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Regulation and the Undertaking of physical Measures

PROJECT CO-ORDINATOR : Dr Susan Grant-Muller, Institute for Transport Studies

**PARTNERS : Institute for Transport Studies, University of Leeds (ITS)
University of Antwerp (UFSIA)
Transport Studies Unit, University of Oxford (OXFJQ)
Technical Research Centre of Finland (VTT)
University of Technology Vienna (TUV-IVV)
University of Las Palmas (EIET)
University of Budapest (BUTE)
University of Leuven (KU Leuven)
Institute for System Integration Units (ISIS)
Institute of Transport Economics, Oslo (TOI)
University of Gdansk (UG)**

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1. Executive Publishable Summary

SPECTRUM is a fifth framework, EU funded project with a general aim of assessing the potential to move towards a more market orientated approach to managing the transport network. A research framework was initially defined with five components: broad transport and social objectives, transport context, indicators and measurement, assessment framework and classification of instruments. Case studies were carried out at both urban and interurban levels to provide quantified evidence on the performance of a range of economic and other instruments alone and in packages. Both passenger and freight transport were considered and all modes were studied. A large number of specific results were obtained at detailed case study level, which were subsequently reviewed together in terms of both efficiency and feasibility. Transferability of the results was considered in both ex-post and ex-ante terms.¹ In general it has been found that there remains considerable potential for the greater use of economic instruments at both urban and interurban levels, particularly when implementation in packages with other instruments.

More specifically, at the urban level, some of the best performing packages involved distance charging and fuel taxation, however in terms of implementation there are questions on the public acceptability of such measures, especially with short term implementation. Cordon charging was also a high performing measure in some cases (but not in other case studies) and the interpretation on this finding needs some care. In some cases, an instrument combination generated disbenefits when assessed in a short term time horizon in a road sector case study, but generated positive benefits when assessed over a long term time horizon (such as 30 years) in a multimodal case study. Synergy was found with respect to two combinations: cordon pricing and traffic signal optimization (in York); and distance-based road pricing and bus lanes (in Leeds). The assessment of benefits from combinations including public transport fare changes was highly dependent upon the value assigned to the Marginal Cost of Public Funds (MCPF).

The interurban research in SPECTRUM has provided a range of significant results for a selection of uni-modal (air, rail, sea and road) and multi-modal case studies as well as at a more general level. Three key results are as follows. The uni-modal case studies highlighted the importance of the social costs associated with externalities, and the appropriateness to internalise them through economic instruments was pointed out in all case studies. For example, the air case study (Madrid Barajas Airport) demonstrated the relevance of introducing specific noise charges to address noise problems. The rail case study recommended that rail operators should be charged for the infrastructure capacity they use in accordance with the social opportunity cost of that capacity. The multi-modal case studies confirm the findings from the uni-modal case studies clearly indicating that internalisation of externalities is the most significant instrument in terms of generating (positive) changes in welfare. Therefore, the EU initiatives concerning fair and efficient pricing are likely to be welfare enhancing even implemented on their own. Furthermore, the planned investment programme with respect to the Trans European Network priority projects should be implemented as part of a package with fair and efficient pricing – linked to revenue recycling.

The SPECTRUM deliverables are of relevance to many stakeholders in the European transport community, particularly in informing transport and social- policy or decision makers. Other groups that will have specific use for particular deliverables will be local and national

¹ Ex-ante transferability analyses the hypothetical transferral of instruments and methods before such a transfer has occurred, whilst ex-post transferability makes an analysis after the transfer

governments, transport practitioners, transport providers and the European research community. For further information on the SPECTRUM project, see: www.its.leeds.ac.uk/projects/spectrum

2. Objectives of the project

The main objective of the SPECTRUM project is to: *'develop a theoretically sound framework for defining combinations of economic instruments, regulatory and physical measures in reaching the broad aims set by transport and other relevant policies'*

This forms a direct contribution to the key challenge of Key Action 2: Sustainable mobility and intermodality i.e. 'how to reconcile the increased demand for transport on the one hand and the need to reduce its impact on the physical, social and human environment on the other hand, and how to reduce the transport intensity of economic growth'. This expresses a tension between managing the transport system in such a way as to minimise social costs and simultaneously managing the system to meet increased demand. In other words, the need is to achieve a complex of transport and social objectives with multiple stakeholders and thresholds of acceptability on some impacts (social costs) resulting from the chosen solution. The work of SPECTRUM addresses this problem by looking at the potential effects of using either individual instruments, complementary packages of instruments, or the consequences of substituting instruments, in managing the transport system.

The research helps to solve a problem that is of a Europe wide dimension. The policy driven agenda is that which underlies the objectives of action 2.1: 'Socio-economic scenarios for mobility of people and goods form part of a wider building block for a European strategic decision support and information system in the field of transport for policy-makers, authorities, industry and operators'. The tension between the impacts of alternative transport management instruments and social objects is one that affects nations individually and collectively through international transport and wider societal needs. The project therefore addresses issues of equity and sustainability, including definitions and indicators for these (economic, social and environmental) within transport.

The work has the following original research goals: the definition of multi-stakeholder objectives and the criteria for success on these, application of assessment methods and tools in the context of assessing packages of instruments, derivation of a theoretically sound framework for defining combinations of transport instruments (economic, regulatory and physical) that produce synergy, measurement and treatment of the impacts of particular instruments operating in isolation and especially in packages, a thorough ex-ante and ex-post consideration of transferability within the development of the framework and specific examples of technical novelty, for example the measurement of impacts on safety and accidents of instruments, the measurement of impacts for freight.

The main project outputs are as follows: Firstly, provision of a theoretically sound framework for analysing the trade-off between objectives and identifying optimal

combinations of instruments to achieve them. Secondly, analysis and assessment of transport packages - providing quantified evidence on the use of alternative instruments in managing urban or inter-urban capacity and the likely practical impacts of different approaches. Thirdly, generalisation - informing target users of the synthesised evidence and transferability of alternative transport management packages across the broader urban/inter-urban spectrum and their wider social impact. Finally, Guidance and recommendations - enabling policy makers to achieve a better balance between different, often conflicting objectives.

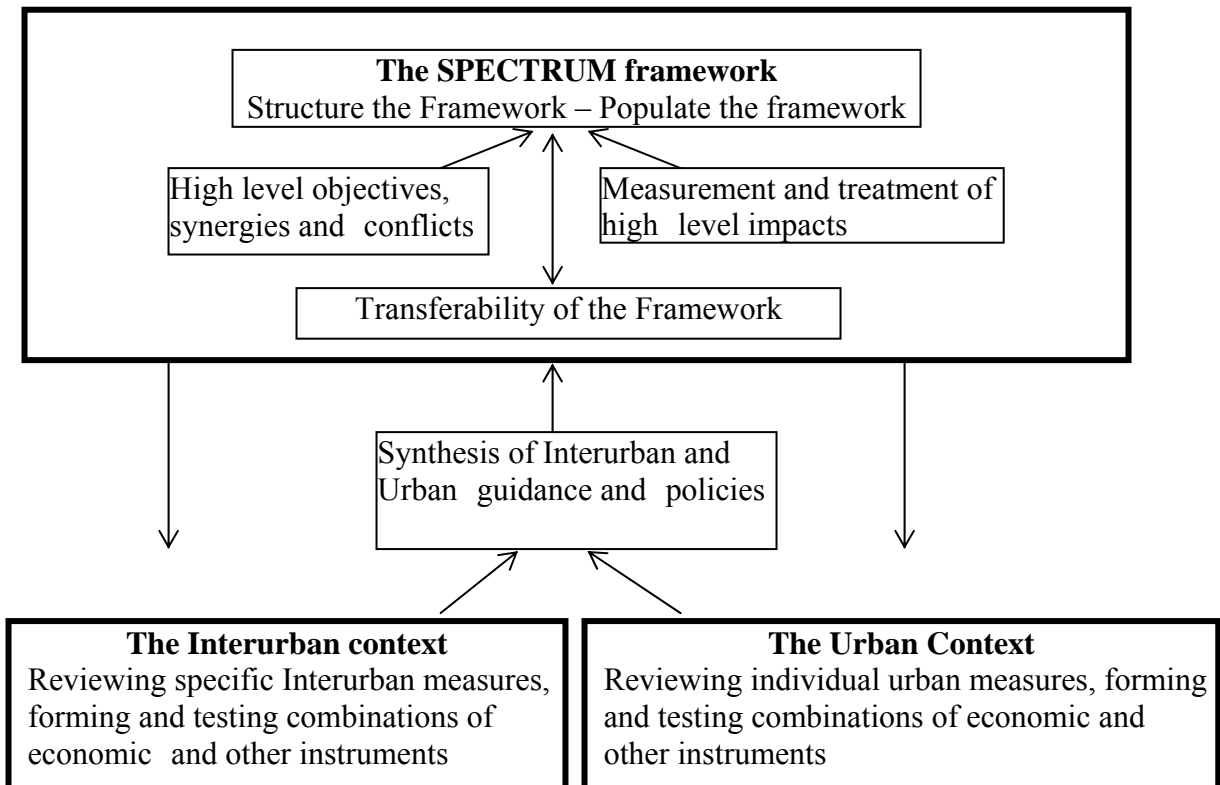
The SPECTRUM project contributes to economic growth through primarily supporting the successful delivery of EU priority policies that directly and indirectly result in economic growth. Strong exploitation potential exists for the outputs for national and European policy and decision makers, planners, transport practitioners and providers within the context of charging policy development resulting from the white paper on 'Fair Payment for Infrastructure Use' (1998) in the short term. The wider societal benefits of balanced transport and social priorities will emerge in the medium and longer term. In terms of Scientific and Technological Prospects, the SPECTRUM outputs demonstrate and are built upon state of the art techniques in modelling, assessment and specialist skills.

3. Scientific and technical description of the results

3.1 summary of the spectrum approach

The formal objective of the SPECTRUM project is summarized as follows: *‘to develop a theoretically sound framework for defining combinations of economic instruments, regulatory and physical measures in reaching the broad aims set by transport and other relevant policies’*. It expresses a tension between managing the transport system in such a way as to minimise social costs (including adverse environmental impacts) and simultaneously managing the system to meet increased demand. This is a complex problem, so some focus has been applied to the scope of the research. The approach taken in SPECTRUM is given here (Figure 1) as it forms an important background to understanding the scope and limitations of the outputs reported. A skeleton structure to the framework was initially defined considering the broad transport and social objectives, transport context, indicators and measurement, assessment framework and classification of instruments. This formed the basis for the definition of so-called high level objectives against which the success of particular instruments and instrument packages could be measured. The objectives were represented within a specific objective function calculated numerically for each package, effectively giving each economic instrument or package a ‘performance score’. This led into the more detailed and practical level issue of how indicators (directly linked to the objectives) could be measured in practice – both within the case studies, but more generally by practitioners involved in transport policy decision making.

Figure 1: Outline of the SPECTRUM research approach



At this stage, the research followed two parallel and distinct areas linked separately to the urban and interurban contexts. Practical examples from previous work and case studies were used to explore the performance and impacts of different economic instruments and combinations of economic and other instruments. The aim of the case studies was to provide quantified evidence, which when combined with previous results and experience of practitioners could be used to ‘populate’ the framework. Throughout the research a key consideration has been that of transferability and generalisation. The following questions were used as a steer to the research:

- What level of the economic instrument is needed to replicate or improve the benefits of current (economic or other) measures?
- If the economic instrument is introduced in conjunction with one or more other instruments, what levels of benefits could be achieved by the package?
- Is the economic instrument (or package) feasible in terms of political acceptability?
- Does it have negative side effects in terms of any of the impact indicators in the SPECTRUM assessment framework?
- Is the instrument or package practical (in terms of actual implementation)?
- Does the instrument have particular impacts in terms of equity?

Formal project outputs were defined as follows. Firstly a theoretically sound framework providing an illustration of the trade-off between different objectives. Secondly, analysis and assessment of transport packages through case studies and by examining practical applications. Thirdly, generalisation – synthesised evidence and discussion on the transferability of alternative instruments and packages. Finally, guidance and recommendations – enabling policy makers to achieve a better balance between different, often conflicting objectives.

To summarise, the research faced a number of challenges and had an ambitious scope covering urban and interurban contexts. Consultation with stakeholders was one mechanism for drawing practical expertise and considerations into the framework. Stakeholders were involved in several aspects of the research, including the review of past experience, instrument selection for case studies, reviewing outputs and in the feasibility ranking of instruments and packages. The five principle components of the framework are outlined in further detail within Section 3 below.

3.2 The Five Components of the SPECTRUM Framework

3.2.1 Transport and other social objectives

A first step was to determine the objectives to be achieved by the instruments. A review of relevant transport and social objectives was carried out in order to establish a set of ‘SPECTRUM project objectives’. Objectives at a European level were a starting point, specifically those within the White Paper “European transport policy for 2010: Time to decide” (Com (2001 0370)). The principle objective given within the White Paper was to

gradually break the link between economic growth and growth in transport through a mixture of transport policies, primarily in three ways. These are summarised as 1) to shift the balance of transport modes, 2) to eliminate bottlenecks and 3) to place users at the heart of transport policy. Objectives of other high level organisations such as the UN World Summit and ECMT were also examined, as were those derived by previous research and those which exist at national level within European countries. Past EU research work relating to sustainability in the transport sector was reviewed including the projects PROSPECTS, SAMI, TRANSPLUS and EUNET. Often national targets are categorised in more detail than those at European level, for example regarding infrastructure and regional targets, whilst different government authorities may have different objectives within a country. Considering the different relevant sources it became possible to reach a common view of objectives relating to a sustainable transport system from which the SPECTRUM objectives could be derived.

In SPECTRUM two main objectives of efficiency and equity were formed with five sub-objectives, three under efficiency and two under equity (see Table 1 below). From these, a high level objective function in mathematical form was derived which was used to represent the extent to which instruments had achieved the objectives within a particular case study. Details of the function are specified in SPECTRUM (2003). Differences between values of the objective function (between the reference scenario and when the economic instrument was introduced) were used to indicate relative performance.

Table 1a: Efficiency objectives and sub-objectives (SPECTRUM 2003)

Objective	Description of sub-objectives
1. Economic efficiency in a strict sense (excluding external effects)	<ul style="list-style-type: none"> • Achieve economic efficiency in both passenger and freight transport by all modes and all market levels: local, national, European and even global
1.A Net user benefits for consumers	<ul style="list-style-type: none"> • Efficient production of all transport services • Improve accessibility at all levels, for example to services and work locations, economic nodes and gates • Reduce congestion and eliminate bottlenecks • Improve reliability and quality of services both for passengers and freight and both in domestic and international transport
1.B Producers' surplus	
1.C Net government revenue	<ul style="list-style-type: none"> • Attain the government's revenue raising objective of the transport sector as efficiently as possible
1.D Efficiency in the rest of economy	<ul style="list-style-type: none"> • Economise on taxpayers' money • Use of the revenues in an efficient manner • Minimise adverse effects on other markets, e.g. labour markets
2. Environment and health effects	<ul style="list-style-type: none"> • Protect population and environment from pollution (local and regional), noise and vibration, and from other harmful effects of transport (visual intrusion etc.) • Protect valuable areas: green areas, cultural heritage sites, landscape and vulnerable areas • Avoid urban sprawl and land take for transport purposes • Reduce fragmentation of settlements and habitats • Promote health benefits from physical activity from non-motorised modes
3. Safety and security effects	<ul style="list-style-type: none"> • Reduce traffic related fatalities and injuries • Increase security for transport system users, both passengers and freight

Table 1b: Equity objectives and sub-objectives (SPECTRUM 2003)

Objective	Description of sub-objectives
1. Inter-generational Equity	<ul style="list-style-type: none"> • Reduce depletion of non-renewable resources • Avoid climatic change due to human activity in the transport sector • Promote biodiversity and protect vulnerable ecosystems
2. Intra-generational Equity	<ul style="list-style-type: none"> • Promote desirable regional development • Promote desirable distribution of benefits among social and income groups (e.g. specific groups such as mobility impaired persons)

3.2.2 Transport environment and instruments

An important basis for considering the potential for economic instruments is to define the transport context and reference scenario within which the instruments will be assessed.

This involved setting parameters on the current transport context and identifying a reasonable reference scenario for the future. The aim was to outline a common set of basic assumptions that the case studies could adopt wherever feasible in order to produce results that were as comparable as possible. Following recommendations of the SCENARIOS project (INRETS, 2000), the clustering of variables shown in Table 2 below was used.

A considerable tranche of previous work has been carried out to establish reference scenarios within European research (for example the work of EXPEDITE, SCENARIOS, STREAMS, ASTRA, TIPMAC, IASON, PROSPECTS). It was possible to use these to form a solid foundation for the reference scenario within the SPECTRUM project. To avoid duplication of effort, the EXPEDITE database (built on the basis of the SCENES database) was also used. This database includes a number of detailed demographic and socio-economic input files for the base year 1995 and the projection year 2020 by NUTS2 zones. This included, for example, population (by category), GDP and employment.

Table 2: Parameters of the transport context

Scenario variables	Example components
Socio-economic	population (population level, age and gender structure, population change); GDP level and annual growth rate; labour productivity (GDP per employed person), employment level and rate of change (possibly by main sectors – agriculture, industry, services); trade flows by main goods categories (for freight);
Technology variables	information technologies, transport operating/management systems, new vehicle and fuel technologies etc.;
Endogenous or supply related factors	qualitative factors (e.g. level of competition, regulation of the transport markets), quantitative variables (car ownership rates, fuel prices) and other transport supply factors (e.g. extension of public transport networks, PT fares etc.)

In addition to these, other data relating to transport supply (e.g. fuel prices), passenger transport demand (e.g. vehicle occupancy, trip rates) and freight transport demand (e.g. trade flows) form part of the SPECTRUM reference data. The treatment of variables by different models (i.e. whether fixed internally or forming external outputs) was a further consideration. In terms of future trends, projections currently available from international sources (e.g. EUROSTAT and UN) and scenarios defined by other EC studies were used.

3.2.3 Indicators and Measurement

The third component of the outline framework is a set of indicators relating to the transport and wider environment (see SPECTRUM, 2004). The definitions of the objectives lend themselves to indicators that have an inherently quantified or qualitative

nature. It is then an issue of detail on how the indicators should be treated in terms of measurement, this could include the level of disaggregation or specific units. Guidance on the measurement and treatment of transport impacts has been divided into six sectors each of which has been treated separately:

- impacts on passengers (excluding externalities and equity issues),
- impacts on freight (excluding externalities and equity issues),
- impacts on the transportation system performance,
- measurement and treatment of safety and accident impacts,
- measurement and treatment of other externalities,
- measurement and treatment of equity aspects.

For some impact groups there are numerous components which could possibly apply, so it is a question of selecting those appropriate in a particular context. As an example, for passenger transport this could include: travel time components, variable out-of-pocket costs, costs that are partly variable, partly fixed and other costs (e.g. subsidies, compensation and information provision)

3.2.4 Assessment Framework

The main requirements for determining the appraisal framework to be used for assessing the instruments were that it must allow consideration of:

- Both urban and interurban contexts
- Different stakeholders
- Elements that will be monetised / not monetised
- All modes
- Passenger and Freight

In addition to which, of course, it should be capable of reflecting the SPECTRUM objectives relating to sustainability. These points are discussed in more detail below.

Historically, completely separate appraisal frameworks have been developed for the urban and interurban contexts - for example PROSPECTS (urban appraisal) and EUNET (interurban). This may reflect differences such as objectives, stakeholders and modes between the contexts. Within the SPECTRUM framework (SPECTRUM 2003a) a classification is presented of objectives that are largely appropriate to urban or interurban context, or potentially both. In theory, all the relevant stakeholders should be included in the appraisal process; in practice for the SPECTRUM case studies three main groups (government, producers and consumers) were considered. Sub-groups could also apply, for example, local government in urban decision-making or regional government for inter-urban projects. A final issue is whether to use country or project specific values. In a research context, project specific values could be used to allow comparisons across case studies. In practice, preferences should reflect local or national values. For further discussion on valuation issues, see Nellthorp et al (2001).

The SPECTRUM framework has three facets given by the CBA, MCA and Descriptive Analysis. The main criterion for including an impact in a CBA was that it is capable of being monetised. From Table 1, most of the economic efficiency objectives, including environmental, health, safety and security can be monetised and thus may be subsumed in the conventional CBA. However, some sub-objectives cannot be readily monetised such as the issues of equity, quality of life, welfare of future generations etc. which are very relevant and some of these would be included in an MCA rather than the CBA. The main rationale for using a descriptive assessment would be to cover all impacts that would not necessarily be accommodated by the CBA or MCA, or where data required for particular models is not available. In terms of outputs, as a minimum, a single value can be produced, e.g. the NPV within the CBA. More detail is then provided at disaggregate level, for example by stakeholder groups, by individual impacts in the MCA or components of the CBA such as investment costs. A series of recommendations have been produced on dealing with uncertainty in the assessment process

The treatment of equity brings particular issues. For SPECTRUM the urban road sector case studies were chiefly concerned with short term impacts and therefore did not consider intergenerational equity. For the multimodal studies, intergenerational equity can be addressed by tracing changes in welfare of different segments of the population (income, gender, etc.). As a result of use of differing types of models within the case studies, different measures of equity were used. These provided case-specific outputs for equity, but it became inappropriate to draw general conclusions in this respect. Issues surrounding equity measures are discussed in more detail in SPECTRUM (2004). For a discussion of social aspects related to economic instruments see Rajé et al (2003).

3.2.5 Classification of Instruments

The final component of the framework was given by a classification of the transport instruments according to:

- the transport market (interurban road, rail, air, water modes, urban transport),
- the operational mechanism (economic, regulatory and physical),
- target (change of market access and competition rules, transport capacity and transport activity)
- level of decision making (international, national, regional and local).

There is inevitably some overlap in terms of which categories particular instruments fall into, however the classification formed a starting point towards selecting the instruments for study. Definitions of the three main types of instruments for the research were as follows:

<p>Economic instruments: All actions aimed at modifying transport market actors' behaviour by distributing or withdrawing wealth.</p> <p>Regulatory instruments: All actions aimed at modifying transport market actors' behaviour through a system of rules (restrictions, standards, controls).</p>

Physical instruments: All actions aimed at modifying transport market actors' behaviour through a change in the quantity and/or quality of the available transport infrastructure capacity, equipment and vehicles.

Source: SPECTRUM (2003a)

A glossary was generated giving further brief details and information sources for over one hundred instruments (SPECTRUM 2003a).

3.3 INTERURBAN CASE STUDIES

The aim of the urban and interurban case studies was to provide quantitative evidence on the performance of economic instruments implemented alone, or in packages with physical or regulatory instruments. The choice of case studies was intended to cover a number of different modes/nodes, geographical spread across Europe and allow a variety of impacts to be estimated in terms of spatial and temporal horizons. The overall approach taken can be summarised in the following steps:

- Identification of a provisional list of economic and other instruments
- Combinatorial analysis of these instruments leading to selection of a subset of instruments
- Case studies through modelling (or review) to investigate potential impacts, synergies and substitution effects
- Consultation with practitioners on issues such as choice of instruments for case studies, practical experience of instruments and outcomes obtained

The interurban work in SPECTRUM comprised two main components. Firstly, assessment of specific interurban measures for the air, rail, road and sea sectors, with particular emphasis on capacity allocation and charging and the internalisation of externalities. These were all on a local scale and concerned single modes. The second group of case studies were on a national, regional and European scale, concerning multi-modal aspects for both passenger and freight sectors. In particular, five model-based studies have been considered distinguishing between “passenger case studies” and “freight sector case studies”. In addition, the passenger and freight transport model SCENES has been used to examine the interfaces between modes of interurban transport systems on a European scale.

3.3.1. Mode specific case studies

The mode specific case studies are related to the following transport infrastructures: Madrid Barajas Airport (Spain), the East Coast Rail Line (United Kingdom), the Port of Antwerp (Belgium) and part of Road Corridor IV (going through Germany, Czech Republic, Austria, Hungary). Table 3 provides an overview of instruments examined in these case studies. Further details are given in the SPECTRUM (2005).

Table 3: Description of mode specific case studies

Mode	Infrastructure	Type	Instruments
Air	Madrid Barajas Airport	Node	<i>Slot Allocation</i> <i>Slot Pricing</i> <i>Noise Charge</i> <i>Airport Expansion</i>
Railways	East Coast Main Line (UK)	Corridor	<i>Access Regimes</i> <i>Access Charging</i> <i>New Infrastructure</i> <i>Quality Regulation</i> <i>Subsidies</i>
Sea	Port of Antwerp (Belgium)	Node	<i>Deepening of the River Scheldt</i> <i>Removing Locks</i> <i>Standard Loading Unit</i> <i>Better Trained Seafarers</i> <i>Different Handling Methods</i> <i>Introduction of Marginal Cost Pricing</i>
Roads	Road Corridor IV (Hungary)	Corridor	<i>Fuel Taxation</i> <i>Motorway Tolls</i> <i>Extension of the Infrastructure</i> <i>Social Regulations</i>

Madrid Barajas Airport

The airport case study involved Barajas airport, a principal gateway of the Spanish airport system. In 2003 it moved a total of 35 million passengers, and accounted for 27% of air traffic between the EU and South America. Analysts have foreseen that future air deregulation will put continued pressure on the Spanish airport system. A capacity expansion programme for Barajas airport will increase current capacity of 80 air traffic movements per hour to 120 air traffic movements in two phases. On completion, Barajas airport will have a design capacity of 80m passengers/year with four runways and four passenger terminal buildings.

Four instruments were analysed in this case study as shown in Table 3. Given the close links between instruments, a joint consideration of slot pricing, slot allocation and the impact of new infrastructure was made initially. The study proceeded by analysing the impact of a noise charge. The potential impact of different pricing policies was examined using the concept of ‘potential loss of social welfare’ developed by Lu and Pagliari (2004), whereby the lack of adequate capacity precludes potential demand from using the airport. Distinct pricing policies are compared, such as the optimal airport charge (“first best prices”), “second best prices” in which the financial constraint of cost recovery is considered for each period, and the “market clearing prices” in which airport capacity is used at its maximum levels and actual prices.

The results suggest that for most weekday hours, potential demand exceeds capacity and as a result market-clearing prices coincide with first-best prices. Where there is excess capacity (for example at night time), first-best prices and market-clearing prices are lower than present average aeronautical charges. In this case, airport authorities would need to cut prices in order to reduce the potential loss in social welfare. For market-clearing prices, the airport authorities would need to subsidize the use of the airport during these hours. Nevertheless, this result would be difficult to implement in practice due to existing problems with night time noise disturbance for adjacent areas.

For the analysis of noise externalities, a similar methodology to that of Morrell and Lu (2000) and Lu and Morrell (2001) was applied, deriving the annual total noise social cost from hedonic pricing studies. Estimates of the total costs of noise at Madrid Barajas airport show that these are expected to decrease substantially from year 2000 to the future scenario (2004-2014-Maximum capacity). The reduction of almost 60% is the result of a combination of abatement measures, including reduction of noise at source and careful selection of approach and climbing procedures. It is noteworthy that the reduction is expected despite an anticipated doubling of the number of operations and processed passengers.

Contrary to ICAO (International Civil Aviation Organization) recommendations that advice noise charges are designed to recover the cost of their alleviation or prevention (insulation schemes, noise monitoring), a basic framework for a noise charge at Madrid Barajas airport is proposed to be based on the marginal social costs of noise. Differentiated noise charges for different types of aircraft should be established according to their specific noise footprints.

Rail

This study examined the issue of charging for scarcity as part of variable infrastructure charges for rail. Where capacity is scarce, a lack of a scarcity charge may encourage operators to operate excessively frequent services with short trains that make poor use of the infrastructure. Alternative ways of dealing with the problem include administrative allocation of scarce capacity, (currently adopted in Britain) and auctioning (Nash and Matthews, 2003).

The East Coast Main Line Railway (Great Britain) formed the basis for the study. A charging regime is currently in force charging franchisees on a two parts tariff, the variable part of which reflects wear and tear, electricity and some congestion costs. Other operators (freight and open access passenger services) only pay the variable element of the charge. There is competition for scarce capacity on the East Coast Main line between several passenger and freight operators. The study used a detailed rail passenger simulation model (PRAISE), which models the volume of passengers and their train choice as timetables change, allowing for desired departure times, degrees of crowding and fare choice (Preston et al., 1999). The model produces estimates of revenue, costs, consumers' surplus and diversion to/from other modes. Estimates of changes in external

costs are then made to derive results for the overall social benefits of alternative allocations of capacity.

In terms of net social benefit, it was found that the use of the representative peak path by the major passenger operator, GNER, gave the highest values for passenger use. However, there were very large differences between private and social profitability, with the small open access operator Hull Trains making more private profit from the use of this path. This suggests that auctioning without payment of explicit subsidies to operators (to reflect the social benefits of the use of the paths) would not always give the optimum result. However, the imputed benefit from using the paths for freight was much greater than the benefit from using the paths for passenger trains. Whilst it is not clear how much capacity would be required for an additional freight train, the large disparity between benefits for passenger and freight suggests that this result would be robust, at least for the one peak path (each direction) studied here. A policy of developing alternative routes for freight may be the most appropriate solution. A secondary route does exist between Doncaster and Peterborough via Lincoln, but would require upgrading for heavy freight flows. The results confirm that existing variable charges for the use of infrastructure on key main lines where capacity is scarce are too low due to omitting scarcity in the charges set.

Sea

For this case study the Port of Antwerp was chosen. The Port is located within one of the world's most active maritime areas and handles a wide mixture of commodity types. There is a large maritime entrance (the river Scheldt), giving an extra element of complexity, with diverse hinterland connections. The port is served by various vessel sizes and is linked with many types of ports throughout the world, handling local and international traffic. There is a strong industrial presence with a landlord type administration (locally but publicly organised), however the cargo handling actors in the port are all private. In terms of labour - every worker must be part of a pool system, i.e. a grouping of workers out of which all companies operating within the port perimeter have to select their workers.

A first set of physical measures were considered: deepening the river Scheldt and removing locks inside the port. For the first scenario, a further deepening up to free draught of 14m was investigated. The monetary benefits for transport users (shippers, i.e. goods owners) and shipping companies were calculated. For lock removal, the actual costs at the handling side are shown and how these could be influenced by making the inner port tidal instead of locked. The sources of costs and benefits that could be generated (on behalf of shippers and ship-owners) are identified.

As regulatory measures, the introduction of standard loading units and of improved training requirements was considered. For the first, a number of cost items are simply shifted to the terminal operator, but also to hinterland modes and to shipping companies. The shipper could be disadvantaged as more moves are required to load/unload the same volume of cargo if smaller units are used. In terms of training, it could be presumed that

at full sea this measure brings many benefits. However, within the port lower additional benefits may be expected as a low accident rate already exists. Pilotage and towage are partly responsible for this. Different handling methods, however, can change safety conditions. If the change in accident probabilities through new investments can be assessed, the methodology used in the case study allows the calculation of a corresponding increase/decrease in costs.

In terms of pricing measures, it is assumed that current practices do not always conform to (social) marginal cost pricing. However, the actual pricing structure lacks transparency due to the mixture of public/private actors involved and the wide dispersion of activities (Meersman et al., 2001). More research is needed to gain further insights and a similar exercise carried out for neighbouring competing ports to measure the price sensitivity of a port's activities.

Road

The road case study focussed on the Hungarian sections of Road Corridor IV, a TEN high priority corridor in a number of Central and Eastern European countries (CEEC). Currently, northern regions (e.g. Poland and Czech Republic) have a well-developed infrastructure, but infrastructure improvements would be needed towards the south (e.g. Romania and Bulgaria). With respect to the CEEC generally, the Hungarian road network is generally well-developed. The rail network along the entire corridor is extensive but some upgrading work is needed.

The first step was to determine the demand for travel as a mathematical function of a number of parameters. This would allow calculation of user benefit changes as a result of different transport policy measures. Calculations were carried out for the different parts of Road Corridor IV, i.e. motorways or country roads and separated according to whether tolls are payable or not. Different elasticities were produced as outputs, while basic data (such as prices, road lengths and incomes) formed inputs to the modelling exercise. A multivariate regression model was applied and results were generally in accordance with expectation: negative price elasticity and positive income elasticity. Several cases (e.g. road demand on the motorway M5 and country road R5) have apparently counterintuitive results with negative income elasticities or positive fuel-price elasticity. However, these results can be explained by other economic factors (such as modal split change, war in Ex-Yugoslavia, etc.).

For two economic instruments (fuel taxes and motorway tolls) four different scenarios each were examined to test the demand and welfare effects of varying the level of the instruments. Results showed that both instruments could have a very strong financial effect on users with resulting welfare losses. This might be compensated by a gain in welfare through reduced external costs and perhaps impacts associated with revenue recycling. A significant difference was found between the two economic instruments however. Fuel taxes had a limited influence on traffic demand but a strong economic effect and could therefore be used primarily to generate income for central government. Motorway tolls, however, had relatively small welfare effects. This represents what may

be called an “economic regulatory paradox”, i.e. the smaller welfare influence from tolls had a stronger effect on user behaviour than fuel taxation.

For road infrastructure extension (enlargement of the M5 to the Hungarian/ Ex-Yugoslavian border), user benefits from improved speed and reduced accidents were calculated. Results suggested that this would lead to significant increases in user benefits.

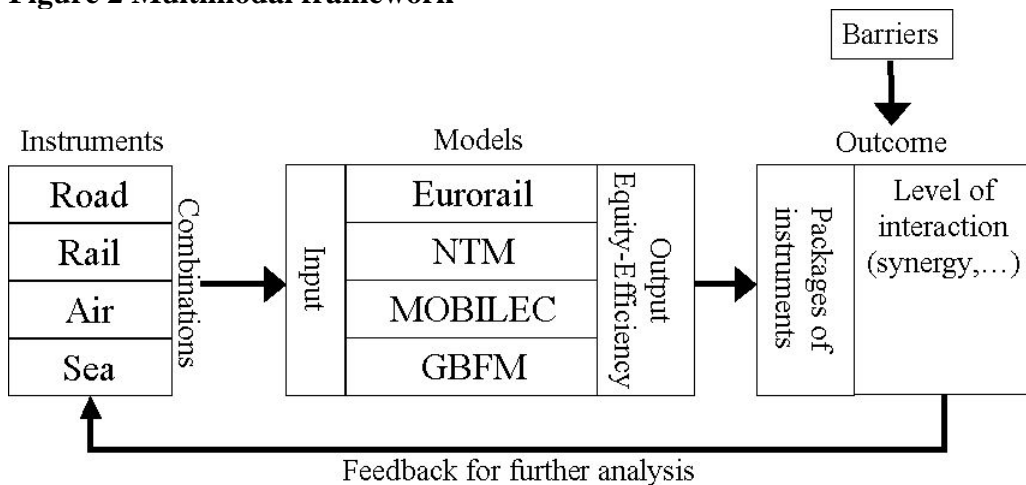
Impacts of the regulatory instrument “social regulations” were described in qualitative terms as a quantitative analysis was not feasible. It was proposed that the main impacts relate to improved road safety and enhanced working conditions for employees in the road haulage industry. Road hauliers may be negatively affected due to higher costs, which may have some negative effects on transport demand and possible mode choice towards other modes.

3.3.2. Multimodal case studies

Two passenger transport models (EURORAIL, Norwegian National Transport Model for Passenger Travel), two freight transport models (MOBILEC, Great Britain Freight Model) and the passenger and freight model SCENES have been used to examine the interfaces between modes of interurban transport systems. A modelling methodology was established to predict the impacts of individual transport instruments and combinations of instruments quantitatively (see Figure 2).

The connection between the instruments and the models with their inputs and outputs can be seen in Figure 2. The outcome, (which may be compared again with the initial instruments), is then dependent on barriers such as political acceptability or administrative issues. This illustrates the difference between “theoretical and practical outcomes”. Specific frameworks were then developed for each case study to highlight differences between the models and comparability of results.

Figure 2 Multimodal framework



The passenger models (EURORAIL and the Norwegian Transport Model) cover all relevant modes. In the case of EURORAIL (corridors London-Paris-Brussels) modes included were rail, air and road, while the Norwegian Transport Model includes car, air, rail, bus and ferry modes.

Comparing the freight case studies, whilst the MOBILEC model is able to model inland navigations, the GBFM only models road and rail options. Both models have the input variables: travel distance, travel times, travel-time costs and travel-distance costs, while MOBILEC also requires real wages, infrastructure and load factors/ occupancy rates. As a result it is possible to have outputs on tonnes lifted and tonne kilometres by mode but also economic data such as regional product, employment and investment. In the MOBILEC case study, the outcome depends on administrative and political acceptability, i.e. national (Belgian) and regional decisions with respect to fuel taxes and infrastructure measures. It was shown that some negative effects can be changed into positive ones if packages of instruments are combined. The effects of combined measures in the GBFM were compared with Marginal Social Cost (MSC) based road pricing measures.

For the European scale case study, instruments considered were fuel taxation, social marginal cost pricing and TEN infrastructure expansion for all modes.

Table 2 summarises the instruments studied in each case study. An overview of findings is given here, with further information available in SPECTRUM (2005a).

Passenger Case Studies

One passenger case study involved a multi-modal analysis of passenger traffic on the *London-Paris-Brussels corridors*, looking at rail, air and road travel. For road traffic, two options for crossing the English Channel were examined: ferry services and Le Shuttle. The main travel purposes are independent and inclusive holidays along with a significant amount of business travel. In 1998, there were 81.2 million Cross-Channel trips of which some 46 million were independent or inclusive holidays, while business trips amounted to around 17 million. The majority of these trips were made by air (51%), car had a modal share of 26%, while coach and rail accounted for 11% and 8% respectively (1998 figures) (DETR by Arthur D. Little 2000).

The model used was an adapted version of the EURORAIL model. The basic structure is a series of mode choice models for the modes: rail, air and road (ferry or Le Shuttle). It is based on a binomial logit model framework, where two modes are considered at any one time. A reference scenario and 13 alternative policy scenarios were established for the forecast year 2012. Instruments considered included fuel taxation, SMCP pricing, rail fares, rail infrastructure expansion and road infrastructure expansion.

The results suggested that under some scenarios an increase in the value of the high level objective function would be seen compared to the reference scenario. The preferred package involves a combination of fair pricing for all modes combined with road infrastructure improvements. This package resulted in substantially larger values of the high level objective function (HOV) compared to the other 12 scenarios.

Further analysis would be required to determine optimal revenue recycling strategies with respect to revenue from fair pricing initiatives. The results suggested benefits of using revenues on road rather than rail infrastructure improvements, as the latter appears to be relatively more expensive than road infrastructure expansion. However, other possible ways to allocate the revenue should be considered to reach a firm conclusion.

Further results indicated the presence of synergies between policy instruments. In particular, there may be synergies between fair pricing and road infrastructure improvements as well as between pricing for different modes (e.g. car and rail).

The *Norwegian case study* covered interurban travel for the whole of Norway. Norway (excluding Svalbard) has an area of 385,155 square kilometres, a population of about 4.6m and population density of about 14.1 per square kilometre. It is a dispersed country and little congestion is experienced by any of the modes of travel. The Norwegian National Model System for Passenger Travel (NTM), (Ramjerdi and Rand 1992; Ramjerdi and Rand 1996; Hamre 2002) was used and all modes of travel, car, air, rail, bus and ferry are included. A reference scenario alongside 10 alternative policy scenarios was designed for 2012.

Single instruments considered (or a combination of instruments) included pricing, regulatory and infrastructural instruments. The selection took into account “feasibility” i.e. political acceptance and financial constraints.

Table 4: Instruments used in the multimodal case studies

Model	Economic instruments	Regulatory instruments	Physical instruments
EURORAIL	<ul style="list-style-type: none"> • Fuel taxes • Price regulation for service provision (rail fares) • Out-of-pocket costs (car) • Out-of-pocket costs (rail) • Social marginal cost pricing 		<ul style="list-style-type: none"> • Expansion of rail-based transport infrastructure • Expansion of existing road networks
NTM Norway	<ul style="list-style-type: none"> • Fuel taxes • Price regulation for service provision (rail fares) 	<ul style="list-style-type: none"> • Speed limits 	<ul style="list-style-type: none"> • Expansion of conventional rail-based transport infrastructure – public transport frequency
MOBILEC	<ul style="list-style-type: none"> • Fuel taxes 	<ul style="list-style-type: none"> • 	<ul style="list-style-type: none"> • Expansion of conventional rail-based transport

			infrastructure <ul style="list-style-type: none"> • Expansion of existing road network • New and/or improved infrastructure on seaports
GBFM	<ul style="list-style-type: none"> • Fuel taxes • Road pricing at marginal social cost • Financial incentives to rail operators/ Infrastructure access rights allocation in the rail sector (tunnel access) 	<ul style="list-style-type: none"> • Social regulations of working conditions 	<ul style="list-style-type: none"> • Expansion of conventional rail-based transport infrastructure
SCENES	<ul style="list-style-type: none"> • Fuel taxes • Social marginal cost pricing 		<ul style="list-style-type: none"> • TEN infrastructure expansion (all modes)

Present transport policies regarding long distance travel in Norway are considered to be close to optimal. However, this case study suggests there are potential gains from an increase in fuel tax. An increase in fuel tax combined with a decrease in rail fare (price regulation) and an expansion of rail-based infrastructure (by increasing the frequency) of services will potentially produce additional benefits. It was concluded that these instruments are potentially complementary. The geographical distribution of welfare in the “optimal” package (a package that includes a fuel tax increase of 25%, a decrease in rail fare by 10% and an increase in rail frequency of 1% per year) was compared to those in the reference scenario. The changes were found to be similar for all counties in Norway.

Freight Case Studies

A freight case study focused on the *Antwerp-Ruhr corridor*. Scenarios were evaluated based on an adapted version of the MOBILEC model. MOBILEC (MOBILity/Economy) is a dynamic, interregional model that describes the interaction between transport and the economy in connection with infrastructure and other regional features. Both freight transport and passenger transport are included within the model (Van de Vooren, 2004). Ten scenarios were developed: one reference scenario (used as a benchmark) and nine other scenarios based on a specific adaptation of the reference scenario and comprised pricing, physical and regulatory measures.

The tariff scenario simulated the effects of an increase in fuel tax by 25%. The rise of the travel-distance costs per kilometre in this scenario has a negative effect on the growth of regional product, employment and transport. Because of the lower economic growth, the transport of goods by train and ship also decreased. The negative effect of economic growth is larger than the positive effect of substitution (here from lorry to train or inland navigation; considered as positive). This option shows the lowest growth of transport by lorry in comparison with all other scenarios.

In the road expansion scenario, the capacity of the road infrastructure is extended in all regions in such a way that the travel time of the road traffic does not rise in spite of the increasing traffic. As a result, the HGV travel time costs do not rise, which has a positive effect on the growth of regional product, employment and transport by HGV. With higher economic growth, the transport of goods by train and ship also increases. The positive effect of economic growth is higher than the negative effect of substitution (here from rail or inland navigation to road; considered as negative).

The rail freight scenario simulated the relative effects of a decrease in distance and travel time by 10% on the district Antwerp (“arrondissement”) and Germany. The effects were rather small on a national level and as a result a rise in rail freight transport in Belgium was recorded. Similar conclusions were drawn for the inland navigation freight scenario, which simulated a decrease in travel time by 10% in the same way.

The results of the combination of the tariff scenario and the road extension scenario showed that the negative effects of the tariff scenario were compensated by the positive effects of the road extension scenario. By combining the rail freight scenario and the inland navigation freight scenario, extra growth in inland navigation and rail freight were noticed. For the combination of the tariff scenario and rail freight scenario, a slightly lower growth in rail freight compared with the rail freight scenario alone was noticed. Similar conclusions apply with respect to inland navigation. The analysis showed that it is important to simulate the effects of combined measures, since some negative effects (at first sight) can be changed into positive effects.

The second freight case study examined transport instruments for Great Britain using the Great Britain Freight Model (GBFM). This is designed to model domestic freight flows across Great Britain and international flows involving Great Britain, focusing on the Cross-Channel corridor. It combines a number of data sources and computer algorithms within a single system and applies simple micro-economic rules, seeking to explain the distribution of freight traffic, including commodity, mode, and route. It currently forms part of the Department for Transport’s National Transport Model. The aim of the study was to examine the impact of various scenarios on mode split and volumes of freight. The effects of these policies were compared with a MSC Road pricing scenario (RUC) over the 2004-2012 time horizon. The following measures were analysed:

- Regulatory: Implications of Road Transport Directive (RTD)
- Economic: Changes in rail subsidies/tunnel subsidies
- Physical: Effect of the UK Department for Transport’s 10-year plan for rail infrastructure improvement

Infrastructure improvements and rail and tunnel subsidies were grouped together as a PRORAIL scenario. The PRORAIL measures were also combined with the RTD for the ALL scenario. These measures were implemented in GBFM through appropriate adjustments in road and rail (fixed and operating) costs, capacities and speeds, along with forecasts of economic growth for various sectors.

Tonnes lifted and tonne kilometres increase from 2004 to 2012 reflecting economic growth forecast over the period. If no instruments are used, rail loses not only market share, but also the number of rail tonnes lifted and tonne kilometres will fall for this mode.

All packages showed a degree of complementarity between instruments. Only road pricing (RUC) decreases road tonne kilometres below current levels. Only the scenario ALL, (which combines all instruments, excluding RUC), comes close to the effectiveness of road pricing alone. This leads to a doubling of rail's market share but a welfare impact slightly below that of the road pricing scenario.

European Scale Assessment

European scale assessment of physical and economic transport instruments has been facilitated through the transport model SCENES (ME & P, 2002). Whilst other case studies focused on local/regional or national levels of assessment, the SCENES model allowed for assessment on an aggregated European level, for all the individual EU15 countries and also for 8 CEEC countries (although freight traffic within the 8 CEEC is not included). The modelling structure of SCENES is essentially a comprehensive framework for modelling at the European scale. All aspects of the transport market are accounted for within the model using a detailed European network for assignment.

A reference scenario was specified as a benchmark for a series of policy scenarios, with 2020 as the forecast year. This reference scenario was based on the Business-as-Usual (BaU) TIPMAC scenario (TIPMAC, 2003). Overall, the Policy Scenarios considered three main instruments: (1) SMCP pricing, (2) TEN Infrastructure expansion and (3) fuel taxation. These basic instruments can be adjusted in different ways and provide for an extensive list of possible combinations and variations.

The analysis suggested that some policy initiatives can generate positive welfare changes at an aggregated EU15 level compared to the reference situation. In particular, the results indicated that introduction of SMCP pricing is the preferred option. It should be noted that the SMCP charges in the preferred scenario are increased by 10% compared to the TIPMAC SMCP charges. The second-best option would involve a combination of SMCP pricing (based on the TIPMAC charges) and TEN infrastructure expansion. In contrast, TEN infrastructure expansion alone has only limited impact and the overall performance of this instrument on its own is negative. The results suggested significant synergies between SMCP and infrastructure expansion when implemented together compared to the case where these instruments are implemented individually.

The results concerning equity implications of the preferred option focused on the impacts on travel costs. The findings suggest that travel costs increased in all countries when compared to the reference scenario, but especially those countries with high marginal external costs. This may suggest that the revenue recycling arrangements should be dedicated towards those regions/countries with high external costs (including congestion

and air pollution) to compensate for the loss of user benefits, e.g. in the form of financing of transport infrastructure improvements in those areas.

3.4 Urban Case Studies

The urban case studies took part in two stages. Firstly, a review of urban instruments identified a list of those that could be potentially tested. Following this, modelling work assessed the potential benefits and synergies between the instruments, considering different levels of economic instruments and also reporting on issues such as equity and feasibility.

A comprehensive review was made of urban transport instruments (SPECTRUM, 2005b) as follows:

- economic instruments (road pricing, fuel and vehicle taxes, financial incentives to production and purchase of clean fuel vehicles, property taxation),
- physical restrictions to car use (dedicated lanes, pedestrian areas, limited access zones, car-free zones and traffic calming schemes),
- urban freight distribution (city logistic terminals and city freight management measures),
- intelligent transport systems (automatic traffic signal control, intelligent speed adaptation)
- infrastructure provision, maintenance and land use measures (road infrastructure expansion, road infrastructure maintenance, development mix, landscape compatibility of infrastructure),
- parking measures (on-street parking, off-street parking, using parking to tackle congestion, controlling parking supply, enforcing on-street parking policy, workplace parking), and
- public transport instruments (bus prioritisation, tariff systems, fare levels and concessionary fares, new infrastructure, information provision and marketing, legislation on emission standards, taxes and subsidies, service level requirements).

Following this review, four urban case studies were undertaken (SPECTRUM 2005c), distinguishing between ‘multimodal case studies’ (in Oslo and Leeds) and ‘road sector case studies’ (in Leeds and York). The main difference between the two types of case study was that the multimodal case studies placed particular emphasis on demand issues, particularly with respect to the choice by trip makers between public and private transport, whilst the road sector case studies were more focused upon supply issues affecting vehicular traffic on the road network. Furthermore, assessment in the multimodal case studies was made over a long term (15 or 30 year) time horizon, whilst only a short term (‘current year’) time horizon was considered in the road sector case studies.

The instruments tested in these case studies were a subset of those instruments considered in the review (SPECTRUM 2005b) and covered a broad range of economic, regulatory and physical instruments, both in isolation and as part of packages of instruments. Economic instruments considered were: road pricing (cordon charging, distance-based charging, increases in fuel tax and ‘corridor charging’); public transport fare changes and parking charges. From a modelling perspective, increases in fuel tax were taken to be equivalent to distance-based charging. Non-economic instruments considered were: reductions in speed limits; changes in public transport frequency; bus lanes and bus-only streets; traffic signal optimization; street closures and traffic calming. Whilst some instruments were tested in only one case study, others were tested in more than one, as illustrated in Table 5:

Table 5: Instruments combinations tested in more than one case study

	Oslo multimodal	Leeds multimodal	Leeds road sector	York road sector
Distance charging + Cordon charging	*		*	
Cordon charging + PT frequency changes	*	*		
Cordon charging + bus only lanes / streets		*	*	
Distance charging + bus only lanes / streets		*	*	
Cordon charging + reductions in speed limits / traffic calming	*			*

OSLO multimodal Case study

The Greater Oslo area has a population of about a million with an area of 5,305 km². The population density is about 140 inhabitants/km². Oslo city has a population of about 512,000. The mode share in the region is about 55% by car, 32% by public transport and 13% by slow modes (walk and bicycle). The multi-modal Oslo case study used the model RETRO developed at the Institute of Transport Economics (TOI).

None of the policy scenarios that included ‘decrease in speed limits’, in combination with ‘cordon charging (toll ring)’, showed an improvement in efficiency. The main reason is that a reduction in the speed limit results in a decrease in consumer surplus and a decrease in government surplus. Together these reductions were not compensated by the gains given through reduced external costs. The literature review carried out in SPECTRUM (2004a) and SPECTRUM (2005a) found on the other hand that a reduction in speed increases traffic safety and has effects on vehicle travel.

With respect to efficiency in the Oslo study, the combination of cordon charging (time-differentiated toll scheme) and an increase in fuel taxes scored the highest. It results in

the largest decrease in user benefits of all combinations tested in this study. The number of car trips was reduced in the peak by 5.2% and in the off-peak by 3.0%. Some critics argue that road pricing represents “double taxation” since motorists already pay road related taxation such as fuel taxes and vehicle registration fees. However, existing road user charges are insufficient to cover total roadway costs. Such fees are far lower than the marginal cost of driving under urban-peak conditions.

The second best package in terms of total benefits in the Oslo case study is a scenario that includes cordon charging (time differentiated toll scheme) together with an increase in fuel taxes and increased public transport frequency. This combination also results in a large decrease in user benefits. This combination of three instruments has lower total benefits but higher external benefits than the best package. With increases in fuel taxes one can expect shifts towards the slow modes of transport (walk and cycle) and public transport. The information about cross-elasticity values of demand for public transport with respect to fuel prices is abundant and shows a large variability. With an increase in the fuel price some trips will not necessarily switch to other modes, but may not be made at all or made to a closer destination whilst still using a car. Increases in fuel prices should be accompanied by improvements in the services of alternative modes and therefore also to offset any adverse effects on equity objectives. (SPECTRUM, 2004a)

Leeds Multimodal case study

Leeds is a city of approximately 750,000 inhabitants in the north of England. Although the textile industry, the main source of prosperity and growth until the Second World War, has now declined, Leeds has been very successful at reinventing itself as a finance and service centre in recent decades and is home to two large (and growing) universities. Currently, the city has a reputation as one of the most upwardly mobile urban areas in the UK (Stillwell and Unsworth, 2004).

The multi-modal MARS Leeds case study found that the highest welfare benefit could be reached through a combination of distance-based road charging of 1.5€/km and the introduction of bus lanes. This combination has high synergetic effects compared to introducing those instruments alone, e.g. the total benefits from the combination were 39.5% higher than the sum of the total benefits from each instrument applied alone. The external benefits are approximately the same as for distance charging alone. The demand for car decreases by 4.9% while demand for public transport (+43.9%) and cycling and walking (+20.5%) will increase.

A further feasible (but second best) combination in this case study was the introduction of distance based charging of 1€/km with an increase in public transport frequency by 150%. While user benefits decrease for car users, toll operators benefit most from this combination. In this scenario only the demand for public transport will rise by 50.6%, while cycling and walking will decrease by 5.7% and car use by 10.3%.

A very efficient, but politically infeasible instrument combination was the introduction of cordon charging in combination with an increase in public transport frequency. The

highest welfare value was reached with 1.5€ cordon charge and +125% frequency increase. The strategy results in a value for public value of finance (PVF) of –400 million €, however, which politically may not be feasible. If a constraint on the PVF value being equal to or higher than zero is in place, the best result was found for the combination of public transport frequency of +125% and 3.5€ cordon pricing.

It is often argued that improving the public transport system is a necessary complementary measure to road pricing as it provides those that are priced off the road with a good alternative. In doing so, it makes road pricing more efficient as an instrument to influence demand, or put otherwise, it makes the optimal charge lower. A side effect of this is that the more that is invested in the public transport system, the lower the ability of road pricing to finance the investment. (SPECTRUM, 2004a, p.28)

Leeds Road sector case study

The SATURN model used in both the Leeds and York road sector studies is based on “elastic assignment”, through which the exogenously defined matrix is adjusted in response to changes in infrastructure or cost (such as road pricing). Although SATURN is mainly concerned with the assignment of cars, it can make estimates of the effects of congestion on bus travel time and hence upon bus user travel time (when assumptions about bus occupancy are made). In contrast to the models used in the multi-modal studies, it focuses upon short-term behavioural responses, particularly upon route choice.

The instrument combination leading to the greatest total benefit in the SATURN Leeds case study was medium level distance-based charging combined with corridor charging. Most of these benefits resulted from the distance-based charging element of the combination. When applied alone, medium level distance charging had the second highest level of total benefits (compared with other instrument combinations). These results were robust to changes in the Marginal Cost of Public Funds (MCPF) from 1.0 (default value) to 1.2 and 1.4. Distance charging at all levels (either alone or combined with corridor charging) led to positive total benefits. The main contributions to these benefits were made by car user time benefits and external benefits. However, bus users also had positive benefits. These results are remarkably similar to the results for distance charging in the Leeds MARS case study, which considered “all-day” benefits over a 30-year time horizon, as compared with the short-term peak-hour benefits considered in the Leeds SATURN case study.

All levels of city centre cordon charging in the SATURN Leeds case study led to total disbenefits when introduced in combination with bus only streets or any further combination with other instruments. Although they had positive time benefits for bus users, these were of the same order as the bus user time benefits from distance charging. These results were very different from those arising from the Leeds MARS case study, which showed positive total benefits) over a 30-year time horizon for city centre cordon combined with bus lanes. The most likely explanation for this is that the benefits of city centre cordon charging and bus lanes (or bus only streets) are likely to grow over the years as congestion grows (as in the do-minimum scenario). Thus although these

measures lead to disbenefits in the short term, they are likely to lead to positive benefits over a longer time horizon. Although city centre cordon charging and bus only streets are likely to be more publicly acceptable than distance charging in the short term (particularly in the congested peak hour), this combination is not likely to lead to immediate economic benefits in the peak period.

York Road sector case study

York is a city in the North of the United Kingdom, with a historic city centre and a population of just over 177,000 people and covering a total of 27,200 hectares. The majority of the population (approx. 133,000) live within the main York urban area (6,500 ha) contained within the Outer Ring Road. This area is also the main location for business, industry, shopping and services. The SATURN model was used again for this case study.

The two instrument combinations in the York case study leading to the highest level of total benefits involved Inner Ring Road (IRR) cordon pricing, with (1) signal optimisation and with (2) signal optimisation plus an increase in short term parking charges. Essentially, signal optimisation contributed to a significant increase in car user time benefits and a small increase in bus user time benefits, when compared to IRR cordon pricing implemented alone. It was found that there was synergy between the two instruments. It has also been found that road pricing is an imperfect instrument to handle congestion in parking areas, whilst parking charges would only be able to internalise the externalities on the road in an imperfect way (see SPECTRUM, 2004a). More generally, there is a need for many different pricing instruments to be used together as long as there are externalities of different types and in different locations. Signal optimisation is a frequently used instrument to increase the overall efficiency of the traffic system. In the SPECTRUM case study, signal optimization was carried out by minimizing delay for all vehicles (i.e. for both buses and cars together). However, further improvements could have been found for bus users if public transport priority measures had been included (public transit improvements: Victoria Transport Policy Institute, 2004).

3.5 Broad Performance Ranking Of Measures

A consultation with stakeholders took place within the SPECTRUM project with two primary goals:

- to review the results of the modelling in the light of expert opinion: the rankings of packages of transport instruments according to economic efficiency were submitted to experts in order to gain qualitative insights about their performance when applied in real life conditions.
- to gather information about issues which are not treated in the models used (or not treated homogeneously enough to allow a comparison), such as barriers to implementation and equity.

The consultation was carried out through a questionnaire and a seminar. The questionnaire comprised 10 questions, concerning both the urban and interurban policy areas. The respondents specified whether their answers concerned local/regional, broad national or EU level impacts, and were asked to provide the following:

- their own ranking of a selection of ten packages, in terms of impacts on efficiency and of feasibility;
- their own judgement of the relevance of barriers for each instrument/package of instruments;
- a comment on foreseeable effects on equity.

The questionnaire was sent to a wide range of approximately 100 contacts across Europe. 14 questionnaires were returned including respondents from 8 EU countries (Belgium, Denmark, Finland, Hungary, Ireland, Poland, Spain, UK). Respondents were asked to indicate their level of practical experience with economic instruments and all declared a medium/high level of practical experience or knowledge. In terms of the employment/interest area of the respondents, the following responses were given (number of responses in brackets):

- National government (5)
- Academics (3)
- Consultancies (2)
- Local government (1)
- Lobbying groups (1)
- Not declared (2)

It was also important to establish the spatial level of experience at which the respondents were providing judgements on the performances of instruments and packages. The majority of returned questionnaires (12 out of 14) gave judgments based on experience at a local/regional and national level.

Further views were gathered at a seminar which was held in Brussels on the 19th of July 2005, which included project partners, Members of the SPECTRUM Advisory Group and other external representatives, including the Commission Services.

User consultation provided detailed feedback on instrument combination with some general comments as follows:

- Political acceptability of some measures is a concern which may outweigh the benefits in terms of efficiency; moreover the perception of what is acceptable seemed to vary according to the nationality of the respondent.
- In the urban context, there was strong support for including various public transport measures regardless of efficiency or other performance
- The administrative issues in implementing packages that included measures implemented at local level eg public transport and those generally implemented at national level (eg fuel taxes) were raised. Further administrative issues were

- raised in the interurban context with respect to the setting of rail fares and frequency.
- Fuel taxes were seen by some stakeholders to have particular negative equity implications
 - Infrastructure expansion (eg through TEN) was perceived to be inevitable and therefore a key question was to identify which other measure, or combination of measures, would support this in bringing additional benefits.

As a result of the consultation process, it was possible to carry out a ranking of the instruments and packages taking into account both efficiency and feasibility. The high level objective function (HOV) formed the basis for assessing the social benefit of an instrument or combination and an initial set of results were reported according to the HOV, but also disaggregate to show impacts such as the environmental impacts, safety impact etc. Subsequently, a broader assessment was carried out taking into consideration both performance against the HOV and also possible barriers to implementation. This took the form of a ranking process to allow an approximate comparison across case studies distinguishing between urban and interurban contexts.

A first ranking was according to the value of the HOV and was based on per capita (or per vehicle) values of: 1) consumers' surplus; 2) producers' and government surplus; 3) external costs without any weighting. Values were calculated as changes in relation to the case study reference scenario, divided by the population of city for the urban case studies. For the interurban case studies per vehicle-km values were calculated for the HOV, in order to ensure comparability across case studies with very different dimensions.

In order to accommodate the range of scores produced by the different scales of the case studies, a Normalised score for the elements of the HOV was used as follows:

$$\left[\frac{(X - Min)}{(Max - Min)} \right] \times 100$$

where X is the value (or changes in value) of the consumers' surplus, producers' surplus etc. for each policy or policy package. Min is the minimum value achieved by the worst policy/policy package and Max is the maximum value achieved by the best policy/policy package.

A second ranking was according to an assessment of the practical feasibility of policies based on an MCA approach. This considered five factors - political/cultural acceptability, legal/institutional acceptability, financial requirements, practical/technical requirements, potential unintended effects of policy implementation with weights produced through a "Rank Order Centroid" (ROC) process (see for example Goodwin and Wright, 1998).

The two rankings were finally brought together through simple addition to produce an overall ranking. The policies at the higher positions in this overall ranking are those that, according to the analysis, are the most efficient and the less problematic to implement.

Instruments in the lower positions were the ones which were either very inefficient or which had overwhelming problems regarding feasibility or both.

Detailed findings of the ranking case studies can be found within SPECTRUM (2005b). A brief summary of the five highest and lowest ranking policy packages for both the urban and interurban contexts is given here in Tables 6-9, with a score of 1 reflecting the highest rank. It should be noted that this exercise was not undertaken as a strictly controlled and highly scientific process, but rather as a means of synthesising the case study results to allow broad guidance to be formed.

Table 6: Relatively high performing instruments - urban context

Model	Package	Efficiency rank (A)	Feasibility rank (B)	Overall ranking (A+B)
Mars Leeds	Cordon charging (2€) & Bus lanes / Bus only streets	5	2	7
Retro Oslo	Cordon charging (toll ring: peak 2,5 today prices, other periods today prices) & Increase in fuel taxes by +50% & Increase in PT frequency by 5.8% & Reduction in speed limits	1	10	11
Mars Leeds	Cordon charging (3.5€) & Increase in PT frequency (+125%)	4	7	11
Retro Oslo	Cordon charging (toll ring: peak 2,5 today prices, other periods today prices) & Increase in fuel taxes by +50% & Increase in PT frequency by 5.8%	15	8	23
Retro Oslo	Increase in fuel taxes by +50% & Increase in PT frequency by 5.8%	31	1	32

Table 7: Relatively Low performing instruments - urban context

Model	Package	Efficiency rank (A)	Feasibility rank (B)	Overall ranking (A+B)
SATURN Leeds	City centre cordon charging (low level: 1,2 €/access)	19	41	60
SATURN Leeds	Distance-based charging (medium level: 0,1125 €/km)	39	26	65
SATURN Leeds	Corridor charging (1,2 €/link)	28	38	66
MARS Leeds	Bus lanes / Bus only streets	29	39	68
RETRO Oslo	Cordon charging (toll ring: peak 2,5 today prices, other periods today prices)	38	36	74

From Tables 6 and 7 a number of points can be seen. Economic instruments performed best overall when implemented in packages with other instruments – particularly those that involved improvements to public transport. The best overall package emerged from the Leeds case study and involved cordon charging alongside the implementation of bus lanes. Interestingly, this package did not score the highest on either efficiency or feasibility alone. From the highest five, two were more complex packages that involved the use of three or four instruments together (the Oslo case studies). Whilst one of these was the most efficient package overall, it was assessed less highly in terms of practical feasibility. Urban instruments performing less well overall included economic instruments implemented in isolation (such as corridor charging).

Table 8: Relatively High performing instruments - interurban context

Model	Package	Efficiency rank (A)	Feasibility rank (B)	Overall ranking (A+B)
SCENES	Social marginal cost pricing excl. rail	10	5	15
SCENES	Social marginal cost pricing + 10 %	6	11	17
SCENES	Social marginal cost pricing	8	10	18
EURORAIL	Rail fares +10%	4	18	22
GBFM	Social marginal cost pricing (road)	11	12	23

Table 9: Relatively Low performing instruments - interurban context

Model	Package	Efficiency rank (A)	Feasibility rank (B)	Overall ranking (A+B)
EURORAIL	Out of pockets costs (car) +20%	38	25	63
EURORAIL	Out of pockets costs car and rail +10%	36	28	64
SCENES	TEN Infrastructure expansion excl. Motorways of the Sea	34	31	65
SCENES	Fuel taxes 25% & TEN infrastructure expansion	29	40	69
EURORAIL	Internalisation of externalities & Speed for rail travel +10%	40	36	76

In the interurban context, from Tables 8 and 9, marginal cost pricing performed well for both road and rail and unlike the urban case, the top five packages emerged with very similar ranking scores. It is interesting to note that an increase in Rail fares of 10% was highly placed, due to a high efficiency ranking which managed to counterbalance a low feasibility ranking. In the interurban case, economic instruments applied alone rather in packages were highly ranked. Three of the EURORAIL scenarios were amongst the lowest ranking interurban packages.

Considering the packages that were within the middle rankings of the tables (not shown in full here), there were some with high rankings for one criterion e.g. efficiency but very

low scores on feasibility. In the urban context an example of this was a SATURN (York) scenario comprising an inner ring road cordon charge together with bridge pricing. This was the second highest ranked policy in terms of efficiency but ranked low (35th) for feasibility. A corresponding example in the interurban context was the EURORAIL scenario involving internalisation of externalities and increase in speed for car travel +10% due to road transport expansion. This was the highest ranking interurban measure in terms of efficiency, but with a feasibility ranking of 37 was placed in the middle of the table in terms of overall performance.

The broad overview presented here has emerged from a combination of specific modelling and numerical outputs together with consideration of broad past experience (informing initial instrument choice and general user priorities). The questions remains for stakeholders as to how localised the findings are and the extent to which these may be transferable to a wider context. These questions are addressed within Section 3.6 below.

3.6 Transferability

Transferability of the outcomes has been a key theme within the research. Various aspects of transferability have been considered: urban, interurban, rural and transferability to the New Member States (NMS) and Candidate Countries (CC) of the EU. An initial overview of transferability methodology, distinguished between two main types of transferability: ex-ante and ex-post. In the SPECTRUM context, ex-ante transferability considers the transfer of policy instruments before such transfer takes place, whilst ex-post transferability consider transfer after it has occurred. An ex-ante transferability analysis has taken place for urban, interurban and rural contexts, whilst for NMS/CC, both ex-ante and ex-post analysis has been undertaken. Conclusions about these analyses are presented below, with the results from the two types of NMS/CC analysis being combined.

3.6.1 Urban transferability

Analysis of transferability of the SPECTRUM urban case study results compared results with those obtained by the CUPID/PROGRESS projects. The aim of CUPID (2004) was to provide support and synthesise results from the PROGRESS project, which carried out full-scale demonstrations, trials and modelling exercises in eight EU cities (Bristol, Copenhagen, Edinburgh, Genoa, Gothenburg, Helsinki, Rome and Trondheim). These activities were organised by the local authorities of the cities concerned and so had a particularly practical focus. The urban transferability analysis distinguished four classes of instruments / instrument combinations:

- city centre cordon pricing
- distance-based charging
- combinations of city centre cordon pricing and distance-based charging
- combinations of road pricing with parking charges
- combinations of road pricing with public transport instruments

City centre cordon pricing

In general, SPECTRUM recommendations for city centre cordon charge levels lie within the middle of the range of recommendations from PROGRESS cities. With respect to practicality issues, the PROGRESS analyses were similar to the SPECTRUM analyses in that it was considered that there were a number of well-tried technologies for operating cordon pricing. However, with regard to political acceptability, the PROGRESS cities provided a more complex picture than was presented in SPECTRUM. Both projects emphasised the importance (for generating new city centre cordon charging schemes) of the current perceived-to-be-successful schemes in Oslo and London. With respect to equity issues associated with road pricing, the PROGRESS cities put particular emphasis upon two factors: exemptions and use of revenue. The SPECTRUM case studies only considered the issue of exemptions on a high level of abstraction. With respect to revenue use, SPECTRUM listed the following four options:

1. All revenue is used for road infrastructure and maintenance of road space.
2. All revenue is used to fund public transport.
3. All revenue is used by the national government to reduce income tax.
4. All revenue is used by the national or local government to support spending in other policy areas such as health and education.

PROGRESS cities unanimously recommended that all revenue should be used for only (1) and (2) above. This probably reflects the more practical orientation of the PROGRESS cities, where issues of public acceptability were key.

Distance-based charging

For distance-based charging, the Leeds Road Sector study in SPECTRUM made a recommendation towards the lower end of the PROGRESS cities range for charging in the morning peak (€0.01 per veh-km to €0.67 per veh-km). The Leeds Multimodal recommendation was, however, significantly higher than the top of the range proposed by the PROGRESS cities (€0.67 per veh-km). Furthermore, the Leeds recommendation applied all-day and throughout the city. As an off-peak outer zone charge, it was approximately ten times higher than the top of the range of the PROGRESS suggestions for off-peak outer zone charging, i.e. €0.01 per veh-km to €0.13 per veh-km.

Combinations of cordon charging and distance-charging

All the PROGRESS studies which considered distance-based charging (Copenhagen, Gothenburg and Helsinki) devised charging rates that differed between the city centre and middle/outer zones. The combination of cordon charging and distance-charging (or fuel tax increases) tested in SPECTRUM case studies (Oslo Multimodal and Leeds Road Sector) can be seen as an approximation of the PROGRESS geographically-distinguished charge levels. The Oslo combination of cordon charging and fuel tax increases led to the highest level of total benefit for all the packages tested in the SPECTRUM Oslo case study. However, in the Leeds Road Sector case study, the total benefit from the combination of cordon-pricing and distance-charging was lower than the total benefit from distance-charging alone (for all levels of distance charge). This would suggest that a

flat-rate distance charge would be preferable to a variable distance charge. The discrepancy between the Oslo and Leeds results might, though, be explained by the fact that the Oslo case study considered a future target year whilst the Leeds (Road Sector) Case study considered the present year.

Combinations of parking charges with road pricing instruments

The York Road Sector case study in SPECTRUM considered a number of parking charge instruments, some in combination with road pricing instruments. Two PROGRESS cities specifically considered parking charges: Rome and Helsinki. In the former, an “extra” charge was made upon those cars entering the city centre that also wanted to park in the city centre. This scheme was in a broad sense equivalent to the York recommended scheme of increasing short term parking charges in the city centre in combination with cordon pricing. The Helsinki PROGRESS scheme recommended that parking charges be reduced once road pricing was introduced. Such a scheme was not tested in the York case study. Furthermore, Genoa and Rome (in PROGRESS) made specific mention of using road pricing revenues to support park-and-ride systems. Such systems are an important long-standing aspect of York’s transport development strategy, and are thus, by default, included in all packages suggested for York.

Combinations of public transport instruments and road pricing instruments

All the PROGRESS cities recommended the introduction of public transport instruments alongside (or before) the introduction of road pricing instruments. These public transport instruments were, in most cases, not specified in detail, although there seemed a general interest in physical instruments. In view of this interest, the bus lane instruments recommended by the SPECTRUM Leeds Multimodal case study seem very appropriate. Out of the PROGRESS cities, only Helsinki made specific mention of reduction in fares and increases in frequency, the other public transport instruments recommended by the Leeds Multimodal case study. In general, given the local authority control of the PROGRESS case studies, it is unlikely that they would support the Leeds Multimodal recommendation of free public transport, even though the instrument could potentially be funded by a high level of distance-based road pricing charges.

3.6.2 Interurban transferability

In the analysis of intra-EU-transferability of interurban packages, the results of the SPECTRUM interurban case studies (SPECTRUM 2005a) were considered against the European Transport Policy White Paper (European Commission 2001). As part of this consideration it was assumed that the policies described in the White Paper are transferable and applicable within the ‘old’ EU countries (i.e. the countries in the EU before the accession of the New Member States).

Both the European Transport Policy White Paper (European Commission, 2001) and the results from the interurban case studies (SPECTRUM, 2005a) conclude that the external costs have to be paid by the user/ polluter. This policy (“internalisation of externalities”) and a harmonisation of fuel taxes require regulations among EU Member States. Furthermore, they need to be implemented at the same time in different countries to

eliminate avoidance of paying and to overcome political/ acceptance barriers. In passenger transport as well as in freight transport the priority should be on the expansion and improvement of rail, sea and inland waterway instead of expanding road infrastructure, as this would lead to a growth in road transport and not fulfil the goal of sustainable development.

There is a social need to meet public service requirements in passenger transport (e.g. frequency and punctuality of services, availability of seats, preferential fares for certain categories of user). However, an operator might not necessarily meet such needs if it were only considering its commercial interests. Hence, a member state or any other public authority can require or reach an agreement with a private or public undertaking in order to ensure that minimum standards are achieved. In freight transport, European legislation concerning the regulation of working conditions is required due to or despite of a strong road lobby. A reduction in access charging for rail freight infrastructure seems not to be transferable to the 'old' EU contexts, as this would contradict the fundamental principle of infrastructure charging, and raise the question of who is going to finance it. When introducing economic measures to raise funds for infrastructure expansions, political barriers may occur when the money raised is not sufficient for the expansion. Therefore, it is important to concentrate on the most important and sustainable infrastructure projects in order to avoid an explosion of costs and thus also raise acceptability.

Overall, the SPECTRUM recommendations in the interurban context fit with the emphasis in the EC White Paper regarding internalisation of externalities as a key issue. Furthermore, it was also concluded that the use of charging revenue towards infrastructure projects should be allocated with care in order to ensure socioeconomic viability.

3.6.3 Rural transferability

The research considered various different types of transferability to rural areas, comparing the results and methodology used in the SPECTRUM case studies with a variety of reports concerning rural transport (for example Gray, 2001) . Some of these reports attempt to make classifications of different types of rural area. It was found that for transport purposes the most useful type of classification was one that distinguished between different levels of peripherality of rural areas. At one extreme (the least peripheral) are "peri-urban" areas, whilst at the other extreme are remote island regions. The transferability analysis considered transport for various types of areas within this classification. Furthermore, transferability was assessed according to three different types of movement in rural areas: tourist traffic; through traffic; and non-tourist local traffic. These issues will be described below.

Tourists

Charges for tourists to enter sensitive rural areas could be made with a cordon charging system, which conceptually operate in a similar way to the city centre cordon charging schemes examined in the SPECTRUM case studies. A question arises as to suitable

levels of charge. In practice, this will depend upon the balance required between restricting traffic and maintaining a level of tourism to support the “local tourist industry”. For a very remote area of outstanding beauty, a high charge, compared to the charge levels recommended by the SPECTRUM case studies, seems appropriate. However, in a more populated rural area, the charge levels might be similar. Following a similar logic, taxes can be made on tourists to access islands (such as the Balearic eco-tax and the Corsica transport tax). Given the physical separation of islands from the mainland, it is arguably easier to operate such a scheme in an island context than in a mainland context, particularly because the entry points can be more clearly identified and monitored.

Decisions need to be made on how to use the revenue raised from road pricing aimed at tourists. One clear option (analogous to suggestions resulting from the SPECTRUM urban case studies) would be to subsidise public transport for tourists, given that tourists have contributed this revenue. Given that tourists and inhabitants typically share the same public transport (if on the same routes), this would also lead to the subsidising of non-tourist public transport.

Through traffic

Instruments are required to direct through traffic away from sensitive rural sites and routes, and these instruments will, on a conceptual level, be similar to urban instruments for directing through traffic away from residential areas and congested city centres (as discussed in the SPECTRUM urban case studies). A question arises as to whether economic instruments can be used in support of such instruments in rural areas. In theory, it should be possible, once the technology is available, to implement differential distance-based charges on different types of route, so that less environmentally sensitive main routes (such as motorways) have a lower rate of per-km charge than small country roads. It should be recognised though, that such a policy would be in direct contrast to current interurban charging practice in the EU (particularly in southern countries) whereby motorways are charged and alternative routes are uncharged.

Non-tourist access traffic

The SPECTRUM urban case studies examined the possibility of using revenues from urban road charging to subsidise urban public transport (as mentioned above in the discussion of tourist traffic). An extension of this idea would be for urban road pricing revenues to subsidise rural transport. If such a scheme were to be considered further, it would need to be resolved whether such revenues should apply only to public transport from rural to urban areas, or whether it should apply also to “intra-rural” transport. A number of equity issues would be raised here.

Although the SPECTRUM case studies did not consider exemptions in charges for particular groups, the CUPID/PROGRESS projects (mentioned above) paid particular attention to this issue. A strong case can be made that rural inhabitants should be exempted from paying charges that are mainly aimed at curbing tourist car demand in sensitive areas. However, definitional questions arise as to how this might be put into operation. In particular, it is likely that there is a relatively large heterogeneous group of

travellers who cannot easily be labelled as either “tourists” or “local”, such as seasonal workers in rural tourist industries, “long-stay” visitors, and city inhabitants with second homes in rural areas.

3.6.4 New Member States and Candidate Countries

The research included both ex-ante and ex-post analyses of the transfer of policy instruments to New Member States (NMS) and Candidate Countries (CC). The ex-ante analysis has concentrated particularly upon the transfer of recommended packages resulting from the SPECTRUM case studies (urban and interurban), whilst the ex-post analysis has reported on previous experiences. Both types of analysis have paid particular attention to issues concerned with the barriers to transferability. The results of these analyses show that the transferability of transport policy differs very much by individual country. In both urban and interurban contexts, it has been shown that the New Member State which best prepared for transferability is Slovenia, followed by the Czech Republic and Hungary. Poland and Slovakia could be characterised as “quite well prepared” but the existence of serious barriers needs to be taken into account in these two countries. Although the three Baltic countries (Lithuania, Latvia and Estonia) are often treated as a homogeneous block, there are in fact many differences between these countries that are of relevance to the transferability of transport policy packages. Out of the three countries, Estonia can be ranked as the best prepared for transferability and Latvia as the worst prepared, with the likelihood of a large number of barriers in the latter. The countries where the most serious barriers would be expected would be Bulgaria and Romania, both of which are CC, where the likelihood is comparatively low of positive impacts from transferred transport policy packages.

A comparison between different types of barrier has shown that the most important obstacles in the transferability of packages in the urban context are “political/cultural barriers” and “resources barriers”. Resource barriers occur particularly for those packages where economic instruments are combined with physical instruments, but where the finance for the latter cannot be fully raised by the former. In the interurban context the main barriers concern social and political commitment (characterised as “political/cultural barriers”), especially with respect to the implementation of economic instruments. Furthermore, it needs to be pointed out that “practical/technological barriers” are significant in the interurban context, whilst “legal/institutional barriers” are important in the urban context.

4. List of deliverables

The following represents the list of deliverables produced during the research:

Deliverable no./Title	Responsible Workpackage	Issue date
D1. Inception Report	WP1	Issue date 10/03/03

D2. Review of specific urban transport measures in managing capacity	WP 8	Issue date 17/08/04
D3. Review of specific interurban transport measures in managing capacity	WP 6	Issue date 1/3/05
D4. Synergies and conflicts of transport instrument packages in achieving high level objectives	WP3	Issue date 26/2/04
D5. Outline specification of a high level framework for transport instrument packages	WP2	Issue date 26/09/03
D6. Measurement and treatment of the high level impacts of transport instrument packages	WP 4	Issue date 3/5/04
D7. Analysis and assessment of the practical impacts of combinations of instruments in an inter-urban context	WP 7	Issue date 24/1/05
D8. Analysis and assessment of the practical impacts of combinations of instruments in an urban context	WP 9	Issue date 19/4/05
D9. Urban and inter-urban guidance and policies	WP10	Issue date 8/6/05
D10. A theoretically sound framework for the combinations of regulatory, economic and physical measures - concrete guidance and recommendations	WP2	9/12/05
D11. Transferability of the SPECTRUM framework: theory and practice	WP 5	7/11/05
D12. Specification and transferability of a framework for measures to reach transport and other relevant policies	WP2	14/10/05

5. Results and Conclusions

The aim of the SPECTRUM research was to provide a framework and quantified evidence to demonstrate the potential to move from command and control to a greater use of economic instruments. A description of the scope of the research and approach taken has been given in this report in order to clarify the background, scope and limitations to the work. It has been demonstrated that there exists considerable potential within both the urban and interurban contexts for a more market driven approach.

A skeleton structure to the framework was initially defined considering the broad transport and social objectives, transport context, indicators and measurement, assessment framework and classification of instruments. This formed the basis for the definition of so-called high level objectives against which the success of particular instruments and instrument packages could be measured. The objectives were represented within a specific objective function calculated numerically for each package, effectively giving each economic instrument or package a 'performance score'. This led into the more detailed and practical level issue of how indicators (directly linked to the objectives) could be measured in practice – both within the case studies, but more generally by practitioners involved in transport policy decision making. Having defined the outline framework, the research progressed to examine the performance and transferability of packages of economic and other instruments in terms of quantified and qualitative evidence. The main conclusions are provided by area below.

5.1 Package Formation

The ways in which instruments perform when implemented in packages of more than one measure may be categorised according to the following outcomes:

Complementarity exists when the use of two instruments gives greater total benefits than the use of either alone. This can be represented using the following notation:

$$\begin{aligned} \text{Welfare gain (A+B)} &> \text{Welfare gain A, and} \\ \text{Welfare gain (A+B)} &> \text{Welfare gain B} \end{aligned}$$

Additivity exists when the welfare gain from the use of two or more instruments in a policy package is equal to the sum of the welfare gain of using each in isolation. This can be represented as:

$$\text{Welfare gain (A+B)} = \text{Welfare gain A} + \text{Welfare gain B}$$

Synergy occurs when the simultaneous use of two or more instruments gives a greater benefit than the sum of the benefits of using either one of them alone:

$$\text{Welfare gain (A+B)} > \text{Welfare gain A} + \text{Welfare gain B}$$

Additivity and synergy can therefore be considered as two special cases of complementarity.

Decreasing returns to packaging occur when the welfare gain of the simultaneous use of A and B is smaller than the sum of the benefits of using either one of them alone:

Welfare gain (A + B) < Welfare gain A + Welfare gain B

Incompatibility refers to a combination of instruments that does not lead to any welfare benefits and is not suitable for a combinatorial application.

Welfare gain A \cap Welfare gain B = 0

These definitions indicate the broad direction of interaction effects that may be seen to occur in practice through the implementation of economic measures alongside physical and/or regulatory measures.

5.2 Interurban conclusions

The uni-modal case studies highlighted the importance of the social costs associated with externalities and the appropriateness to internalise them through economic instruments was pointed out in all case studies. For the mode specific case studies the following key conclusions can be put forward.

- In the *airport case study*, the instruments under scrutiny demonstrated the close inter-relationship and very frequently they were found to be implemented as packages. In addition, economic instruments appeared to be very relevant, representing a valid (sometimes optimal) capacity allocation mechanism and a market based way to internalise problematic externalities at airports. Specifically, the air case study demonstrated the relevance of introducing specific noise charges to address noise problems.
- The *rail case study* determined that operators should be charged for the capacity they use in accordance with the social opportunity cost of that capacity. Simulation exercises (PRAISE) established that if auctioning could be arranged with appropriate subsidies in place, it would give the best outcome in terms of social welfare.
- Analysis of infrastructure expansion was the main objective of the *sea case study*. Important benefits were generated for shippers, passengers and shipping companies, though in the case of the instruments removing locks a large part of the problem shifted towards the handling side and therefore towards terminal operators.
- For the *road case study*, as with the other case studies, economic instruments were prominent in the analysis. It was found that motorway tolls would have a relatively small welfare effect compared to fuel taxes.

The results from the *multimodal case studies* indicated that instruments linked to internalisation of externalities had significant effects on welfare. This was confirmed in the context of the European Scale Assessment, where the scenario involving introduction of SMCP pricing had the highest positive welfare changes.

This highlights at least two important issues:

- the EC initiatives concerning fair and efficient pricing are likely to be welfare enhancing even implemented on their own,
- the planned investment programme with respect to the Trans-European Network (TEN) should be implemented as part of a package with fair and efficient pricing. This could be linked to the issues concerning revenue recycling, i.e. how to use the SMCP revenue.

5.3 Urban conclusions

Looking across the urban case studies, some of the best performing packages involved distance charging and fuel tax, however in terms of implementation there are questions on the public acceptability of such measures, especially with short term implementation. Cordon charging was also a high performing measure in some cases (but not in other case studies) and the interpretation on this finding needs some care. Other key conclusions are:

- In some cases, an instrument combination generated disbenefits when assessed in a short term time horizon in a road sector case study, but generated positive benefits when assessed over a long term time horizon (such as 30 years) in a multimodal case study.
- Synergy was found with respect to two combinations: cordon pricing and traffic signal optimization (in York); and distance-based road pricing and bus lanes (in Leeds).
- The assessment of benefits from combinations including public transport fare changes was highly dependent upon the value assigned to the Marginal Cost of Public Funds (MCPF)

5.4 User Consultation and ranking

In the urban context, distance based charging combined with bus lanes/streets was given the highest ranking in terms of efficiency, positive interaction effects and equity. This combination was ranked less highly in terms of feasibility however. In the interurban context, internalisation of externalities, packaged with road infrastructure improvements (improved speed) was most highly ranked in terms of efficiency and equity (up to the broad national level, but not at the broad EU level). This again scored rather less highly in terms of feasibility. It may be an issue for further policy research to establish how some of the feasibility issues could be overcome in both contexts. User consultation provided detailed feedback on instrument combination with some general comments as follows:

- Political acceptability of some measures is a concern which may outweigh the benefits in terms of efficiency; moreover the perception of what is acceptable seemed to vary according to the nationality of the respondent.
- In the urban context, there was strong support for including various public transport measures regardless of efficiency or other performance
- The administrative issues in implementing packages that included measures implemented at local level eg public transport and those generally implemented at national level (eg fuel taxes) were raised. Further administrative issues were raised in the interurban context with respect to the setting of rail fares and frequency.
- Fuel taxes were seen by some stakeholders to have particular negative equity implications
- Infrastructure expansion (eg through TEN) was perceived to be inevitable and therefore a key question was to identify which other measure, or combination of measures, would support this in bringing additional benefits.

5.5 Conclusions in the context of feasibility

Instrument performance has been compared with respect to two aspects ie efficiency gains and feasibility issues. Efficiency was assessed through The High level Objective Function (HOV) approach, whilst feasibility considered five factors - political/cultural acceptability, legal/institutional acceptability, financial requirements, practical/technical requirements and potential unintended effects of policy implementation. More detailed results at case study level also considered particular impacts, including safety and the environment. In practice, an instrument or package should not be implemented with a high negative score on either, regardless of efficiency gains or other feasibility issues. A further and very significant factor not included in the ranking process was that of equity as it was not possible to measure this using a common basis across the different models. It was outside the scope of the research to consider revenue recycling which would have a significant impact on equity issues. This issue was considered as part of the EU project REVENUE. It is also possible that the instruments or packages would involve a number of costs not reflected in the analysis, such as costs of monitoring and enforcement, public information costs etc. Considering efficiency and feasibility together:

- In the urban context, economic instruments performed best overall when implemented in packages with other instruments – particularly those that involved improvements to public transport. Urban instruments performing less well overall included economic instruments implemented in isolation. In the interurban case, marginal cost pricing measures performing strongly.
- Overall it should be considered that policy instruments that provide efficiency gains without costs to a particular stakeholder or group are rare and possibly non-existent. For example changes in public transport fares would be at the cost of the operator, which may be unacceptable for privately operated public transport systems.

- The key to a successful move towards a greater use of economic instruments would seem to lie in a package of measures where the costs are spread in such a way that the barriers on feasibility are low across the board and there is not a strong adverse impact on any single indicator.
- A final issue may be the maturity of the transport system. A system that is already mature (in the sense of levels of saturation, current instruments in use, levels of future demand and other factors) may have much to gain from a step change in management approach and be less resistant in terms of barriers.

5.6 Transferability

- *Urban transferability* was assessed by comparing the results from the SPECTRUM urban case studies with the results from CUPID, an EC Thematic Network which synthesised the results from demonstrations of road pricing in eight EU cities. Although there were some differences in the instruments and scope of the two projects, the results of SPECTRUM were found to be broadly in line with those of CUPID with respect to charging levels and general recommendations. The CUPID recommendations were rather more complex and very cautious with respect to public acceptability issues.
- *Interurban transferability* was assessed by comparing the results of the SPECTRUM interurban case studies with the European Transport Policy White Paper. Both conclude that the external costs have to be paid by the user/ polluter. This policy (“internalisation of externalities”) and a harmonisation of fuel taxes require regulations among EU Member States. Furthermore, they need to be implemented at the same time in different countries to eliminate avoidance of paying and to overcome political/ acceptance barriers.
- *Rural transferability* analysis was based upon the level of peripherality of a rural area (considering islands as “ultra-peripherals”), and considered three different types of movement: tourist traffic; through traffic; and non-tourist local traffic.
 - Charges for tourists to enter sensitive rural areas could be made with a cordon charging system, similar in concept to the city centre cordon charging schemes tested in the urban case studies. In practice, the charge will depend upon the balance required between restricting traffic and maintaining a level of tourism to support the “local tourist industry”. For a very remote area of outstanding beauty, a high charge, compared to the charge levels recommended by the SPECTRUM case studies, seems appropriate. In a more populated rural area, the charge levels might be similar.
 - For through traffic in rural areas, instruments will conceptually be similar to urban instruments for directing through traffic away from residential areas and congested city centres. A question arises as to whether economic instruments can be used in support of such instruments in rural areas. In theory, it should be possible, once the technology is available.

- For non-tourist local traffic, the possibility arises for urban road pricing revenues to subsidise rural public transport (which would, in a sense, be conceptually similar to the policy, considered in the SPECTRUM urban case studies, of using revenues from urban road charging to subsidise urban public transport). If such a scheme were to be considered further, it would need to be resolved whether such revenues should apply only to public transport from rural to urban areas, or whether it should also apply to “intra-rural” transport. A number of equity issues would be raised in this case.

In terms of the transferability of SPECTRUM results and recommendations to the New Member States (NMS) and Candidate Countries (CC) of the EU, an ex-ante analysis was made of the transfer of recommended packages from SPECTRUM case studies, whilst an ex-post analysis reported on previous experience. A comparison was made between different types of barrier, i.e. political/cultural barriers, social/cultural barriers, institutional/legal barriers, resource barriers and finally practical/technological barriers. The results of these analyses showed:

- New Member States and Candidate Countries differ from the “old” EU (EU-15) countries in relation to economic conditions and the readiness of society to accept financial burdens instead of a higher quality of living conditions. The transferability of transport policy differs very much by individual country.
- For packages including physical instruments, resource barriers gain importance, which can be potentially overcome by adding economic (revenue-generating) instruments to the package. In such cases, practical/ technological barriers also play quite an important role.
- In case studies where the basic role is given to economic instruments, two types of barriers, legal/ institutional barriers and political/ cultural barriers, have the most significant role. In such cases, it is important that institutional and legal steps to be taken to try to overcome such barriers in advance of their implementation.
- The most important obstacles in the transferability of packages in the urban context are “political/cultural barriers” and “resource barriers”.
- In Estonia, Slovenia and Hungary the pressure of barriers is the weakest. These countries are relatively small (especially Slovenia and Estonia), and economic potential and GDP per capita are the closest to the EU-15 average. Moreover, their government administrations are relatively efficient, and their legal and regulatory frameworks meet the requirements of a well-developed economy.

6. References

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9. Annex: Definition of High level objective function (HOV)

In a simple setting of one transport market, one mode of travel and identical transport users, the type of interaction between the different policy instruments can be assessed on the basis of the following welfare function that represents the high-level objective of economic efficiency (HOV):

$$W = N.CS + (1 + \lambda)(REV + PS - b.R) - EEC$$

The first term (N.CS) represents the consumer surplus of the transport users. The second term gives the impact on the government, which consists of the sum of net government revenue from the transport sector (REV) and producer surplus (PS)(under the assumption that a negative producer surplus in the transport is eventually paid for by the government), from which the accident costs paid by the government (b.R) are subtracted. This term is multiplied by the social value of government revenue (1+λ). The last term of the welfare function gives the external environmental costs (note that the accident and congestion costs are already incorporated in the first two terms of the welfare function). By comparing the welfare function for different packages of policy instruments, one can determine the most efficient package. Moreover, one can assess whether two specific instruments enhance each other's performance and to what extent.

The welfare function can be broken down by the relevant stakeholder groups, including transport consumers, producers, government and non-users, which allows to show where efficiency gains and losses are being incurred. Further discussion is given in SPECTRUM 2003