyclists. Also new radial public transport lines tend to accelerate decentralisation of residences and jobs, and so promote urban sprawl. Building walkways and cycling lanes has no negative side effects but will do only little to reduce car traffic unless supporting push measures make car driving less attractive (see Integrated Strategies).

- *Infrastructure management*: better public transport, park-and-ride schemes, inner-city parking management and efficient traffic control systems reduce inner-city and motorway congestion. Better road-space management serves other objectives by making inner-city streets usable by pedestrians.

- *Public transport*: the policies addressed in the Public Transport Synthesis Report have close links with those covered in the Infrastructure Provision and Infrastructure Management Synthesis Reports. Like the policies mentioned there, public transport policies in general have positive effects on environmental indicators, accessibility, equity and accidents. However, public transport infrastructure, in particular rail infrastructure, reduces and fragments open space and can contribute to further suburbanisation.

- *Travel demand management*: travel demand management measures have become more popular in recent years as a way to make urban transport more sustainable. Marketing efforts, company travel plans, ride sharing (also known as car pools or car sharing in some countries) and car clubs (confusingly referred to as car sharing in some countries) have been shown to contribute to at least slowing the increase of car travel. Flexible work hours contribute to decreasing peak-hour congestion but not to vehicle-km travelled over-

all. There is recent evidence that teleworking, due to its interaction with residential location choice and other trip purposes, contributes only little to reducing vehicle-km travelled per person per day, but on a weekly basis teleworkers do travel less than non-teleworkers. The effects of teleshopping (e-commerce) on urban sustainability are as yet less certain.

- *Information*: radio, TV or Internet-based traffic information systems or on-board navigation systems enable drivers to avoid congested areas, however it has yet to be ascertained whether the high expectations put into these technologies are justified. Public transport passenger information systems and mobility centres serve a different goal, to improve access to public transport also for people without local knowledge or mobility handicaps.

- *Pricing*: making car travel more expensive, either by fuel taxes or taxes on car purchases, is the most effective way of reducing car travel and so congestion, road accidents, pollution, noise and greenhouse gas emissions. Road pricing on all or selected roads is equally effective but suffers from the risk of displacing rather than suppressing car trips if applied selectively. Parking charges in inner city areas are very effective in increasing pedestrian access and in no case have been found to endanger the vitality of city centre retailing. Reducing the cost of public transport through subsidies attracts more travellers to public transport but only a few of the new passengers are former car users. Only where there are simultaneous measures to make driving more expensive is there notable modal switch from driving to public transport use.

- *Walking/cycling*: these policies have already been treated under the headings of Infrastructure Provision and Travel Demand Management. The importance of slow modes regarding their contribution to reduce pollution, noise and greenhouse gas emissions seems to be underestimated. Reasons for that are methodological issues (unclear definition of trips made by slow modes, inadequate travel survey designs, etc) and the lack of consideration of slow modes in existing transport models and transport strategies.

- *Urban freight transport*: access constraints for heavy goods vehicles have positive effects on pollution and noise and pedestrian access in city centres. More comprehensive efforts to make urban freight transport more sustainable in the past have been less successful because of fragmentation and competition of both shippers and carriers.

Table 5.2 Impacts of Policies on Problems

		... have impacts on problems																		
		Environmental							Social					Economic						
Policies/measures ...		Air pollution	Noise	Land	Greenhouse gases	Visual impact	Cultural heritage	Health	Access	Social exclusion	Mobility handicaps	Equity	Health impacts	Congestion	Accidents	Financial barriers	Economic activity	External costs	Equity	Health impacts
Land-use planning	Settlement planning	○	●	●	○	○	○		○	○		●		○				●	●	
	Settlement size/containment	○	●	●	○	●	○		○	○		●		○				●	●	
	Concentration/densification	○	●	●	○	○			○					○				●	●	
	Urban structure	○	●	●	○	○	○		●	○				○			○	●	●	
	Location by accessibility	○	●	○	○				○	○		○		○			○	○	○	
	PT-oriented development	○	●	○	○			○	○	●		○	○	●			○	○	○	○
	Car-free development	○	●	○	○	○	○	○	●					○	○			●	○	
	Urban design	○	○	○	○	●	●				●			○	●					
Infrastructure provision	Motorways	●	●	●	●	○		●	●				○	●	○			●		○
	Local roads	●	●	●	●			●	●				○	●	○			●		
	Walkways	○	○		○	○	○	○	○	○	○	○	○	○	○					
	Cycling lanes	○	○		○			○	○	○			○	○	○					
	Public transport	●	○	●	●				●	○	○	○		○	○			○	○	
	Freight infrastructure	●	●	●	●				○					●	○		○			
	Parking	○	○	○					○					○						
Infrastructure management	Better public transport	●	○		●	○	○	○	●	●	○	○	○	●	○		○	●	○	○
	Park and ride	●	○		●		○	○	○	○	○	○	○	○	○			○	○	○
	Parking management	○	○		○		○	○		○	○	○	○	○	○			○	○	○
	Road space management					●	●	○	●	○	○	●	○	●	●			○	●	○
	Traffic control systems	○	○		○				○					●	○					
Public transport	New infrastructure	○	○	●	○	●		○	●	○	○	○	○	○	●	○		○	○	○
	Better service	○	○	●	○	●		○	●	○	○	○	○	○	●	○		○	○	○
	Fares								●			○				○			○	
	Travel information								○											
	Mixed-mode travel				○				○					○						
Travel demand management	Marketing	○	○		○				○		○	○			○					
	Company travel plans	○	○		○									○	○					
	Ride sharing	○	○		○									○	○					
	Car sharing	○	○			○														
	Flexible work hours	○	○		○									○	○					
	Teleworking	○	○		○									○	○					
	Teleshopping	○	○		○									○	○					
Information	Radio/TV-based services													○						
	Internet-based services													○						
	PT passenger information								●	○										
	Navigation systems								○					○	○					
	Mobility centres								●	○	○	○			●	○	○			

● Strong impact ○ Weak impact

Table 5.2 Impacts of Policies on Problems (continued)

Policies/measures ...		*... have impacts on problems*																				
		Environmental							Social					Economic								
		Air pollution	Noise	Land	Greenhouse gases	Visual impact	Cultural heritage	Health	Access	Social exclusion	Mobility handicaps	Equity	Health	Congestion	Accidents	Financial barriers	Economic activity	External costs	Equity	Health
Pricing	Fuel taxes	●	●	●	●			○	○	○		○	○	●	●	●		●		○
	Car taxes	●	●	●	●			○	○	○		○	○	●	●	●		●		○
	Road pricing, motorways	○	○	○	○									○	○			●		
	Road pricing, all roads	●	●	●	●			○	○	○		○	○	●	●			●		○
	Parking charges	○	○	○	○	○	○		●	○				○	○			●		
	Rail network charges				○									○				○		
	Public transport fares				○				○	○				○				●		
Walking cycling	Walkways	○	○		○	○	○	○	○	○	○	○	○	○	○					○
	Pedestrianisation					○			○	○	○				○		○			
	Safe crossings										○				○					
	Cycling lanes	○	○		○			○	○	○			○	○	○					○
	Bicycle service stations								○											
Urban freight transport	Access constraints	○	○			○	○		○					○	○			○		
	Loading zones								○					●				○		
	Freight terminals	○	○		○	○			●					○				○		
	City logistics	○	○		○	○	○		○					○				○		
	Parcel delivery points								○					○						
Vehicle technology	Cleaner cars	●			●			○					○					●		○
	More energy-efficient cars	●			●			○					○					●		○
	Safer cars														●					
	Hybrid cars	●			●			○					○					○		○
	Natural gas vehicles	○						○					○					○		○
	Alternative fuels																	○		
Innovative modes	Personal Rapid Transit	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Ultra-light rapid transit	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	Cybercars	○	○		○					○	●			●	●			○		
	Co-operative Highway	○	○	●	○					○	●			●	●			○		
Integrated strategies	Infrastructure	●	●	○	●	○	○	○	●	○	○	○	○	●	○		○	○	○	○
	Infrastructure and pricing	●	●	○	●	○	○	○	●	○	○	○	○	●	○		○	●	○	○
	Infrastructure and land-use	●	●	●	●	○	○	○	●	○	○	○	○	●	○		○	○	○	○
	Pricing and land-use	●	●	●	●	○	○	○	●	○	○	○	○	●	○					
	Infrastructure and TDM	●	●	○	●	○	○	○	●	●	●	●	○	●	○					
	TDM and information	○	○	○	○	○	○	○	●	●	●	●	○	●	●					
	Integrated programmes	●	●	○	●	○	○	○	●	○	○	○	○	●	○		○	○	○	○

● Strong impact ○ Weak impact

- *Vehicle technology*: cleaner cars (three-way catalysts) have in the past greatly contributed to reducing atmospheric pollution in cities. More energy-efficient cars are available on the market but have a small market share because fuel is still relatively inexpensive. The role of vehicle technology may become more important as fossil fuels will become more expensive in the future. Rising oil prices will also likely facilitate the market penetration of hybrid-propulsion cars, natural-gas cars or alternative renewable-energy cars. Technological advances making cars safer have contributed to reducing the number of fatal accidents. However, they tend to benefit those inside the vehicle more.

- *Innovative modes*: personal rapid transit systems combine the advantages of public and private mobility, i.e., offer some of the advantages of the private car without its environmental costs. Advanced driver assistance systems or automated vehicle guidance systems reduce congestion and accidents and to a certain extent also reduce emissions.

- *Integrated strategies*: it has been shown that integrated land-use and transport strategies are most successful in achieving sustainable urban development. This is based on the synergies between individual policies exploited in integrated strategies. In addition, integrated strategies serve the broadest range of efficiency and sustainability goals and are best suited to make rational trade-offs between conflicting objectives.

In summary the projects of the Land-Use and Transport Research cluster have revealed a wide range of land-use and transport policies that can be applied to achieve sustainable urban development. In general, transport policies have been shown to be more effective in the short to medium term; however, land-use policies are essential for achieving a settlement structure that is not too dispersed as a prerequisite for less car-dependent cities.

5.3 Policy Implications

This section attempts to synthesise the policy implications of the research in the Land-Use and Transport Research cluster even further across policy fields. It draws on a combination of theoretical analyses, empirical studies and model-based predictions, all of which provide similar indications of the impact of the principal types of policy intervention. In this final level of aggregation, land-use policies, transport policies and integrated land-use and transport policies are considered.

Land-use policies

Land-use patterns affect trip length. High-density mixed-use residential neighbourhoods with a balanced labour-to-job ratio have shorter trip lengths. However, longer distances from residential locations to employment centres result in higher trip lengths. Thus, centralisation of employment results in longer trips. Attractive neighbourhood facilities and pedestrian-friendly urban design contribute to shorter trip lengths and a higher share of public transport, cycling and walk trips. The larger a city is, the shorter are mean travel distances with the exception of some of the largest metropolitan areas.

Conversely, none of the land-use policies assessed has a significant impact on the number of journeys made. This is confirmed by the theory of travel budgets, and none of the empirical or model-based studies reported a significant impact of any factor on trip frequency.

Land-use policies can affect the choice of mode. Increased residential and employment density, larger city size and more rapid access to public transport all help to increase the modal

share of public transport. 'Traditional' higher density mixed neighbourhoods generate a higher share of non-car modes. Neighbourhood design and a mixture of workplaces and residences with shorter work trips are likely to increase the share of cycling and walking.

Land-use planning policies that limit urban sprawl by development restrictions, e.g., a green-belt around the city, strengthen the economy of the city centre and lead to shorter trip lengths and more trips by public transport. Policies that decentralise employment, such as peripheral industrial estates and out-of-town shopping centres, negatively affect the economy of the inner city and produce longer and more car trips.

Transport policies

Impacts of transport policies on transport patterns tend to be much stronger than those of land-use. Increases in travel cost and travel time lead to reductions in both trip length and trip frequency. Conversely, reductions in travel cost and travel time have a positive impact on trip length and frequency, resulting in longer work and leisure trips. Studies on changes in trip frequency are only known for travel time improvements, where time savings were found to result in more trips being made.

Mode choice depends on the relative attractiveness of a mode compared to all other modes. While some modes, such as car and rail, are inherently more attractive, increasing the speed and reducing the cost of any mode increases its modal share. Offering more frequent or lower cost public transport is more likely to induce a significant mode switch of walkers and cyclists than of car drivers, although there are a few positive counter-examples.

Transport in turn affects land-use by changing the accessibility of a location. Higher accessibility increases the attractiveness of a location for all types of land-uses thus influencing the direction of new urban development. If, however, accessibility in an entire city is increased, it results in a more dispersed settlement structure. The impact of accessibility varies by land-use. It is an essential location factor for retail, office and residential uses. Locations with high accessibility tend to be developed faster than other areas. The value of accessibility to manufacturing industries varies considerably, depending mainly on the goods produced.

New road infrastructure, such as an outer ring road, may result in a short-term relief of congestion but also in further decentralisation of population and increasing travel distances. New public transport lines have little impact on location choices, except where new radial lines significantly improve the accessibility of suburban locations, then they strengthen the inner-city economy but contribute to suburbanisation.

Introducing speed limits results in shorter trips and increased use of public transport. The effect of increased fuel taxes on the number and length of car trips is particularly strong. Significant fuel tax increases curb the further dispersal of residences and workplaces. Higher downtown parking fees and congestion charges reduce car traffic in the centre but make out-of-town shopping centres more attractive and may so generate negative economic effects in the centre, although it is too early to draw conclusions from the few congestion charge experiments to date. Free public transport reinforces a pattern of centralised employment and decentralised residential locations, but has little impact on the volume and length of car trips.

Integrated land-use and transport strategies

One important finding of many projects in the Land-Use and Transport Research cluster was that integrated land-use and transport strategies are more successful than isolated individual policies in either field:

- Land-use and transport policies are only successful in reducing travel distances, travel time and the share of car travel if they make car travel less attractive (i.e., more expensive or slower) and provide attractive land-use alternatives to suburban living.

- Land-use policies to increase urban density or mixed land-use without accompanying measures to make car travel more expensive or slower have little effect as people will continue to make long trips to maximise opportunities within their travel cost and travel time budgets. However, these policies are important in the long-run as they provide the preconditions for less car-dependent lifestyles in the future.

- Transport policies making car travel less attractive (more expensive or slower) are very effective in achieving the goal of reducing travel distances and the share of car travel. However, they depend on a spatial organisation that is not too dispersed. In addition, highly diversified labour markets and different work places of workers in multiple-worker households set limits to an optimum coordination of work places and residences.

- Large retail and leisure facilities that are not spatially integrated increase the distances travelled by car and the share of car travel. Land-use policies to prevent the development of such facilities (‘push’) are more effective than land-use policies aimed to promote high-density, mixed-use development (‘pull’).

- Transport policies to improve the attractiveness of public transport have in general not led to a major reduction of car travel, attracted only limited development at public transport stations, but contributed to further suburbanisation of population.

In summary, where there are integrated strategies in which land-use and transport policies are combined, land-use and transport policies reinforce each other so that positive synergies can occur. The key policy implications of the major land-use and transport strategy approaches are summarised in the box below. In general, the impacts of 'pull' measures, e.g., of land-use measures or of improvements in public transport, are much weaker than the impacts of 'push' measures, i.e., of increases in travel time or travel cost, or other constraints on mobility. If land-use and transport policies are compared, transport policies are far more direct and efficient in achieving sustainable urban transport than land-use policies. However, accompanying and supporting land-use policies are essential for creating less car-dependent cities in the long-run. Therefore only co-ordinated land-use and transport planning will lead to sustainable cities. This requires substantial changes in the institutional and financial framework of urban and regional planning.

Summary of Policy Implications

Land use policies: high-density mixed land use
High-density mixed-use residential neighbourhoods with a balanced labour-to-job ratio have shorter trip lengths. Attractive neighbourhood facilities and pedestrian-friendly urban design contribute to shorter trip lengths and a higher share of public transport, cycling and walk trips.

Land use policies: land use controls
Land-use planning policies that limit urban sprawl by development restrictions, e.g., a greenbelt around the city, strengthen the economy of the city centre and lead to shorter trip lengths and more trips by public transport. Policies that decentralise employment, such as peripheral industrial estates and out-of-town shopping centres, negatively affect the economy of the inner city and produce longer and more car trips.

Transport policies: travel time and cost
Increases in travel cost and travel time lead to a reduction in trip length and trip frequency. Reductions in travel cost and travel time result in more and longer trips. Faster, more frequent or less expensive public transport attracts walkers and cyclists but only few car drivers, although a few positive counter-examples do exist.

Transport policies: accessibility
Making transport faster (or slower) or less (or more) expensive changes the accessibility of locations. Higher accessibility increases the attractiveness of locations and so influences the direction of urban development. If accessibility in an entire city is increased, it results in a more dispersed settlement structure.

Transport policies: new infrastructure
New transport infrastructure may result in a short-term relief of congestion but contributes to long-term decentralisation of population and increasing travel distances. New public transport lines have little impact on location except where new radial lines significantly improve the accessibility of suburban locations; then they strengthen the inner-city economy and contribute to suburbanisation.

Transport policies: inner-city access charges
Higher downtown parking fees or congestion charges on their own reduce car traffic in the centre but make out-of-town shopping centres more attractive and may so generate negative economic effects in the centre, although it may be too early to draw long term conclusions from the few congestion charge experiments to date.

Integrated strategies
Land-use policies to increase urban density or mixed land-use without accompanying measures to make car travel more expensive or slower have only little effect on car mobility. Transport policies which make car travel less attractive are very effective in reducing car mobility but they depend on a not too dispersed spatial organisation. In integrated strategies in which land use and transport policies are combined both types of policies reinforce each other so that synergies can occur. Integration of complementary transport policy instruments is also essential. For example, where inner-city access charges are combined with public transport to ensure continued good access to the centre, and thus avoid negative economic impacts.

Summary
Transport policies are more efficient in achieving sustainable urban transport than land-use policies. However, supporting land use policies are essential for creating less car-dependent cities. Therefore only co-ordinated land-use and transport planning will lead to sustainable cities. This requires substantial changes in the institutional and financial framework of urban and regional planning.

6 Decision Support Tools

Decision making in land-use and transport policies and actions is a very complicated process having a number of linked socio-economic, environmental (local and global), institutional and political issues. Very often the decisions are made without a clear perception of what the effects will be of the initiatives, measures and policies being undertaken.

Land-use and transport policies and measures can have significant environmental and socio-economic effects, the estimation of which should be a key element of the appraisal process. We need, in practice, decision support tools allowing a technical comparison of alternatives and providing a quantification of impacts, necessary for ensuring sustainable land-use and transport policies.

6.1 PLUME Decision Support Tools

In general terms a decision support tool can be defined as any guideline, best practice identification, assessment method, planning methodology, or software tool providing decision makers with 'support' in making the best decisions. The PLUME projects have been concerned with developing decision support tools for sustainable land-use and transport, whilst PLUME itself has drawn together the state of the art regarding the best land-use and transport policies, and practices.

The ARTISTS, ECOCITY and PROMPT projects provided guidelines for arterial street redesign, land-use and transport planning, and promotion of walking respectively. ASI and SCATTER considered assessment methods for quality of life and urban sprawl. CITY-FREIGHT and PROPOLIS defined assessment and planning methodologies for urban freight transport, and land-use and transport planning respectively. ISHTAR and PROSPECTS provides software tools for designing and assessing land-use and transport policies, whilst VELOINFO established a web based expertise centre on bicycle use. TRANSPLUS identified best practice regarding land-use and transport policy instruments.

This section of the final State of The Art Report will primarily consider the software planning tools that decision makers can use in designing and assessing land-use and transport policies. Decision support tools in general and software planning tools in particular are one of the main outcomes of the PLUME projects. A variety of conclusions regarding selection of policy strategies ('what to do'), and a rich menu of instruments to be used ('how to plan and assess it') has been put together through the state of the art reviews for the Synthesis Reports.

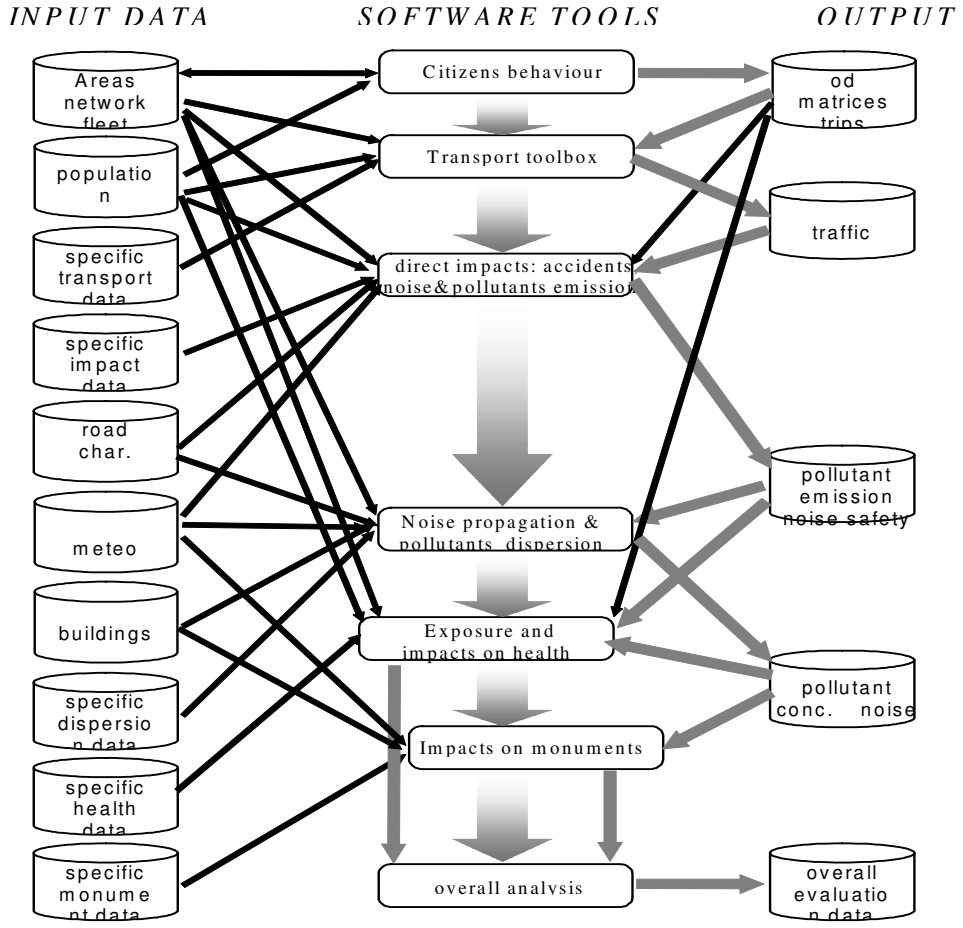
6.1.1 ISHTAR and PROSPECTS Decision Support Tools

The ISHTAR and PROSPECTS projects developed two particularly good decision support tools. ISHTAR built an advanced software suite for the analysis of effects arising from short term actions (lasting just a few days) through to medium term strategies (i.e., those with annual horizons). Effects are analysed in terms of environmental quality, citizens' health and safety, and heritage preservation. PROSPECTS developed a sketch planning model to analyse the interactions between land-use and transport at a strategic level (with a horizon up to 30 years hence), and provide a time saving alternative to the traditional four steps transport models.

In practice the two tools are complementary. Long term land-use and transport policy can be analysed with the PROSPECTS sketching planning model, whilst the associated environmental impacts could be estimated with the ISHTAR software suite.

Figure 1 illustrates the modules and data in the ISHTAR software suite. The modelling chain starts with the citizens' behaviour following the implementation of a given policy, proceeds with transport analysis and consideration of direct impacts (noise, atmospheric pollutants, accidents, etc), continues with the dispersion modelling to arrive at the effects on health and heritage and concludes with a cost-benefit analysis or multi-criteria analysis.

Figure 1 ISHTAR Software Suite Structure



The ISHTAR software suite has been utilised in decision making for the following projects:

1. ATHENS-ATTIKI: new motorway from city to airport,
2. BOLOGNA Province: new infrastructure at provincial level (city of Imola),
3. BRUSSELS: selective traffic banning from city centre,
4. GRAZ: new tunnel in city (focus on noise),
5. GRENOBLE: new public transport line replacing private car lane
6. PARIS: car free day
7. ROME: selective car bans in HEAVEN project area (north of city centre).

The key features of the PROSPECTS decision support system include a:

- Sketch planning model,
- Land-use and transport model,
- Analysis of impacts on car owners and non-car owners,
- Analysis of commuting and non-commuting trips,
- Non-motorised modes,
- Residential and workplace location preferences,
- Impacts of policy instruments (e.g. public transport fares, parking or road pricing, etc),
- Assessment against sustainability indicators.

The PROSPECTS sketch planning model has been used to identify the optimal policy combinations in seven EU cities. The optimal strategy in most cities has proved to consist of a reduction in public transport fares accompanied by an increase in service levels, and charges for car use. The cities using the sketch planning model include:

- Edinburgh,
- Helsinki,
- Leeds,
- Madrid,
- Oslo,
- Stockholm
- Vienna

6.2 Conclusions Regarding Decision Support Tools

Different categories of decision support tool have been provided by the PLUME projects, including: guidelines, best practice, assessment methods, and software tools. The involvement of end user cities across Europe in the development of PLUME's various decision support tools has allowed wide and meaningful realisation, validation, comparison and application of the tools. The harmonisation of decision support tools to be used for land-use and transport planning is an agreed target, and although reality shows that a variety of solutions can satisfy the same modelling requests, the PLUME projects have contributed to progress towards harmonisation. It is particularly important to note that such efforts towards harmonisation further co-operation amongst conflicting municipal units and objectives.

7 Vision of Future Cities in Europe

This statement sets out to portray an overall vision of a future city in the EU to the year 2030. It is just one vision, and inevitably developments will vary between city types, and some readers may completely disagree with the vision presented here. However, the intention here is to be thought provoking, and encourage decision makers to think creatively about where their city is going, what it might be like in 25 years time, and what they can do now to shape a sustainable future for their city. This vision is based on current, and likely future trends in urban passenger and freight transport, as well as the state of the art in land-use and transport planning as identified by PLUME. The statement is structured around an archetypical city (Futuresville), and begins by setting out the current and future trends by way of a benchmark for considering future developments. The vision is conveyed by a citizen of Futuresville who is looking forward from 2005, but at the same time, imagining what Futuresville will be like on 2030, and looking back at the changes that have taken place. Following this, future innovations are considered to allow an assessment of what land-use and policy instruments may be in place in Futuresville.

7.1 Futuresville 2005

Futuresville is a traditional European city with an old medieval centre, around which various civic and economic quarters developed. Industry also became significant in the nineteenth century, but much of that land-use has now been redeveloped into modern, mixed use urban villages. The whole is surrounded by a significant ring of suburban residential neighbourhoods.

The core road network in 2005 radiates from the city centre, having developed to link the centre to the heart of each of the surrounding civic and economic quarters, and then extended into the industrial developments of the 19th Century, and beyond into the suburbs in the 20th Century. These radial roads are interlinked by grids of criss-crossing roads, including wide boulevards linking civic and economic quarters, and later industrial areas, but in 2005 only the boulevards are served by public transport (trams); other interlinking roads have virtually no services as heavy rail and bus routes have focused on connecting suburban and more distant residents with city centre jobs.

A further reason for poorly developed interlinking public transport is the traditionally dominant role of cycling within Futuresville. Topography, climate and infrastructure all favoured cycling. The criss-crossing grids of streets ensured that short, direct routes were available between many origins and destinations. Further, infrastructure had been developed to support cycling, through management to prioritise and guide cyclists at crossings, shared use of road space on the minor roads, which cyclists traditionally dominated (although by 2005, the increasing car use meant that cars were dominating these routes, and there was little safe, segregated space for cyclists), and cycle only river crossings across the central river.

The river running through the centre of Futuresville is also served by a river boat service. In an attempt to reduce growing congestion, passenger services on the river were re-introduced in 2005 after successful implementation elsewhere in Europe. These run between the outer suburbs of the city, and stop at key locations en-route, including several peers in the centre. The service also links into park-and-ride sites at either end of the route on both banks of the river.

Other public transport in Futuresville consists of bus, rail and tram services. Trams run along the radial routes, and the wide boulevards, but the network does not extend beyond the old industrial areas of the city into the residential suburbs. Heavy rail forms a radial network fanning out of the city with some stops in the suburbs, but mainly serving outlying towns, and more distant cities. Buses radiate from the city centre using the radial routes until they reach the suburbs, where they divert off into residential areas, but the networks are still not particularly dense. Trams are the only mode (apart from the new river boat services) that allow cross city journeys without changing in the city centre. However, since the 1960s the number of stops on tram routes has been reduced in an attempt to increase journey speeds. Additionally, segregated tram tracks have been removed over this period, and replaced by shared space for cars, trams and buses, in an attempt to increase capacity for car traffic. Not all stops, stations, rolling stock or vehicles are fully accessible to people with mobility impairments, but conditions are improving.

A ring road was built around Futuresville back in the 1980s in an attempt to remove through traffic from the centre of the city, and thus reduce congestion. However, it was not accompanied by city centre traffic restrictions, calming, or increased parking charges, thus the net effect of the ring road by 2005 was induced traffic, and no reduction in city centre congestion. The ring road is served by a bus service, but this is the only circular route in the city. Within the ring road, the wide boulevards have formed natural inner ring roads for private cars, and by 2030, many of these routes have been utilised in the introduction of personal rapid transit.

7.2 Passenger Transport and Freight Trends

Like many cities in the EU30[4], trends in passenger transport were for increased car use at the expense of public transport, walking and cycling in 2005. However, patterns of change up to and beyond 2005 were not simple. Reductions in walking were minimal as in relative terms the modal split of walking was fairly stable, and remains so in 2030. Cycling decreased rapidly from the later half of the 1990s, and this was of great concern to the authorities, since previously favourable conditions seemed insufficient to maintain cycling levels in the face of growing safety concerns arising from increased car traffic. Bus use on the radial routes decreased most significantly despite the introduction of luxury bus services around the city. Surprisingly, rail use was increasing in 2005 - due to growing commuter distances arising from urban sprawl. There were also increases in tram use for the same reason, once the network was extended to new park-and-ride developments at some of the old out-of-town retail centres. However, increases in rail and tram use were not sufficient to counteract the overall reduction in the public transport modal share. It is also worth observing that many of the longer commuter journeys are by rail or tram and car, as use of park-and-ride facilities at tram and rail termini, and old out-of-town retail centres is increasing. Overall, people are travelling further, faster, more often. By 2010 congestion had become severe. The result of these passenger transport trends and those relating to freight outlined below was severe congestion across the city, with speeds below 1 mile per hour. By 2030 car use within the city had decreased in favour of other modes, particularly public transport, and especially the personal rapid transit system. Nevertheless, individuals' total travel has continued to increase.

For freight, trends were also for increased volumes overall, and increased road freight in particular in 2005. There are now (2030) a number of urban freight centres on the outskirts of Futuresville, and these are fed by heavy rail and road freight deliveries utilising the largest

[4] The EU continued to grow after its rapid expansion in 2004, but at a considerably slower rate, admitting just five more countries by 2030.

lorries. As in many countries, road freight dominates, as attempts to shift freight to the railways are slow due to lack of capacity on the rail network, lack of network in some areas, and problems (largely concerned with planning permission) developing feeder stations for road freight to be transferred onto the rail system and vice versa. Within Futuresville freight is moved around using growing fleets of small delivery vehicles that complete the 'last mile' from the freight centres to the final destination. Just in time delivery has spread from industry to retail outlets as a result of the trend for more frequent changes in product ranges, increasing the demand for road freight trips. Another cause of increased freight trips is the growth in home shopping, as many citizens have their weekly groceries delivered, as well as purchasing consumer products on line.

The changes in retail also affected the nature of retail land-use across the city. In the centre there is a focus on fashion, leisure and luxury goods, with shopping promoted as a leisure activity. This trend is supported by pedestrianisation of the old quarter in the centre of Futuresville, and development of a high quality urban environment including green spaces, street cafes, seating, lighting and outdoor entertainment areas. The old quarter is now a significant tourist attraction, as well as the place to be seen at the weekend for the city's residents.

By contrast, many of the out-of-town superstores are now converting large areas of their premises to freight logistics centres for their home delivery services, with just a small area at the front of the store set aside for conventional shopping. Only the largest regional shopping malls that incorporate restaurants, cinemas, gyms, and other activities have survived. Increasingly, conventional retail areas in the old out-of-town supermarkets only sell fresh produce, as people have non-perishable goods delivered on a monthly basis. These changes mean that there is now surplus parking space at many out-of-town retail centres, and this is being converted to park-and-ride use with new tram services taking car drivers the 'last mile' to the city centre, or other employment centres in the city. These policies are supported by the reintroduction of disused tram stops to help make journeys as near to door-to-door as possible, and increase accessibility for those with mobility impairments, as well as re-segregation of the tracks to increase journey times, and restrict capacity for car traffic, making car journeys longer, and less attractive. People using the park-and-ride services are also purchasing perishable goods from the supermarkets on a daily basis in some cases, representing a return to buying fresh produce daily. This trend is also helping neighbourhood grocery stores increase their trade, with new outlets selling the full range of fresh produce opening in residential areas. This is facilitating short walking trips, which is helping to maintain the modal share of this mode, as well as having positive effects in terms of community cohesion, social networks, and health.

As a result of the excessive and increasing car use and road freight in 2005, atmospheric pollution was a significant problem in the city, with most citizens aware of the issue due to increasing prevalence of respiratory diseases such as asthma, and visible smog on many days. The city authorities consequently introduced car free Sundays every week to force reductions in car use. This solution, was quicker and simpler to introduce than rationing through pricing, but was only a short term fix as car use on other days of the week continued to increase.

7.3 Population and Residential Location Trends and Transport Impacts

These developments in passenger and freight transport are grounded in changes in the population and urban development. In several EU countries the population is aging in 2030 as wealth has increased significantly since joining the EU, and birth rates are consequently dropping. In other countries that had aging populations back in 2005, and now have a signifi-

cantly higher proportion of retired citizens than young people, the birth rate has been reversed through the introduction of considerably more family friendly tax regimes and working practices. However, the EU as a whole has a declining population, but again there is considerable variation, as the population of many cities are growing due to development centres, and residential trends. One cause of this is migration, as people move from poorer parts of the EU, to development centres in the more wealthy regions that have more elderly people, than citizens of working aging, meaning there are more jobs than people able to fill them. Certainly there are more households across the EU due to an increasing number of single person households as people marry later, and live longer. Until 2015 the residential trends favoured suburban and out-of-town living, which partly arose from, and partly generated urban sprawl. This has caused the longer commuting distances that are still experienced in 2030, but land-use planning to reduce car use, and internalisation of external costs in car travel, which made car use less attractive for some, prompted a trend towards densification of cities, and more urban living.

It is mainly the young who are living in our cities, with those with children still preferring the more spacious suburbs and out of town areas. Amongst older people, there is no dominant trend. Some prefer to stay in their suburban family homes, whilst others prefer to move back into the cities. Despite densification and declining populations, car ownership and use is still increasing due to more older people driving, those in cities continuing to own cars to visit friends, family and leisure destinations outside of the cities, and households living in more rural areas owning multiple vehicles, since public transport is scarce in those areas. However, in Futuresville, as in other cities, car use is growing at a considerably reduced rate as public transport experiences a revival. Trends in freight transport though have not changed significantly, although the smaller vehicles reduce the visual intrusion. Noise, air pollution, and general disruption from freight vehicles has also been reduced by performance related pay based on driving standards. Driving standards are monitored through more sophisticated tacographs.

Atmospheric and noise pollution have also been reduced through improvements to public transport (the tram and heavy rail systems are electric, as is the new personal rapid transit network), pedestrianisation of district centres, and other re-use of roads as public spaces. For example, the car free Sundays continued. Strolling around the city became the popular thing to do on a Sunday, as citizens had come to appreciate the relaxed atmosphere, and contact with friends and neighbours as they walked around. Sunday street markets had also started, bringing economic, as well as community benefits to the city. Road space has also been reduced in favour of tree lined pavements with cafes and small market stalls selling fresh produce. Introduction of an extensive one-way system has allowed this reduction in road space and the emphasis has been on urban design for people not cars to achieve a liveable streetscape that has resulted in increased walking and cycling. It is worth noting here though, that by 2030, the car free Sundays had more to do with their popularity than contributing to the reductions in pollution, as growth in car use on other days had outstripped the initial gains obtained when they were first introduced. It is the other changes in allocation of road space through pricing, regulation and design, mode choice, and vehicle technology that really contribute reductions by 2030.

Adoption of new vehicle technology has also helped. EU legislation forced the adoption of more fuel efficient vehicles, and eventually alternatively fuelled vehicles and the fuel supply infrastructure to run them. In 2030, nearly all vehicles are hybrids, using fuel cells and either

natural gas, or more commonly biofuels. The market for hydrogen fuelled vehicles is also taking off.

7.4 Processes and Integration

To achieve the reduction in rate of growth in car use experienced in Futuresville, and other cities, changes in many policies and processes have been necessary. Significant barriers to implementation were institutional issues, as the different players in the built environment (land-use planners, transport professionals, architects) continued to operate as separate professions. However, EU directives combined with the facilitating efforts of national governments forced the different professions to work together, and harmonise their decision making processes, and at the same time, directives forced change in financing and competition regulations that resulted in harmonisation across Europe, and fewer barriers to developments that are in the public interest. Further transport authorities across Europe were given (where they had previously lost it) the remit to specify fares and service levels provided by the private sector. The most prolific result of this was true integration. Transport developments now integrate modes and interchange facilities properly in high quality urban environments and land-use developments are always planned with accessibility for all individuals in mind. Furthermore, land-use, infrastructure, pricing, public transport, and attitudinal and behavioural elements are properly co-ordinated.

The way in which targets are set, and strategies developed has also developed considerably since 2005. Use of targets and their associated indicators is compulsory to monitor progress against objectives, and supply the local data that is disseminated through Futuresville.net, and the area-nets for other regions. Objectives, and the consequent targets, and indicators are guided by EU policy on sustainability, and by local needs. In 2003, Futuresville citizens and their representatives are always involved in decision making, such that local views can stop plans that meet planning regulations, on the basis that local people do not want the planned development. This local involvement also includes citizens in strategy development, which is now a combination of the pragmatic plan-led approach that dominated previously, vision-led, and of course, consensus-led.

The involvement of citizens, land-use planners, architects, and the multiple public and private actors involved in transport means that there are often multiple views on what strategy should be followed. This has forced improvements in strategy impacts forecasting. Advances in programming mean that land-use and transport models are now able to model all (economic, environmental and social) impacts of strategies, including unexpected and secondary impacts. Models have also been standardised so that decisions in different cities are comparable, and the human interface has been improved such that model outputs can be understood by everybody.

Decision making was also helped by state of the art appraisal processes from option generation through the impacts forecasting and strategy appraisal, as well as more extensive public participation. Extensive research was undertaken to derive realistic monetary values for appropriate indicators across all areas of sustainability in the social-cost benefit analysis, and remaining qualitative criteria have been properly defined to reflect citizens' perceptions. Thus, by 2030, appraisal processes are better able to take account of social justice, and equity. Further the indicators used in appraisal were revised to more accurately reflect society's needs, and were harmonised across Europe, with different levels of appraisal appropriate to different scales of project – small local initiatives up to trans-European schemes.

As noted, decisions that affect communities are also taken with those communities who are involved through conventional discussion groups, information technology based consultation that allows visualisation of new designs, and SIM city like simulations to allow experimentation and consideration of long-term effects. The 'SIM-city' for Futuresville contains a database of all land-use and transport policy instruments available to decision-makers. Decision-makers can find information on the performance of these instruments, and appropriate packages of for meeting a range of strategic objectives, and achieving full integration in different circumstances. Advice is also available on strategy development, and appraisal. Decision-makers can experiment with innovative instrument developments and combinations through the development programming function, and set parameters for public consultation uses. In 2005 a range of Internet information services were available for decision-makers, such as the KonSULT knowledgebase referred to previously in this report, but no combined information, modelling and appraisal sites for specific cities had been developed. All land-use and transport professionals are also fully conversant with the appraisal and public participation processes as ex-ante procedures. Residents, businesses, interest groups, and individuals contribute to both understanding of problems, and development of solutions.

7.5 Land-Use Planning and Personal Rapid Transit

In terms of land-use planning, and infrastructure provision the key characteristics are that, Brownfield development has become the norm in Futuresville, and this has contributed to densification of the city. However, demand by citizens for retention of green space, and relatively low rise human scale development, in their city means that densification has not been as greater as policy setters may have desired. One benefit of pressure to ensure that green space is preserved is that the Greenbelt around Futuresville is now strictly enforced as a result of increasingly vocal outcry from community groups in response to Greenbelt planning applications. Back in 2005 and for some years after that, it was not uncommon for the local authority to grant 'exceptional planning permission', allowing development within the Greenbelt. Many of these decisions were as a result of lobbying from development companies who could not afford the clean-up costs associated with Brownfield developments following introduction of the landfill tax. By 2030 however, cleansing technology was considerably more sophisticated and had reduced in cost sufficiently to be cost-effective. Thus, development within Futuresville was concentrated in the old industrial areas, where more and more space was becoming available as labour costs forced manufacturers and call centres to shift their operations overseas. Despite development in Futuresville being less dense than policy makers had hoped for, the utilisation of Brownfield sites means that the city has shifted towards maximum housing density and minimum parking standards (as discussed below), although there is still some way to go due to the slow rate at which land-use changes.

High rise development has been possible in the city centre, and prestigious mixed use developments have appeared, some utilising old historic buildings and areas as a focal point. Many of these new high rise buildings are also linked by an elevated personal rapid transit system. The infrastructure takes the pods directly into residential, office and retail buildings, with access/egress sites integrated with the lift areas for access to other floors of the building. Many existing buildings have also been converted to link into the personal rapid transit network, which also integrates into the conventional public transport system at interchanges.

The network started by linking new buildings and development quarters in and around the city centre, and spirals outwards to link residential neighbourhoods into the system. The infrastructure spirals out from the centre to help fill in the gaps in the pre-existing public transport network, thus public transport journeys within the city are becoming easier. As the per-

sonal rapid transit system moves out of the city, it also begins to operate at lower elevations, so that it is at ground level in residential areas, usually with termini in neighbourhood centres. Often these termini, and sometimes part of the network are hidden underground in residential areas, or where valuable green space needs to be traversed. In residential areas, the access/egress lifts serving the termini provide direct access to local shops and amenities, by taking passengers straight into the buildings they wish to access. The public network and its individual pods has become very popular with young people, families travelling into the city (as some pods can take up to 6 people), and those with mobility impairments since the system provides physically accessible access to many buildings. The pods can also be called from any stop at any time, allowing 'private' transport on demand, but without the need for individual ownership of vehicles.

Car free developments envisaged at the end of the 1990s have generally not taken off due to need for car ownership to access out-of-town destinations. It was thought that car clubs based in these developments would facilitate short-term hire arrangements on demand, which could provide access to vehicles without individual ownership. However, these clubs were unpopular because demand at certain times of day (evenings and weekends, when employees were not at work) was often such that cars could not be supplied on demand without large fleets, but the overall demand was insufficient to support such fleets. The reduced cost of owning a car after taxation was transferred to the point of use when external costs were internalised around 2010 also mitigated against car clubs, as owning a vehicle but only using it for some trips became efficient as pricing at point of use created a more level playing field between modes. Further city charging was introduced so that all car drivers had to pay a charge to drive in Futuresville, with a further charge for the central area. Residents are not exempt, indeed only those with disabilities that prevent use of the now fully accessible public transport and personal rapid transit system are exempt.

7.6 Parking

The densification of the city, and reduced cost of car ownership, both accelerated growth in ownership within Futuresville, and this in turn created a serious parking problem around 2015. The cost of city centre parking has been increased to deter car use for journeys into the city back at the beginning of the 21st Century, and costs had continued rising as car use did, but with little impact as businesses absorbed the cost of employees and visitors parking charges, including the workplace parking levy that was introduced. No stopping/parking zones, and permit only areas were introduced in residential and business districts, but over time, parking became an unenforceable free for all as people refused to park miles from their destination. Eventually, drastic measures were needed, and funded through revenue from the road user charging system. Subterranean and stake parking systems were constructed around the city, including residential areas. In many areas of Futuresville, on street parking is now illegal to preserve the high quality environment that has been created, but charges for parking spaces are not cheap, and this has slowed the rate of growth in car ownership.

In residential areas, removal of on street parking and traffic calming to decrease traffic speeds helped residents re-claim their streets. Streets are one-way and tree-lined as described previously, and children are able to play in the streets again, making high density living more feasible. As noted, many families still prefer the suburbs, but even these are growing in density.

7.7 Conventional Public Transport

In terms of conventional public transport the tram system in Futuresville has been upgraded, as outlined previously. The heavy rail system has been slimmed down with uneconomic lines and/or services into the rural hinterland and beyond being cut. This has allowed greater investment in remaining infrastructure and services allowing more frequent and reliable services, as well as greater physical accessibility to the system, and integration with the rest of the transport network. Heavy rail is now predominantly an intercity mode. In most cases, the suburban parts of the heavy rail system that were cut have been absorbed into the tram network, with park-and-ride added at the outskirts of the city for those who need to drive in from satellite towns and villages. As with the personal rapid transit, some of the park-and-ride sites around Futuresville are hidden underground. The bus network has experienced most change. Patronage was declining rapidly at the start of the 21st Century as passengers would rather sit in their own vehicles if they were going to be forced to sit in a traffic jam almost regardless of mode choice. As a consequence, segregated lanes, which on radial corridors often have guideways to facilitate faster journeys, have been created where there is no tram, or the remaining heavy rail services suffer overcrowding. Elsewhere, bus services have been cut as the more popular personal rapid transit system that runs 24 hours a day has been phased in. Implementation of segregated bus lanes, re-segregation of the tram tracks, and introduction of the one-way system for cars has been combined with creation of car free cells. These often have new development quarters at their centre. These changes to the car network mean that driving around the centre of Futuresville has become more time consuming, and therefore unpopular, especially since the cost increases significantly near the centre. As a consequence, car use in the city centre is increasingly rare, although it is as prolific as ever elsewhere. Within Futuresville, the cities taxi fleet continues to fill any remaining gaps in the supply of other modes. However, the introduction of the personal rapid transit system means that the fleet is considerably smaller than in the past, and is mainly used by visitors, and for unique special needs journeys funded by the local authority to maintain accessibility for everybody.

The changes to the public transport system, and land-use planning decisions discussed above, means that Futuresville has shifted away from built-in car domination to be a more sustainable, public transport, walking and cycling orientated city. Investment in the city's transport system, from the public transport outlined here, to the pricing and parking infrastructure has largely been through public-private partnerships. The diversity of arrangements and degree of privatisation is extremely complex, but overall, provision is of a higher standard than could be provided solely through public funding without unacceptably high taxes.

7.8 Walking and Cycling

Walking and cycling have both benefited from the changes to the public transport network. Segregated cycle lanes, and wider footpaths have been installed, and green routes for cyclists and pedestrians have been created from unofficial footpaths dotted around the city. These routes also take cycle and pedestrian routes out into the satellite towns and villages. Much use is for leisure purposes, but there is a growing group of longer distance cycle commuters. Growth in this area has been helped by provision of secure cycle storage units, with showers and other facilities around the city centre. Many of these facilities are hidden underground, often under key buildings or public transport termini so that employees only need take the lift up into their building, or to transport interchanges. Despite these changes, cycling remains a minority mode. The changes have really only brought back cyclists who stopped due to safety concerns when the city centre was congested with cars; it has not recruited significant numbers of new cyclists for non-leisure journeys.

7.9 Pricing

Other significant policies that have been successfully implemented by 2030 include pricing (potentially, the most significant change), information measures, and travel demand management using a range of attitudinal and behavioural measures. With regard to pricing, all car use is now paid for at point of use with pricing paid for via GPS tracking systems and direct debit mandates to the collection agency. Transition to the system was not easy due to lack of public acceptability. Transferring costs from ownership to point of use, only became widely acceptable once improved public transport provision was in place, and financial regulations were changed to allow hypothecation of revenue to transport investment (it has helped to fund the personal rapid transit system), but use of GPS tracking was unpopular. However, the system was introduced early in some EU countries, particularly the new member states who were working on upgrading their road systems anyway, and success in those countries increased acceptability elsewhere.

Another group amongst whom acceptability of pricing (and the workplace parking levy) was low at the outset was the business community. Businesses were concerned that charging would make neighbouring cities more attractive to other businesses, tourists and shoppers, especially since they felt that traffic calming and restrictions had already worsened their competitive position. However, the Futuresville.net (described below), and information technology systems developed to allow participation in the decision making processes, were extended and combined to take in up to date, real world business and socio-demographic data from across the EU, so that Futuresville knows how it is performing in relation to other cities. Evidence suggests that since similar changes are occurring in many cities, no one city is at a particular competitive disadvantage. However, the data allows businesses to view developments and make changes to ensure they stay ahead. The data also allows local authorities to monitor accessibility and social inclusion indicators, to spot potential exclusion problems, and take appropriate remedial action, as well as monitoring environmental data as they have for many decades. The data collection is automatically funded by the EU, national and local government, and is freely available to all. Residents, businesses and interest groups can analyse raw data via software on Futuresville.net, or purchase analysis from the local authority.

The fair level playing field between modes is now widely accepted amongst the general public, who responded by engaging with personalised journey planning programmes and work/school travel plans to help them change their travel patterns to make more use of existing public transport they were unfamiliar with. These attitudinal and behavioural measures were also used to help the implementation of new public transport facilities, especially the personal rapid transit system, to help people learn how to use the new systems. Long term acceptability of charging within Futuresville has been the ability to make pricing responsive. Pricing of road space, parking spaces and public transport is all responsive to congestion levels, atmospheric and noise pollution levels, and the economy. Typically, road and parking space charges are raised when pollution, and congestion levels are high, or when they are expected to become high, e.g., during special events, summer time when levels of atmospheric ozone are higher, rush hour etc. Charges can also be reduced as the cities economic performance suggests a need to attract more investors, visitors, and shoppers to the city. Revenue for projects is recouped, and pollution balanced out at other times when the economy can sustain higher charges. Walking and cycling are the only completely free modes within Futuresville, with the infrastructure provision and maintenance subsidised by road user charging, and parking charging, as well as general taxation when necessary. Public transport charges are always lower than road user charges, and they are capped so that users know the maximum they will have to pay. However, changes to public transport charges are usually temporary decreases at

times when there is a particular need to reduce car use. Those who buy season tickets are immune to price fluctuations within the period of their ticket. However, this means that season ticket holders do not benefit from price reductions, so most people buy tickets at the point of use. Since all tickets must be purchased in advance of boarding the vehicle through newsagents, market stall vendors, Futuresville.net, or ticket machines at stops and stations, purchase at time of use does not cause delays as passengers board vehicles. Negative impacts on those who may suffer social exclusion as a result of higher charges are avoided by providing citizens receiving social support with a card that caps the price they must pay for road space, parking spaces, and public transport regardless of price changes. Within this, individuals are still charged more for road and parking spaces than public transport, but they retain the choice of which most to use, and can continue to own a car for journeys when it is essential, since costs are at point of use, not annual sunk costs.

7.10 Information

Information measures have also helped the transition to new travel patterns. All public transport is supported by real time information at access/egress points in the network. The information is also available via the Internet, mobile phones, and the city wide Intranet. Futuresville.net is an Intranet that residents and employees in the city can connect to, to obtain information on transport, and many other events, activities and services in the city. It is also key to the new public participation systems used by planners and decision makers. Futuresville.net also helped to reduce the need to travel in a number of ways. Health and social services can be accessed via the net allowing online diagnosis, consultation, counselling and booking of services in many cases. The education sector also provide online courses that reduce the need for travel, as do the shopping portals provided for local stores.

7.11 Futuresville 2030, Better or Worse?

The combined effect of the trends and policy measure implementations outlined here has been to solve many of the environmental, social and economic sustainability problems that existed in 2005. Atmospheric and noise pollution in the city has been significantly reduced as car traffic has been removed, and replaced by the personal rapid transit system that has no point of use pollution, since the system is electrical. Electricity generation is not yet based wholly on renewable resources, so there is pollution associated with the system, but non-renewable, imported energy consumption has been reduced, which at least increases security of energy supply. Some in Futuresville believe the visual intrusion of new high rise buildings and the elevated personal rapid transit infrastructure to be a serious problem. However, the social-cost benefit analysis indicates that the system has positive benefits, and opposition is declining. Indeed many who benefit from the increased social inclusion, and accessibility, as well as those whose green spaces and public spaces have been preserved favour the changes that have been brought about in Futuresville. Removal of the severe congestion that pervaded the city by 2010 has also been viewed favourably by the majority, and it has positive economic benefits. For businesses, goods and customers are no longer stuck in traffic jams, and employees, and customers health has improved in terms of reduced stress, and fewer illnesses caused by pollution. Indeed, there has been a net benefit in environmental, social and economic sustainability.

The changes in institutional arrangements that brought land-use and transport planners together with architects, also brought these groups together with health, education, business and leisure sector decision makers. As a consequence, solutions to many social exclusion problems (e.g., areas of multiple deprivation, exclusion of the young, old and disabled, as well as those with lower incomes) have been found, be they transport or non-transport solutions. Ex-

amples of successes include the personal rapid transit system drawing all areas of Futuresville into the public transport network, accessible public transport and interchange, provision of key amenities in all neighbourhood centres, and removal of food deserts through changes in retail patterns as described.

8 Research Gaps and Future Research Needs

8.1 The identification process

The identification of research gaps and future research needs has been an ongoing part of the PLUME project. Research gaps identified early in the project were addressed by including additional Synthesis Reports. When these were revised, they were updated to reflect the findings of the Land-Use and Transport Research projects, and of related research programmes. The remaining research gaps are summarised in this Section. They provide an outline specification for a future research programme.

8.2 Future research needs

The research needs are structured into seven research domains. The first four research domains broadly relate to the questions concerning knowledge to answer questions such as:

- What is the nature of things?
- How are things related?
- What happens in the world?
- What generally is the impact of *x* on *y*?

These four research domains are:

A. Human behaviour
B. Technical performance
C. New trends
D. Land-use and transport relationships

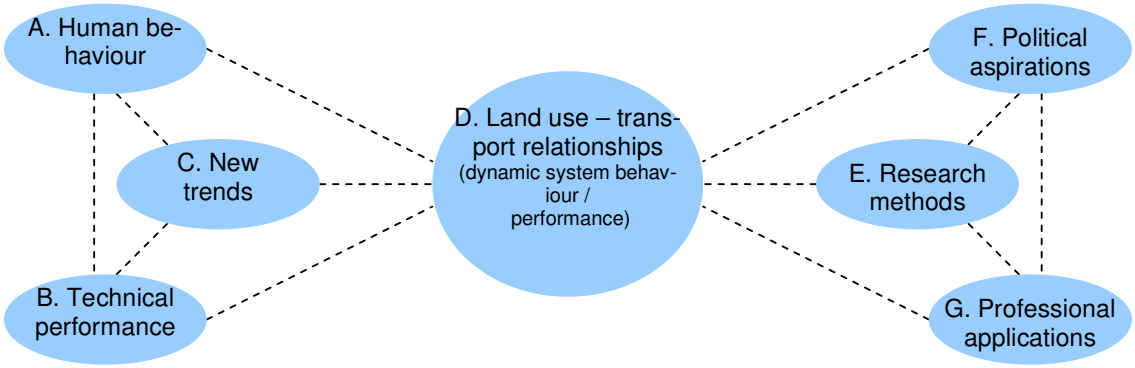
The last three research domains broadly relate to questions concerning how best to gather and use knowledge to inform action:

- How to find out and transmit knowledge concerning the first four domains ,
- How to use this knowledge to formulate policy objectives for the benefit of society collectively,
- How to use this knowledge to develop policy instruments and deliver policy outputs.

The three corresponding research domains respectively are:

E. Research methods,
F. Political aspirations,
G. Technical applications,

The fourth research domain, land-use and transport relationships, lies at the core of this set of research domains. In a sense it builds on the first three, and most directly feeds the last three. The seven research domains may therefore be roughly arranged graphically as follows:



In the following sub-sections the seven research domains are explained and examples of research needs identified from the PLUME research are given.

A. Human behaviour

This research domain concerns human needs and motivations, as applied to the land-use and transport sphere. It applies to what may be regarded as generally 'intrinsic' or 'invariant' behaviour, whatever the historical or technological context. Without a good understanding of human behaviour, the cause-effect mechanisms of policy output and public reaction will be uncertain. Land-use transport research should therefore keep abreast of the latest findings from disciplines such as psychology, behavioural studies, and other social sciences.

Research needs identified are:

A1 There is a need to better understand the human motivation for mobility (the psychological and physiological desire to move and travel) over and above the need for accessibility (the ability to get somewhere or access certain services).

A2 There are two alternative theoretical paradigms identified, regarding human behaviour with respect to land-use and transport - travel cost minimisation versus activity maximisation paradigms. A possibly fruitful research pursuit would be to resolve these paradigms to offer a more effective explanation of human behaviour.

A3 There are knowledge gaps in terms of self-selectivity - the extent to which people who prefer to walk and use public transport will choose living and working locations whose infrastructure supply matches these travel demands.

A4 There is a lack of systematic knowledge about the effects of travel demand management policies on mobility behaviour.

A5 There is a lack of attention paid to the ways in which information provision might influence spatial issues in terms of lifestyle choices. Research into the psychological factors surrounding decisions as to where to work and live, and the ways in which information systems might influence these and assist the evolution of a more sustainable community might be valuable.

A6 There is a need generally for systematic research into the factors that make walking, cycling and travel by motorised modes (as driver or passenger) enjoyable.

A7 There is a need to have more sensitive ways of describing people, beyond categories such as 'residents' or 'bus passengers'. For example, to better understand users' opinions, we must ask how individuals identify themselves both in terms of users of the street but also in terms of other social terms. It is probably so that people adopt differ-

ent roles that become more or less important depending on the current situation they are facing.

A8 There is need for research to address the human factors involved in influencing the desirability of owning and / or using novel modes of transport.

B Technical performance

This research domain concerns the technical operation and impacts of the transport and land-use system. This is to do with understanding how vehicles interact with infrastructure, and their benefits to and impacts on different users and non users. Land-use transport research should therefore keep abreast of the latest findings from disciplines such as mechanical engineering, traffic engineering, highway engineering, and environmental sciences.

Research needs identified are:

B1 More research is needed to understand the generation and the impacts of some pollutants by transport, in particular fine particulates (below 2.5 µm of diameter) and ozone.

B2 Research is needed on the ecological impacts of oil and rubber on surface water run-off.

B3 Research is required to investigate the cumulative impacts of the simultaneous combination of all pollutants arising from transport.

B4 There is a need for quantification and assessment of indirect or secondary effects of noise – not just impacts on hearing, but on annoyance, interference with communication, performance by school children, effects on sleep, and ischemic heart disease. Clearly, this relates to human factors, although it is assumed here that what constitutes an 'annoyance' or 'health disbenefit' is taken as given.

B5 Following earlier EC research into innovative modes of transport, there is now a need to undertake full-scale trials of a range of concepts such as personal rapid transit and the cybercar. Perhaps of greatest significance will be the dual-mode vehicle and its development which will need further support.

C. New trends

This research domain concerns the influence of new trends, which arise externally to the land-use and transport system, or are adjustments unconsciously arising from within the land-use and transport system.

This addresses the introduction of new technologies (other than transport technology covered in research domain 2), the development of new practices, new societal and political trends and circumstantial tendencies – all arising externally to the land-use and transport system – plus new trends or tendencies regarding the way in which the existing land-use and transport system is used, or adaptation of existing behaviour to new situations (even where the same underlying human motivations or technologies continue to hold).

New trends are accorded a category of their own here, because these represent significant drivers of change, and hence create new variables, new mechanisms and new unanticipated effects. In short, these innovations almost inevitably lead to existing conceptual models and research going out of date, and hence the need for new research. Land-use transport research should therefore be aware of general trends in society and the environment.

Research needs identified are:

C1 There is a need for more research on the likely impacts of teleworking on urban mobility and urban land-use.
C2 There is a need for more research on the likely impacts of e-commerce (teleshopping) on urban mobility and land-use.
C3 There is an urgent need for studies that look into the likely future development of urban freight transport as consequences of developments in logistics, such as supply chain management, just-in-time delivery and e-commerce, and their impacts on congestion and the environment, and possible strategies to make urban freight transport more sustainable by advanced forms of city logistics.
C4 There is a need for more research on the impacts of the ageing society on urban mobility and consequential location patterns.
C5 There is a need for more research on how different family size and structure, and spatial distribution of social networks, affects patterns of travel.
C6 In some parts of Europe, an understanding is needed of the implications of population decline.
C7 There is potentially a need to address the general historic effects of democratisation, liberalisation, deregulation and accession to the EC, in Central and Eastern European Countries, on location and distribution of land-uses, and travel patterns.

D. Land-use transport relationships.

The preceding three research domains are concerned with human behaviour, technical performance and the dynamic effects of new trends. This fourth research domain concerns the dynamic behaviour and performance of the land-use and transport system as a whole and in its various parts. It concerns specifically the conceptual and practical relationships between four basic components:

- Land-use – i.e., activities taking place in particular localities,
- Physical form of buildings, public spaces and urban areas – i.e., the 'containers' of the human activities that constitute land-uses,
- Travel – i.e., mobile activities, for getting from an origin to destination, and
- Physical form of transport routes, networks and infrastructure.

In addition to dedicated knowledge about the land-use and transport system, an up-to-date grasp of the three preceding research domains is necessary to be able fully to understand this topic.

Research needs identified are:

D1 There is a lack of reliable empirical evidence to support the arguments made either for or against sprawl. Urban sprawl has negative impacts in general, but there are some interesting exceptions, *such* as "canalising" urban sprawl to secondary spatial concentrations along public transportation lines.
D2 There should be more research on the economic impact of accessibility on location, e.g., the impact of high-speed rail stations on the prosperity of offices.
D3 More research is needed fully to understand and make use of land-use pricing policies.
D4 More research is required on the manner in which the availability and use of new modes will influence urban planning and infrastructure planning.

D5 More detailed understanding of micro-scale land-use and transport interactions may be useful, for example, the influence of local environmental and urban design features on travel, and influences on very short trips.

D6 The effects of infrastructure provision on travel generation are incompletely understood. While some evidence has been collected on road travel, there is not yet a systematic understanding of the effects of provision of pedestrian and cycle infrastructure on travel; nor a systematic understanding of the effect of road infrastructure provision on public transport service provision.

E. Research methods

This research domain concerns the specific mechanisms of research design, execution and dissemination. It concerns knowledge on how to firstly find out and secondly transmit the knowledge of the first four domains in order to assist the last two. The research methods domain here relates to the kinds of research carried out by the research community in its widest sense, including academic researchers and professionals from the public, private and voluntary sectors.

Research needs identified are:

E1 There is too little easily accessible information for decision makers on appropriate indicators with respect to approximately how much effort must be put into collecting the relevant data to make the indicator useful.

E2 There is a need for better definition and description of different settlement or land-use patterns to assist the testing of the influence of these factors, and hence better prescription of these in planning policies. For example, there is not yet a clear (unambiguous) and consistent use of urban form / land-use pattern descriptors.

E3 There is a need to ensure the availability and comparability of information on urban freight movement across European cities.

E4 There are gaps concerning reporting of research on management to prioritise different uses / users groups and to assess the effects.

E5 Methods need to be devised to help technical staff get better access to research results.

E6 Methods need to be improved to inform politicians about the results of research.

F. Political aspirations

This research domain concerns how to use the knowledge gained from the first four research domains to formulate policy objectives for the benefit of society collectively. In other words, it seeks knowledge not so much about the world as it is, but on the world as it could or should be organised. This necessarily takes account of human needs, collectively, and in terms of long-term quality of life.

Knowledge about political aspirations here relates to the kinds of knowledge used not only by politicians, but by professional and technical staff working on their behalf, and to some extent, the public insofar as they are involved in the policy-making process.

Research needs identified are:

F1 Operational definitions are required for the general concept of social sustainability. These definitions should take into account basic theories of social justice and equity.

F2 Methods need to be devised for including these operational definitions of social sustainability in formal appraisal methods.

F3 The valuation of external costs of pollution is an area in which evidence is inconclusive or misleading.

F4 There is a need to establish the long-term present cost of global warming, because economic techniques of discounting are not made for such long-term estimations (over at least a century).

F5 Car use brings with it a range of well-known problems or disbenefits, each of which may be mitigated or eliminated by some solution. But eliminating or minimising one problem requires a readjustment of the perception of the whole problem of the car. For example, if vehicles have cleaner engines, this to some extent reduces the need to restrict vehicle use, but other reasons against unrestrained vehicle use remain. There is a need to establish how best to politically weigh up the different instruments for restraining car use.

F6 Research is required on how to develop mechanisms for incorporating socially excluded groups into active public participation processes.

F7 Public participation has been successful in targeting locally defined stakeholders, but it may be difficult to involve specific kinds of travellers who pass through a particular area. There is a need to improve ways of capturing knowledge about the needs of travellers passing through an area or using infrastructure in transit.

F8 Research is required on how the techniques used in plan-led strategy development processes (e.g., modelling, appraisal, mathematical optimisation) can be used in an overall framework dedicated to encouraging participatory democracy by stakeholders.

F9 Research is required on how to develop mechanisms to encourage the participation in long-term strategic planning of those who are mainly interested in discussing short-term schemes.

G. Technical applications

This research domain concerns the knowledge needed to develop policy instruments and deliver policy outputs. This effectively concerns the technical and operational practices by which the political aspirations of the preceding research domain are realised. In contrast to research domain two (technical performance), this final research domain is in a sense to do with the 'performance' of the transport and land-use planning professionals.

Research needs identified are:

G1 Some implementation tools (indicator research, land-use and transportation modelling) are often not sufficiently well known or used.

G2 The relevance of land-use and transportation modelling outputs is still often hampered by an insufficient understanding of the underlying behavioural and structural mechanisms involved.

G3 Further development is needed in the range of types of predictive model and the interactions between them, so that cities are better able to use appropriate tools to answer questions at different levels of detail.

G4 Financial constraints and political considerations often hinder implementation that might otherwise proceed successfully. An important requirement in implementation research is thus, the accessible and detailed documentation of good practice case studies – as well as potential problem areas – to facilitate learning from experience.

8.3 Concluding Comments

While the first four research domains may be regarded as distinct topics – which may be pursued by researchers of different disciplinary backgrounds – they are to some extent interde-

pendent. Therefore, research activity should 'read across' from one to another, in order to be able to draw robust conclusions. For example, research into new modes of transport should address not just the technological aspects of vehicles and infrastructure, but should also address human factors associated with uptake of new technology. Land-use and transport research should therefore draw from the knowledge of a breadth of disciplines, including but not limited to behavioural science, economics, geography, engineering, technology and environmental science – and the significant linkages between them.

Regarding research domain 5 (on the issue of generation and transmission of knowledge), there would appear to be merit in closer communications between parallel research teams, and pooling of their research findings, allowing gaps and inconsistencies to be identified and corrected, and allowing standardisation of terms where appropriate, and a common understanding of the key results.

Research domain 6 (on the question of "how should the world ideally be organised?"), is perhaps less likely to yield universally agreed answers, since each community (whether a village community or the European Community as a whole) will have its own circumstances and priorities. That said, different communities can learn from each other regarding how best to develop and express their aspirations, considering all sections of society.

Research domain 7 (the question of development and delivery of policy instruments), is perhaps intermediate between the above cases in justifying some degree of collaboration both between researchers and between professionals in different cities.

In each case, it is clear that better communication of key findings from researchers to the ultimate decision-makers – whether these be professionals, politicians, or the public voting on some new transport or land-use policy directly or indirectly – will be advantageous. This not only means better communication of certain research findings within a city context, say from a city authority research team to the political leadership, but also better communication of any 'universally agreed' key findings from the research community as a whole.

PLUME has served these various purposes: to draw attention to commonly understood findings, as well as to identify gaps and any inconsistencies in findings from research. A further future step would be to address the particular research gaps or inconsistencies identified in PLUME by undertaking new research in the areas indicated.

Finally, it may be suggested that the sustainability paradigm may serve not only as a means of organising evaluation of possible benefits and disbenefits of policy outcomes, but also as a means of airing different facets of societal aspiration in the first place. To date, perhaps, the sustainability paradigm has been mostly a concern of the research, professional and to some extent political communities (the language of transport and planning policy often being couched in terms of sustainability). However, in order to more fully engage the public, perhaps a clearer and more tangible expression of sustainability concepts – or the key social, economic and environmental impacts that they relate to – will be required, in order to effectively generate and then resolve the necessary debates about the policy alternatives and their consequences for the city of tomorrow.

9 References

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