ROAD SYSTEM ECONOMICS

19 September 2007 (am)

TECHNICAL COMMITTEE 1.1

INTRODUCTORY REPORT

CONTENTS

0. EXECUTIVE SUMMARY

0.1. Transport system issues

The road network plays an important role in a region's transport system carrying private car traffic, public transport by bus or coach, freight vehicles and emergency vehicles. Cars have remarkable and unique qualities: for users, their performance is marked by their range of speeds and flexibility, and the mode may be used to provide dense geographical coverage and adequate access to a set of settlements. However, roads take up space and vehicular traffic generates accident risk, noise, pollutant emissions and greenhouse gases.

For society, transport networks are facilities that are in the public interest and which serve social and economic activities: they extend market areas and facilitate economies of scale in the production of firms; they permit the productive specialization of individuals, which is a key factor for productivity and integration within the channels of trade.

Society must reconcile the economic issues that relate to transport demand with the interests of other categories of actors: producers and the actors which experience the environmental and social impacts (on residents and the natural environment).

0.2. The community's scope of activity

The community has a variety of means of transport and regulation instruments at its disposal in order to organize the system and create a transport policy. In concrete terms, what is involved is using the various transport modes in a genuinely complementary manner, on the basis of their respective qualities: public transport is well suited to carrying concentrated flows over relatively long distances and its environmental efficiency is better than that of the car. It is also necessary to influence demand by ensuring that it is affected not only by production costs but also by environmental and social impacts: pricing is the preferred policy instrument for expressing these costs and ensuring they are borne by users.

The policy implemented by the community must target equity: equity as regards covering production costs, equity as regards compensation for impacts (particularly environmental damage), and equity between users for access to transport.

0.3. Road pricing

Pricing provides financial resources which can be used for economic and social development and also in order to compensate for impacts. A range of transport pricing instruments exists, including taxes, tolls, and prices which are tolls that are modulated with respect to demand and the conditions of production. Recent technological developments make it possible to price use in an extremely precise manner. Although the equipment required is relatively expensive, it can be amortized by applying technical principles (harmonization and interoperability) and economic principles (durability, spatial extension).

A significant level of price is needed to have a noticeable effect on demand, as well as to provide scope for the action of a social policy for transport use.

Recent road pricing experiments have proved to be both effective and acceptable. They include urban systems, in London, Oslo, Stockholm, etc., and lane pricing systems that have been set up on road corridors, particularly in the United States. These policies are not restricted to pricing, they include a set of measures which provide compensations to most of the actors involved, which renders them equitable and possible to implement.

In return for payment, the road user receives an improvement in the quality of service which is obtained by decongestion or an increase in capacity.

0.4. The planning process and evaluation methodology

A transport policy has long-term effects, and developing and implementing measures constitutes a planning process. In this context, it is possible and desirable for the community to consider several options and evaluate them beforehand when developing measures so as to be able to foresee their impacts and evaluate their effectiveness with regard to the objectives. This is a rational technical and economic process. It is necessary in order to anticipate the reactions of all the impacted actors, according to their specific choice area, objectives and choice behaviour. The technical committee has identified a generic planning evaluation methodology. This includes: identifying impacts, objectives and issues; identifying and reviewing option scenarios; involving the public; simulating each scenario and evaluating its impacts; quantifying benefits and costs; and, lastly, comparing the impacts, benefits and costs of the different scenarios with a view to recommending some of them to decision-makers.

This methodology can be applied to a monomodal or a multimodal transport system. Its technical quality depends on the realism and outreach of the simulation model. This is particularly true as regards the representation of the interactions between transport modes and the formation of travel demand in relation to the location of activities and the system of settlements.

Its effectiveness relies on the design of the option scenarios.

Public involvement is desirable at all stages of the process: it improves the diagnosis of the impacts and problems, the design of scenarios and the discernment of interests for each category of actors.

In order to consider equity effectively, specific analysis must be performed for certain categories of actors. This relates to the issues that affect them, the impacts they generate or experience, their benefits and their costs, and their requirements for compensation.

The impacts to be evaluated involve the following topics:

1) as a priority, the direct economic effects of the service provided, in terms of production costs, and demand costs and surpluses.
2) immediate impacts in terms of accidents and noise and pollutant emissions.
3) more profoundly, the indirect economic effects on accessibility and land use, on the structure of production, on land and property markets; impacts on the quality of the local living environment, on the natural environment (the soil, water and air; animal and plant species).
4) Beyond this, health and climate impacts.
5) In addition, impacts on the cultural heritage.

An international survey of evaluation practices has revealed that topics 1) and 2) are evaluated and monetized, that topics 3), 4) and 5) are identified, and fairly generally evaluated qualitatively, occasionally evaluated quantitatively, and more rarely monetized. Climate impact can be monetized on the basis of a price per tonne of CO2.

More extensive monetization is important as a means of integrating impacts more effectively in the decision-making process.

Environmental and social impacts remain “soft factors” in that they do not exist on a market but are evaluated on the basis of social preferences. The diversity of regions and populations leads to important variations in the values of a given factor: ranges of 1 to 10 have been observed.

0.5. Topics for prospective thinking

Economic analysis should also be used to target prospective thinking to certain social issues which are assuming greater importance:

- the ageing of the population, with its consequences on the occupation of settlements, the housing market and travel needs.
- Energy consumption and prices, in relation to the burning of fossil fuels and its impact on the climate.

COMMITTEE MEMBER RESPONSIBLE FOR THIS REPORT

Fabien Leurent, France

1. INTRODUCTION

This introduction will examine the relationships between a society and its road network: the car is a very flexible transport mode that facilitates trade and structures travel flows (Section 1.1). But road infrastructure and traffic have environmental and social impacts which affect the community and which it attempts to control (Section 1.2). In this context, the economic approach is used in order to plan the development of the network in a rational way through the evaluation of planning projects and management policies (Section 1.3).

The first objective of the committee was to extend evaluation methods, on the one hand by broadening them to consider the multimodal transport system and on the other hand by deepening them in order to consider environmental and social impacts (Section 1.4).The committee’s second objective was to evaluate road pricing as an instrument for financing or regulating the transport system (Section 1.5).

After a description of the committee’s working method (Section 1.6) we shall explain the objective of this report (section 1.7) and describe its structure (Section 1.8).

1.1. Society and the road: the creation of a relationship of mutual dependency

Throughout the world, many human groups make frequent use of road transport. This use occurs at different geographical levels, in urban areas and interurban areas, and involves passenger travel or freight transport.

The road has considerable strong points:

- The fact that each vehicle is independent of the infrastructure it uses permits varied routes between the locations linked by the network. This individual nature frees moving actors from the need to consolidate flows which is inherent to public transport modes. This removes the periods of waiting for consolidation and the need to pass through consolidation nodes. The absence of these constraints makes it easier to modify the route in response to a disruption. The road thus provides a high degree of logistical flexibility for vehicles, allowing the individual making the journey to use the vehicle efficiently.
- Each part of the infrastructure is connected to the other parts of the network in a way which imposes little in the way of constraints. A simple level physical continuity is all that is required for the junction point, and each junction point can be managed simply and independently. In some cases, it is preferable to coordinate the management of neighbouring junctions, but performance is already satisfactory when they are managed independently. Thus, as a type of infrastructure the road provides a high degree of logistical flexibility for the network planner responsible for providing an area with transport facilities.

The road's intrinsic logistical qualities have been progressively strengthened by technological development. For vehicles, this development involves construction costs, ergonomics, reliability, journey distance between two refuelling stops and therefore the overall cost of vehicle use. For the infrastructure, technical innovation involves road materials, construction and maintenance techniques, traffic management techniques and the hierarchical organization of the network.

Together, these factors explain the extraordinary expansion of road transport since the start of the 20th century, in those societies that are sufficiently wealthy to progressively construct the facilities. In industrialized countries, car ownership increased and became commonplace in the second half of the 20th century, in conjunction with the creation of dense road and motorway networks which covered national territories. The use of vehicles and roads has become intensive at disaggregate level by individual motorists and road haulers. The process has occurred at a faster pace in countries undergoing rapid industrialization.

In the societies in question, road transport has developed concurrently with the exchanges it has facilitated and in association with the development of industrial production, which is itself linked to the increase in the population and the socio-occupational specialization of individuals.

1.2. A relationship that has reached maturity?

In any area with an extensive road network, the car, which has become commonplace, represents in social terms little more than a utility device, which serves various productive or optional activities, whose essential role is to provide a link between activities that are located in markedly different locations – in particular home and work for the economically active population.

Once car ownership became commonplace in society, the latter adapted spontaneously to this mode of transport: both the activity schedules of individuals and the processes of economic production have been modified by increasing the number of stages they include, and/or within a given stage, linking activities that take place in markedly different locations. The consequences are an increase of distances travelled by individuals and car dependency.

In addition, a car owning society not only perceives the basic advantages of road transport but also its impacts: ownership, use and production costs, the consumption of space, noise and pollutant emissions in the case of combustion engines, accident risks and the disruption caused in residential districts by the presence and movement of vehicles on the road.

In some areas, society that has become aware of these impacts and attempts to manage them rationally by introducing new adaptations, while at the same time preserving the operation of its economy. The principal aim of these second generation adaptations is to achieve a sustainable match between society's way of living and its road transport network.

To enlarge the scope of possible measures, the attempt is made to achieve a sustainable match between society and the multimodal transport system which includes the road network, public transport modes and environmentally-friendly modes (walking, cycling), and also travel demand i.e. the transformation of the activities desired by the population into transport needs.

1.3. The technical and economic approach to transport planning

The development of a transport network is a natural area for planning: the development process consists of creating links in order to connect locations, interconnecting the links and structuring them by providing each with a suitable capacity and level of service.

The rational technical approach to planning is as follows: a plan is developed and its consequences are evaluated by simulation, which is based on an appropriate model. The design-evaluation sequence may be applied in a repeated manner, which produces a series of tested plans from which a decision-maker and planner may select one in an informed manner, in principle with the aim of obtaining an "optimized" plan.

To concretize the rational nature of the approach, it is necessary to combine appropriate development of the plans, careful evaluation of the consequences, a simulation capability, realistic modelling and an optimality criterion which is appropriate both to the problem and to the planning issues.

The evaluation of the consequences and the determination of a utility criterion for selecting (or recommending) a plan are economic analysis tasks which supplement design tasks. The design of plans and the methodological application of the approach are engineering tasks.

The economic evaluation techniques that are used appeared as early as the 19th century while the engineering techniques were mostly developed in the second half of the 20th century. From the 1960s in industrialized countries there have been many applications to the planning of urban interurban road networks.

1.4. Objective 1: extending evaluation methods

The committee's first objective is to adapt and extend economic evaluation methods in response to changes in societal issues with regard to the transport system. On the one hand this involves broadening methods in order to deal with a potentially multimodal transport system and on the other hand it involves deepening methods in order to take account not only of the basic issues of matching transport supply with demand but also the derivative issues of environmental and social impacts.

Extending methods to multimodality involves both transport supply and demand. Multimodal supply is considered and the different modes are analyzed in isolation and in combination: the conditions of modal transfer, rules for access and use, and pricing. For demand, multimodal sequences in order to meet a travel need are considered, in addition to the choices between the various modal and multimodal services, as well as, when relevant, the nature of captivity which imposes the use of a particular mode.

Deepening methods to include social and environmental issues, known as "soft factors" is much the same in the case of all the modes. The identification of soft factors, the use of one or more indicators to characterize them, giving a qualitative or a quantitative value to an indicator, the possible monetization of a quantitative indicator are all difficult topics. In particular, any monetization coefficient represents social preferences which may vary from one society to another.

1.5. Objective 2: Road pricing as a funding or regulation instrument

The committee's second objective is to analyze road pricing as an instrument for funding or regulating the transport system. The impetus for this comes from recent experiments in road pricing, especially in London, Norway and Sweden, particularly Stockholm.

This is an instrumental objective, in contrast with the first objective which is methodological. However, the two are linked in two respects: first, the economic theory of externalities teaches that pricing can provide a means of internalizing the cost of the impacts of a good, and can therefore make consumers rather than those who experience the impacts bear the cost of the good whose impact may be compensated for by revenue from pricing. Second, the concrete introduction of road pricing not only has a direct intended effect but, because of the complexity of the transport system, indirect effects which may make it pointless or even undesirable. In particular, the effects as regards equity between different groups of users, or between users and non-users, present a risk of this type. Such effects must be anticipated in order to evaluate the scale on an a priori basis, which brings us back to the objective of evaluation.

1.6. The working method

The objectives have been covered by three subgroups within the technical committee.

The first subgroup dealt with the broadening of the evaluation methodology to consider a multimodal transport system. For this purpose a methodological framework was designed in order to characterize applications and study practices in the area of multimodal planning. This was used to design an international survey of practices, the results of which in turn reinforced the framework's structure.

The third subgroup dealt with the deeper consideration of environmental and social impacts, also on the basis of an international survey, which was supplemented by a technical seminar devoted to ex-post evaluation methods for road projects (held in Tokyo on 10 April 2007).

Road pricing was examined by the second subgroup, by collective analysis based on case studies dealing with a variety of urban, regional or national contexts: an international seminar on road pricing and its impacts was organized by the committee (held in Cancun, Mexico from 11 to 13 April 2005).

1.7. Aim and scope of the introductory report

The aim of the present report is to place the technical committee's work in context and in perspective, while presenting a fully detailed account. The principal topic is the technical and economic analysis of the transport system for planning purposes. The task is ultimately to understand the composition and operation of this system and the way in which a community can manage a concrete system in a way which is compatible with social, environmental and economic issues – in other words, in a way which matches society's needs.

The report describes the context created by a multimodal transport system: what are the respective natures of the different transport modes, i.e. what are their qualities, on the one hand for users and on the other for the community. It analyzes the environmental, social and economic issues. It describes some road pricing methods and some of their effects. We shall also briefly describe the contributions of the committee with regard to analysis techniques and the diagnosis of international practices. These areas receive fuller treatment in the three technical reports of the subgroups.

1.8. The structure of the report

Following on from this introduction, the body of the report contains five sections:

- Section 2 deals with multimodal transport planning. It explains the respective characteristics of the different transport modes from the passengers' standpoint. Some of these characteristics determine the use of modes by those wishing to make trips, but the community must consider all of a mode's characteristics, qualities and impacts in order to improve its transport system. We shall show how the characteristics of the different modes can be incorporated into a technical and economic planning process in which transport plans are designed as scenarios then simulated using a supply and demand model and impact models, and finally evaluated with regard to their economic, environmental and social impacts. We shall describe the components of a generic evaluation methodology and diagnose practice at international level based on a specific survey conducted by the committee.
- Section 3 will describe the fundamental concepts that relate to a society, namely equity and the formation of consensus with regard to the acceptance of a community project. We shall then explain the recent increase in societal awareness about transport, in developed countries, and describe its impacts on the planning process and the evaluation methodology. We shall then characterize transport issues and their impacts on society, making a distinction between the basic issue of functional performance, compatibility with the locality and economic, environmental and social priority issues. The section ends with a list of the themes of economic analysis, which contribute to achieving a sustainable match between society and its transport system.

- Section 4 deals with the integrated evaluation of road projects. The first stage in the evaluation of impacts is to consider each type of impact in a qualitative manner: quantitative indicators can be assigned to some types of impacts and these indicators may also be ascribed monetary values whose aim is to express collective objectives and which reflect social preferences. The committee has conducted an international survey of practices in a set of countries with regard to 11 impact themes: it has emerged that some themes constitute a “hard core**”** whose inclusion in evaluation is the subject of a consensus. Other topics are occasionally present, but not (or not yet) generally. Evaluation methods vary considerably depending on the nature of the impact. Ultimately, by bringing together the experience of the countries who responded to the survey, we have monetization principles for 10 of the 11 impact themes.
- Section 5 considers road pricing as an instrument of funding or regulation. After a description of the actors and their interests, the generations of issues and the economic and social principles, we shall discuss the objectives of pricing and list the principal instrumental forms. This section will then summarize specific types of experiments and pricing projects in order to draw lessons with regard to the objectives, impacts on traffic, equity, technologies and also acceptability of implementation. We will also discuss how to integrate road pricing within a transport policy.
- The conclusion, in Section 6, will turn to the scope of the analysis and our technical methods: systems analysis for investigation, decision-making aids for planning. We shall also describe the concrete reality of transport policies. This section also provides a survey of planning methods and indicates where more knowledge is needed. Last, it describes the emerging challenges of sociodemographic change in developed countries and energy and climate issues.

2. THE ROAD NETWORK WITHIN THE TRANSPORTATION SYSTEM

3. ON SOCIETY AND ITS STAKES AS FACED TO TRANSPORT IMPACTS

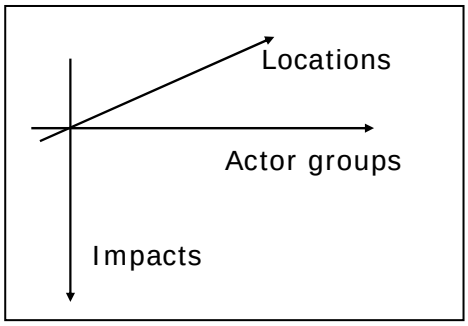

Figure 1 - Three-dimensional analyses of the equity issue.

4. THE EVALUATION OF SOCIAL AND ENVIRONMENTAL IMPACTS

5. ROAD PRICING

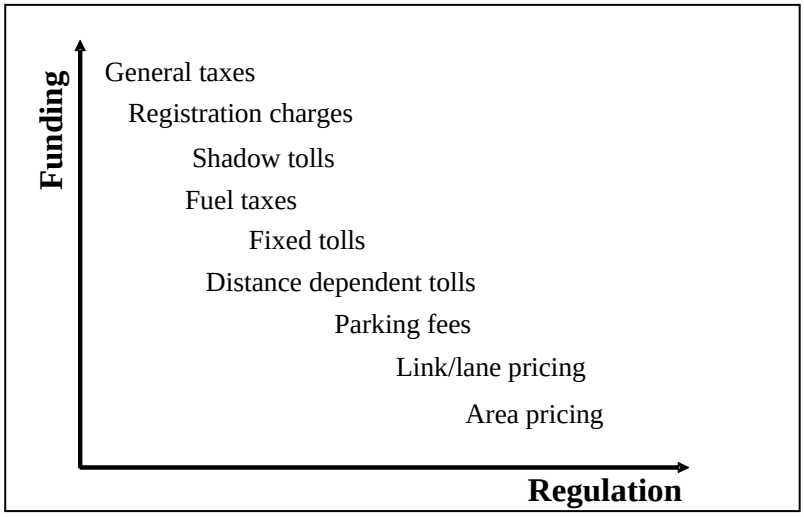

Figure 2 - Pricing tools. (Source: Rico Maggi and Friedrich Schwarz-Herda)

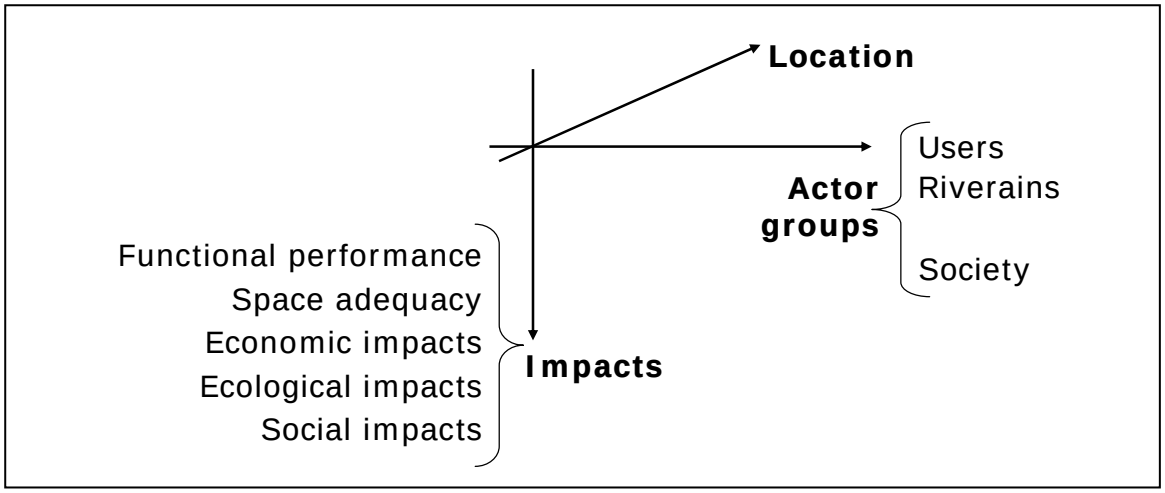

Figure 3 - Outreach of a policy.

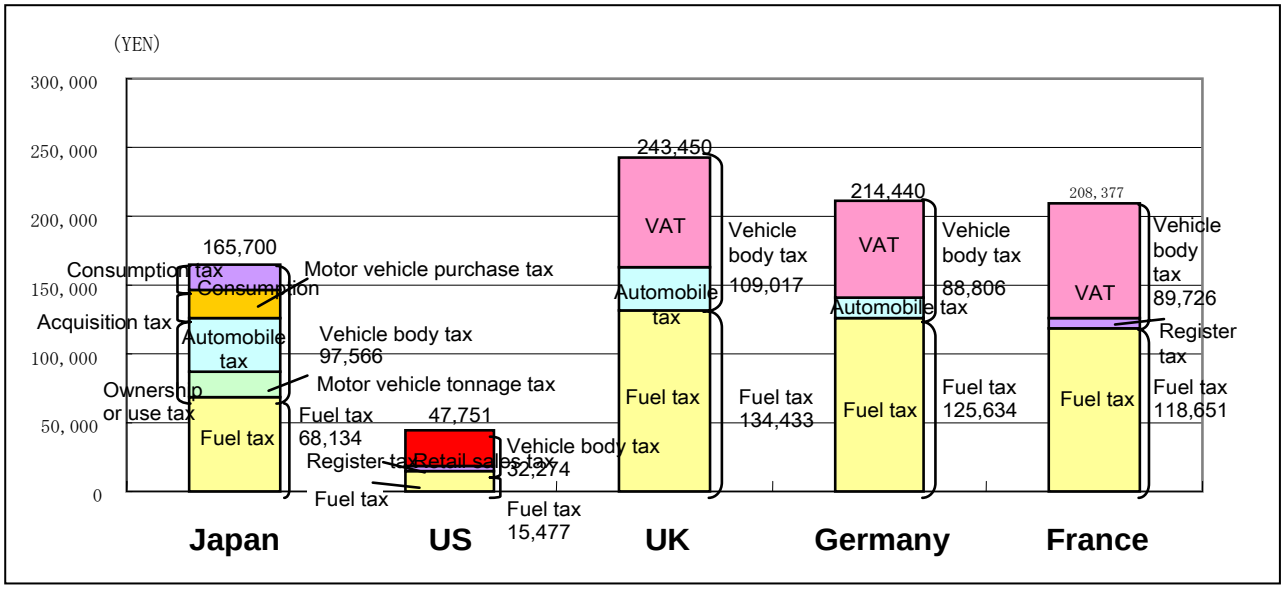

Figure 4 - Cost structures on car use for several countries.
(Source: Yukihiro TSUKADA)

6. CONCLUSION

6.1. Recapitulation of the scope of analysis

Figure 5 provides a graphic representation of the topics covered by our analysis:

- Road transport is part of the transport system. The car has remarkable specific characteristics: in terms of functional performance as a result of its range of speeds and its flexibility, in geographical coverage of the location as it provides dense access, but also in terms of the space it uses and its environmental and social impacts.
- Society uses transport to connect its members' settlements, in order for them to specialize their respective production activities and permit the exchanges required for the specialization of individuals and activities. The collective management of a transport system raises the issues of social development, equity between players and with regard to the different issues, as well as economic principles.
- The community management of transport pursues objectives in terms of functional performance and equity. It aims to achieve these objectives by means of transport policies, which are sets of measures that relate both to material and institutional aspects. It implements a policy by means of regulation instruments.
- Collective long-term management of the transport system makes up the transport planning process. In this process, management decisions may be developed by applying a rational technical and economic approach which includes the design of planning projects and policy, the evaluation of economic, environmental and social impacts, modelling and simulation, as well as the forecasting of changes.

- Of all the regulation instruments, pricing is the economic instrument *par excellence* as the price constitutes a market reward$ and a monetary payment$ for the service provided. Pricing revenue is an economic resource which can be used to finance the transport network or to compensate for adverse impacts. There is a range of pricing measures: modern technology permits very precise pricing of network use and its impacts and could also be used to implement transport-related social policies.

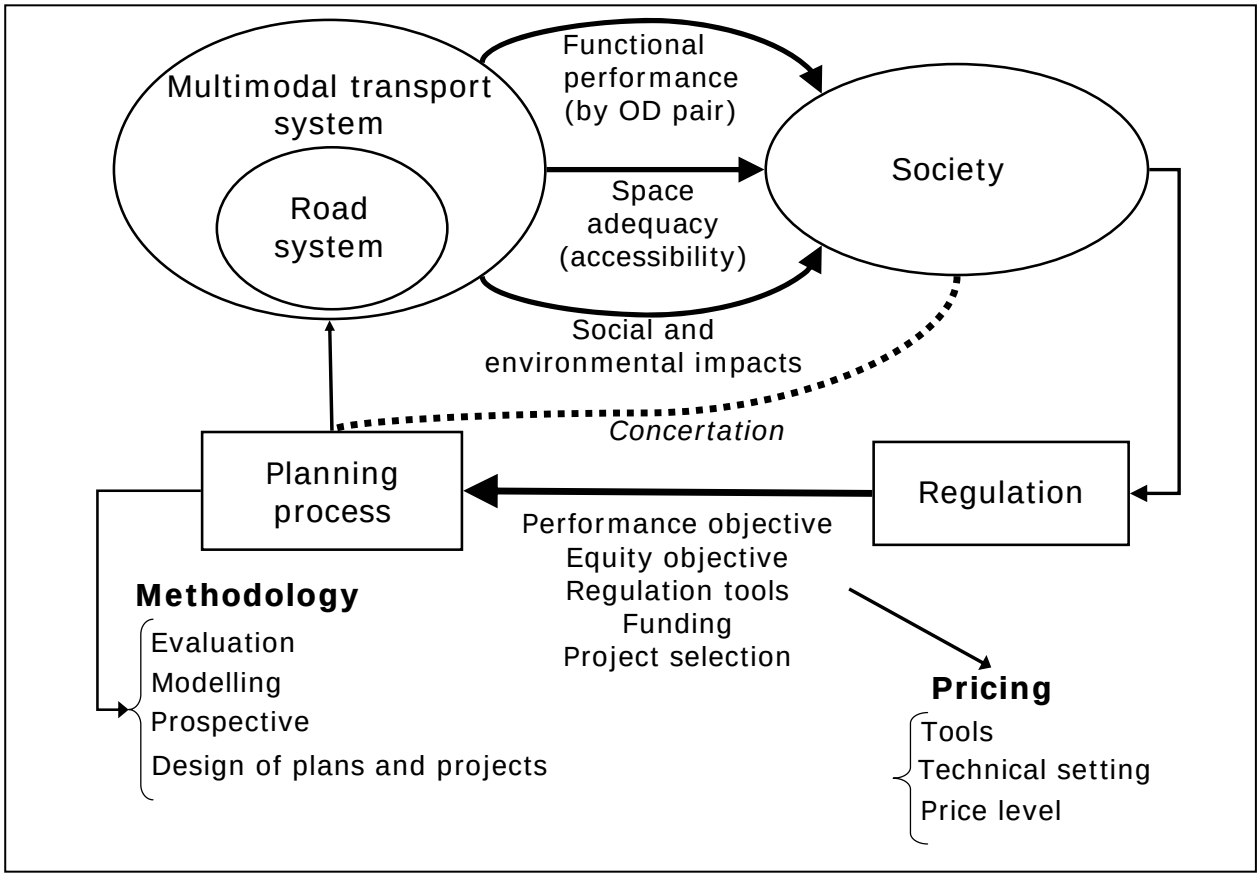

Figure 5 - Diagrammatic synthesis.

6.2. Systems analysis and a technical and economic approach

Consistent with the views of the scientific and technical community, this report and the work of the technical committee on which it is based are part of a rational approach to the transport system and its management. The two principal methods involved in this are:

- systems analysis which involves making demarcation between actors and identifying the relationships and impacts which make up the system, its component parts; and also performing analysis of the interests, goals and behaviours that are specific to each component and which determine the operation of the system.
- The technical and economic approach to decision aid in the planning context: management decisions are prepared by designing planning projects, by evaluating the impacts of projects using simulation models and by characterizing the respective qualities of alternative projects.

6.3. The concrete situation with regard to transport policies

Across the transport policies which are effectively applied two major types are apparent, which correspond to two generations of issues: on the one hand the creation of a main national network, and on the other hand the management of the main network in a way that limits both its direct impacts (service provided, links and access) and its indirect impacts (environmental, social).

The creation of a main network is covered by infrastructure policies which give priority to extending the network, its design and the quality of service it provides. Pricing can be used to finance this development. It is incumbent on the community to fix a target level for traffic, more on the basis of forecast impacts than funding needs: excessively rapid development of the network leads to attempts to maximize the revenue which is used for funding, and generates a level of traffic which is incompatible with community issues and that generates congestion and causes an unnecessary increase in transport infrastructure.

The management of a main network includes the coordination of the different transport modes on the basis of their respective qualities. The car is distinguished by its performance and flexibility but also its external impacts. Public transport is distinguished by its capacity and better environmental efficiency.

In this context, a transport policy appears as a “raft of measures” relating to the various modes. Pricing is one of the prime instruments for financing operation and additional investment, possibly by allocating the revenue from some modes to others. Road pricing can be used to finance the development of more economical transport modes such as public transport and environmentally friendly modes. This strategy is necessary in order to compensate those users who are willing to transfer from the car to other modes for the disbenefits they experience. Vice-versa, the attempt to achieve equity also makes it necessary to improve the quality of service of road transport, in return for the price paid by motorists.

6.4. The situation as regards planning methods

From the methodological standpoint, the scientific and technical community is agreed on the need for a rational approach to transport planning that follows a technical and economic approach which links together project design, the modelling of impacts, the evaluation of impacts, the simulation and comparison of projects on the basis of their impacts, and the recommendation of a preferable project.

There is also a consensus about the inclusion of economic, environmental and social impacts in this decision-making aid approach. Some of the impacts form a widely accepted “hard core” of impacts which are evaluated not only qualitatively but also quantitatively and monetarily. Other impacts, although recognized, are included in the planning process to a lesser extent or in a less general manner: their inclusion needs to be increased.

Other directions for progress are:

- the diagnosis of the transport system in the reference situation, taking account of the diversity of issues and the complexity of impacts. It is useful to monitor the state of the system on a continuous basis in order to observe changes and manage it dynamically by adjusting management measures and instruments.

- analyses for different actors and categories of actors in order to evaluate equity in the reference situation and equity issues with respect to a change in the system.
- the design of sustainable transport policies. One challenge is to coordinate measures which are specific to transport with measures that relate to spatial planning in order to plan jointly the system of settlements and the transport system.

6.5. Knowledge requirements

In order to improve decision making in the area of transport planning, scientific and technical knowledge needs to be improved in two areas:

- the evaluation of impacts and costs in concrete situations in order to discover empirical values and orders of magnitude. The exchange, dissemination and the comparison of empirical data of this type has still to be developed.
- economic analyses of transport, space and the environment are covered by specific economic theories which are fairly well developed, and also by integrated models which are not widely disseminated. It would be helpful to develop an integrated economic theory which includes their mutual interactions in a precise manner. A theory of this type is necessary in order to establish the fundamental economic principles of transport policies which are consistent with spatial, social and environmental issues.

6.6. Forecasting sociodemographic changes

Finally, we should mention two rising challenges which deeply affect transport planning: first, sociodemographic change, and, second, energy and climate issues.

In the developed world, lifestyles are becoming more diversified and fragmented as a result of the diversification of the “demographic profiles” of individuals and households. It is likely that the impacts on transport practices will be mixed: on average, among individuals, the locations of activities and therefore trips are becoming more diversified; at overall system level, we can expect traffic flows to become more highly spread both in space and in time, which will tend to mitigate the deterioration in the quality of service in the periods with the highest demand.

There is nevertheless a danger that the diversification of trips will result in an unnecessary increase in travel distances. Two policy levers exist in order to counteract this tendency, the spatial planning of settlements and activities (in order to restructure demand) and transport pricing (in order to influence demand).

In some developed countries, the ageing of the population is another major issue. Each generation has age-specific travel needs, and the means of transport need to be adapted to suit the needs of seniors. More deeply, the presence of a large elderly population tends to impose stability on the housing market, as remaining in one’s main home for a long time reduces housing supply. In addition, the desire of elderly generations to own a second home competes with the demand of younger generations for a main home, which affects prices and forces to a high proportion of young persons to live far from their work and travel by obligation rather than by choice. This is another major issue for spatial planning and social policy: it is important to facilitate residential mobility while encouraging any change which reduces the distance between the home and the location of activities.

6.7. Energy and climate challenges

Recently, at international level, there has been an increase in the consumption of fuel and more particularly oil and natural gas, in particular because of rapid economic development in South-East Asia.

This increase in the consumption of fossil fuels leads to an increase in greenhouse gas emissions and therefore contributes to global warming. This is a global challenge for human societies.

In view of the nature and dissemination of current technologies, in the medium term the principal solution seems to depend on each society saving energy in the transport activities associated with its production and economic exchange activities.

However, costly investment is required to become energy economical. This applies particularly to the transport sector because current vehicle technologies rely very heavily on fossil fuels.

How would it be possible to finance the energy restructuring of the transport system? This is a difficult issue as on energy markets the increase in consumption has been accompanied by a considerable price increase. This affects private transport costs and means the transport budget of some households is already strained, so it would be unacceptable to raise prices in order to allocate the resulting revenue to restructuring.

An ideal solution would be for international cooperation to bring about a “climatically virtuous” use of revenue from oil and gas. However, this idea seems somewhat utopian, in particular because the producing countries are allocating their revenue on infrastructure plans for uses that consume a great deal of energy…

For consumer countries, the main solution probably lies in the spatial reorganization of activities, combined with transport pricing; the two instruments should be managed jointly so that the revenue from pricing can be used for spatial reorganization and so that prices capture the demand surplus in order to avoid any tendency to exploit the reorganization by increasing activity programmes and travelled distances.