HOW USEFUL ARE SCENARIOS?
A NEW (OLD) APPROACH IN TRANSPORT PLANNING[1]

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Introduction

Scenarios are descriptions of future developments based on explicit assumptions. As a method for exploring the future, they are superior to more rigorous forecasting methods such as statistical extrapolation or mathematical models if the number of factors to be considered and the degree of uncertainty about the future are high.

This clearly applies in the case of transport. Transport is closely interrelated with almost all aspects of human life, is linked with social and economic developments, is influenced by technological developments and is subject to numerous political and institutional constraints.

Moreover, transport has become one of the most controversial fields of planning on all spatial levels. On a European scale, the transeuropean networks as specified in the Maastricht Treaty are designed to reduce the peripherality of remote regions, but in fact are more likely to reinforce the accessibility advantage of the regions in the European core. On a national level, large-scale transport infrastructure projects are increasingly the object of conflict between economic and environmental interests. On the urban level, finally, it is becoming more difficult to mediate between the conflicting goals of mobility, social equity and environmental sustainability.

At the same time the speed of technological and social change is increasing, so that the time for deliberation about policy alternatives is reduced. Decisions in different regions and countries of Europe are becoming more interdependent, so the need for consultation and negotiation is growing. The political system is less and less able to produce consensus solutions in time, so in many cases planning processes are delayed by court rulings.

These changes have also affected the character of transport planning. Traditional transport planning methods followed the engineering paradigm of optimisation of a single goal for a single client in a stable world. These methods are poorly suited for a multi-agent, multi-objective fast-changing policy environment. In particular the traditional type of transport study based on travel-demand forecasting models has become criticised as being technocratic and positivist, because it has too often been misused to justify just another extension of the road network at the expense of public transport or softer transport modes such as walking and cycling. The new decision environment of transport planning requires other planning methods which are more adaptive to change and more open to a broader set of human values.

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Scenarios have the potential of being such a less rigorous and more open method of exploring the future. Perhaps they are the only method to identify 'corridors' of relevant and feasible futures within a universe of possible ones. Scenarios have, in relative terms, only moderate data requirements, permit the incorporation of expert judgment, and, in conjunction with appropriate techniques such as Delphi, facilitate the process of converging initially different views towards one or possibly a few dominant opinions. Scenario writing as a group exercise has the potential of generating awareness of factors and impacts which may have not been identified through more formal forecasting methods. Used in public planning discussions, scenarios have the potential to translate expert opinion into a format comprehensible also to non-experts and so to stimulate the debate between the expert community and the public.

Because of these advantages in recent years scenarios have become a popular alternative to the standard type of transport study based on transport models. In German local governments, for instance, transport modelling studies have been largely displaced by *Verkehrsentwicklungsplanung* (transport development planning), a publicly mediated process of exploring future options of local mobility encompassing all modes of transport (including walking and cycling) and taking account of a comprehensive set of planning goals such as efficiency, equity and environmental sustainability. Scenarios are the central methodological instrument of this process, whereas quantitative modelling, if used at all, plays only a subordinate role.

Although scenarios undoubtedly have enriched the methodological vocabulary of transport planning and freed it from some of the constraints of technocratic and positivist transport modelling, their widespread use is not without risks. Qualitative scenarios, like all qualitative methods, suffer from a lack of objectivity and accountability. They contain a large share of subjective judgment and intuition and are not easily checked for logic, consistency and plausibility. That may be sufficient or even appropriate in policy environments involving a high degree of uncertainty and contingency, in which the future development depends on a host of exogenous factors that are partly unknown or cannot be quantified or be controlled. In a field such as transport planning, however, where the environment of the system of investigation is better known, some more concreteness, accountability and quantification of the scenario results would be desirable.

Therefore in recent years hybrid forms of transport planning combining scenarios with quantitative mathematical models have been developed. In these applications typically 'soft' or qualitative methods are used to project the evolution of the environment of the transport system in terms of technological, economic or social 'megatrends', but quantitative methods, usually mathematical simulation techniques, are used to model the evolution of the transport system itself subject to these megatrends and in response to alternative assumptions about changes in the environment or policy options.

These new approaches are not at all new to transport planning, which always has compared between alternative solutions. However, the new scenario-model hybrids differ from traditional modelling approaches by their incorporation of qualitative expert input and by their consideration of a wider range of policies and a broader set of planning objectives.

The following paper attempts to examine the usefulness of scenario methods for transport planning, including such hybrid approaches. After a brief section on the history, definitions and terminology of the scenario method, seven recent applications of the scenario method to transport planning on different spatial levels, using scenarios for different objectives and of different degrees of 'qualitativeness' are presented. The paper closes with a few recommendations on how the potential of the scenario method might best be exploited without falling victim to its pitfalls.

The Scenario Method

The term scenario originated in theatrical practice where it indicates "an outline of the plot of a play, film, opera, etc. with details of the scenes, situations, etc." (Oxford Dictionary), but today it is understood more generally as a description of future events for strategic planning. The predecessors of scenarios for planning were war games developed in military science in the 19th century, but the first use of the term dates back to Herman Kahn, who since the 1950s used scenarios as a new method of futures exploration. According to Kahn, a scenario is "a hypothetical sequence of events constructed for the purpose of focusing attention on causal processes and decision points" (Kahn and Wiener, 1967). The scenario method was further developed by Erich Jantsch in technological forecasting as "a technique which tends to set up a logical sequence of events in order to show how, starting from the present (or any given situation), a future state might evolve step by step" (Jantsch, 1967).

The rise of the scenario method coincided with the growing popularity of systems theory (von Bertalanffy, Mesarovic) and systems-based models (Forrester, 1961; 1969; 1971; Meadows et al., 1972). These models contributed much to the awareness that social and economic systems, just like natural systems, are highly complex and contain multiple feedbacks and nonlinear behaviour and are therefore difficult to predict. At about the same time the energy crisis and various environmental disasters seemed to confirm that there were ultimate 'limits to growth' and that structural stability was an exception and not the rule, a perception underlined by new theoretical contributions dealing with bifurcations, catastrophes or chaos in system behaviour. It became commonplace to see the future of human societies no longer as a predetermined extension of the past but as open, contingent and mouldable by political action or social movements.

Under these conditions the failure of traditional forecasting methods became obvious. Retrospective studies of population forecasts or, most notoriously, of energy forecasts, revealed that these had consistently failed to anticipate changes outside their narrow domain of investigation and so created an illusion of precision and reliability. Complex forecasting models incorporating more factors fared better in this respect, but were expensive, slow in implementation, and difficult to explain and to communicate to decision makers.

As a consequence, scenarios as a less rigorous, but more open, method of exploring the future have become quickly popular in many fields of corporate and public planning. Today the energy and automobile industries use scenarios as a standard method for technological forecasting (cf. Svidén, 1989), but also pharmaceutical and electronics companies, banks and insurances use scenarios for their strategic planning. Increasingly also applications of the scenario technique for spatial planning, including transport and environmental planning, are reported (e.g. Arras, 1984; Kämper and Kunzmann, 1992; Sieber, 1993).

So the success of scenarios can partly be explained by a loss of confidence in traditional forecasting methods vis-à-vis a rapidly changing world of growing complexity. Given this complexity, scenarios are perhaps the only method to identify 'corridors' of relevant and feasible futures within a universe of possible ones. Scenarios have, in relative terms, only moderate data requirements, permit the incorporation of expert judgment, and, in conjunction with appropriate techniques such as Delphi, facilitate the process of converging initially different views towards one or possibly a few dominant opinions. Scenario writing as a group exercise has the potential of generating awareness of factors and impacts which may have not been identified through more formal forecasting methods. Used in public planning discussions, scenarios have the potential to translate expert opinion into a format comprehensible also to non-experts and so to stimulate the debate between the expert community and the public.

Scenarios can be used in several phases of the planning process. Most frequently they are used to compare potential strategies or policies; however, they can also be applied in the goal formulation step or simply as a tool to explore the future. The most important distinction is between *explorative* and *normative* scenarios (Jantsch, 1967):

- *Explorative* scenarios present alternative futures as they will most likely occur given a certain constellation of assumptions and policies. There are two types of explorative scenarios: The *trend* scenario corresponds to a status-quo forecast; it represents the most likely future if all existing patterns and trends (e.g. in population, lifestyles, economy, technology, etc.), including all regulations and policies, remain in effect. *Alternative* scenarios, however, are scenarios on which one or more of these patterns, trends, regulations or policies are experimentally changed. In other words, alternative scenarios answer questions such as: "What would happen if ...".
- *Normative* scenarios, on the other hand, present a desired future state and show the way how to get there, in other words, they answer questions such as "What do we need to do to achieve that target?". Therefore they are usually called *target* scenarios. *Contrast* scenarios are normative scenarios confronted with a negative (or horror or nightmare) scenario; frequently the trend scenario serves as the horror scenario.

In some applications scenarios are used within a Delphi procedure, in which a panel of experts is asked to respond to scenarios pre-formulated by the study team in order to initiate a discussion process. Such scenarios are called *seed* scenarios.

Scenario writing typically proceeds in the following six steps:

1 *Issue*. Identify the problem (policy issue) and the object of study of the scenario exercise.

2 *Analysis*: Identify the current and most likely future environment of the object of study (facts, values, tensions, policies etc.).

3 *Assumptions*. Make consistent assumptions about alternative future developments of the environment of the object of study.

4 *Scenarios*. Describe the likely response of the object of study to the most likely and the alternative developments.

5 *Evaluation*. Evaluate the impacts of the trend scenario and the alternative scenarios on the problem (policy issue).

6 *Conclusions*. Discuss the policy conclusions of the results.

The *time* horizon of scenarios is generally long-range. Medium-term scenarios covering a time of between ten and twenty years are useful for forecasting material or technological change; however, if social change (values and attitudes) are to be taken into account, long-term scenarios of twenty and forty years are more appropriate. It is recommended that scenarios consist of a sequence of time frames showing the expected state of the object of study in five- or ten-year intervals.

Scenarios can also be classified with respect to their applied *logic* (Svidén, 1989). In most cases, scenarios rely on 'intuitive logic', which is perceived immediately without reasoning. In other cases scenarios are credible because of their quality as literary fiction; in this sense utopian or science fiction literature are scenarios. Also programmatic manifestos or idealist visions are in a sense normative scenarios; their impact rests on their political or moral attraction and not necessarily on their logic. Scenarios built on expert opinion are likely to be more

reliable and consistent than those built on intuitive logic. The highest degree of logic and consistency have scenarios based on expert opinion supported by mathematical models. The reliability of scenario results is improved if only differences between comparable scenarios are considered, because the errors included in all scenarios cancel out in the comparison.

A final way to classify scenarios is by *style* of presentation. The standard qualitative scenario is, of course, a verbal description of what will happen. However, today other, more suggestive modes of presentation have become popular. The most frequent scenario style is the flashback or retrospective narrative by a person imagined to look back from a point in time in the future. Other favoured styles are hypothetical radio interviews or newspaper articles at a future date. These styles exploit the effect that familiar things presented by an outsider take on a different character which may stimulate a new way of thinking about them - this is the 'alienation' principle used by Brecht in his plays. However, scenarios used in combination with quantitative models can be presented using familiar techniques of data representation such as tables, diagrams or maps.

Seven Applications

In order to examine the contribution of the scenario method to transport planning, in this section six applications of scenarios to transport policy issues are presented. The applications range in geographical scale from European to urban issues and differ in their degree of formalisation, from very qualitative and verbal to strictly quantified and mathematical. They deal with as diverse topics as the future development of transport and communications in Europe (1), the regional impacts of the Channel Tunnel in the European Community (2), NO_x emissions of motor vehicles in the Netherlands (3), future spatial development in the Randstad (4), transport development in a small German town (5), and energy consumption of traffic in a larger German city (6). As a final example, a proposal to develop a user interface for the combination of scenarios, simulation models and evaluation procedures (7) is presented.

(1) The Future of Transport and Communications in Europe

In 1986 the Network for European Communications and Transport Activity Research (NECTAR) was set up under the auspices of the European Science Foundation to promote international collaboration and the exchange of experience in the field of transport and communications. One of the core research areas of NECTAR developed long-term scenarios of transport and communications in Europe in a Delphi framework in order to identify relevant fields for future transnational research projects from a European perspective and to discuss alternatives for an integrated European transport and communications policy (Masser et al., 1992). The year 2020 was chosen as the forecasting horizon. The respondents included transportation engineers, planners, economists, geographers, sociologists, psychologists and political scientists from both highly industrialised countries in the European core and less industrialised peripheral countries.

In order to stimulate thinking in terms of fundamental options for the organisation of postindustrial society in time and space, *seed scenarios* covering all aspects of transport and communications in their social, economic, technological and political context were compiled and presented to the respondents. The seed scenarios represented three major paradigms or global scenarios associated with the keywords *Growth*, *Equity* and *Environment*:

- *The Growth Scenario (A).* The first scenario showed the most likely development of transport and communications in Europe if all policies emphasised economic growth as the primary objective. This would most probably also be a high-tech and market-economy scenario, with as little state intervention as possible. This scenario might be associated with the political ideals of many current conservative governments in Europe.
- *The Equity Scenario (B).* The second scenario showed the impacts of policies that primarily try to reduce inequalities in society both in terms of social and spatial disparities. Where these policies are in conflict with economic growth, considerations of equal access and equity would be given priority. This scenario might be associated with the typical policy-making of social-democrat governments.
- *The Environment Scenario (C).* The third scenario emphasises quality of life and environmental aspects. There would be a restrained use of technology and some control of economic activity; in particular where economic activities are in conflict with environmental objectives, a lesser rate of economic growth would be accepted. This scenario might be associated with the views of the Green parties throughout Europe.

In order to make it easier to understand and compare the seed scenarios, they were assembled from less comprehensive 'component scenarios' covering population, lifestyles, economy, environment, regional development, urban and rural form, goods transport, passenger transport, and communications. Each component scenario was a description of the likely development in its field under the assumptions of one of the three global scenarios. To facilitate the assessment of the contents and likelihood of occurrence of the component scenarios, common *background information* was provided for each field including information on past trends, present condition, most likely future trends, opportunities and constraints and policies. Figure 1 shows as an example the three component seed scenarios for *Environment.*

The results of the scenario exercise were both qualitative and quantitative. The qualitative results consisted of the written comments of the respondents to the seed scenarios. On the basis of these comments a fourth scenario combining elements of scenarios B (equity) and C (environment) was assembled that the majority of the respondents considered more desirable than the most likely scenario A (growth). In quantitative terms, this result was underlined by their responses to two standardised questions asking which of the seed scenarios were considered to be (a) most likely and (b) most desirable. The first question showed how the respondents *viewed* reality and the second how they *wished* reality should be; the difference between the two can be interpreted as a *measure of satisfaction.*

Only one example for the results can be given here. In Figure 2 the responses are aggregated by European region in a triangular coordinate space the corners of which are associated with the three overall goals growth (A), equity (B) and environment (C). Each response or group of responses can be located in this coordinate space as a pair of points indicating the 'most likely' scenario (hollow circle) and 'most preferred' scenario (solid circle). It can be seen that the respondents from the northern countries were the least satisfied and the most environmentally concerned. Their colleagues from Mediterranean countries, though some of them were likely to favour the expansion of the transport and communications infrastructure in their countries, thought that protecting the environment is even more important, however, their preferred scenario was closer to equity than to environment because they knew about the disadvantages of being poorly connected. It may seem surprising that the respondents from the Mediterranean countries had the highest satisfaction index, though clearly their infrastructure is less developed. The high index merely indicates that they were less in opposition to the growth-oriented policy in their countries and wished only to make minor adjustments.

Environment

Growth Scenario

In the year 2020, the 800-km train ride from Paris to Berlin takes less than two hours. In a deregulated transport market, only the *SuperTrain* survived against the competition of the airplane and automobile, regional passenger and freight service have long been abandoned (about 2005). As a consequence, the car and truck populations of Europe have doubled since 1990, and so have congestion and pollution on motorways and in urban areas. A completely new network of European toll motorways is nearing completion, some of them cut through the last remaining national parks. The first truck-only motorway was opened in 2003. Congestion in London is controlled by rigorous road pricing: the City cleared for the Rolls Royces. Rome and Athens are drowned under a sea of illegally parked cars and permanent smog, most of their antiquities are permanently damaged.

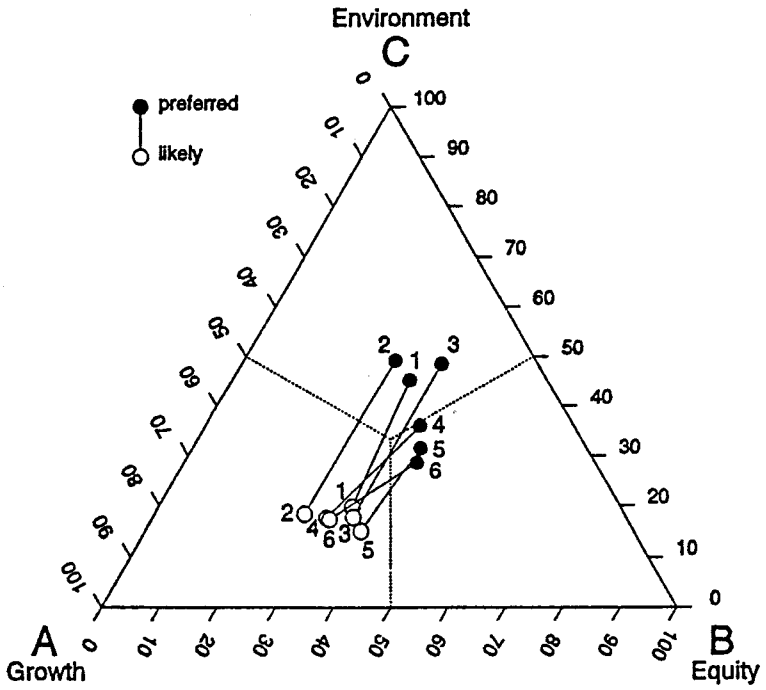
Equity Scenario

It had not been easy to resist the pressure by the national railway companies to close down unprofitable rural services, but the European parliament had agreed that the only way to reduce the disparities between central and peripheral countries in Europe was to promote decentralization. This meant less money for the high-end infrastructure such as airports, high-speed trains and high-capacity telecommunication networks, but more support for the modernisation of the rail and highway systems of Portugal, Spain, Greece and Turkey. This policy was only partly successful. It did help to reduce regional disparities within Europe, but it also constrained its global competitiveness in the eyes of the international business community. In addition, the policy had the undesired side effect that some of the few remaining natural reservoirs at the Black See coast and in the Algarve fell victim to industrial and commercial development.

Environment Scenario

By 2010 Europe has become a leader in environment-conscious policy-making. Despite heavy controversies during the 1990s, finally legislation to clean up the North Sea and the Mediterranean was passed. Emission standards for industry and transport are stricter than in the USA and Japan, the use of fossil fuels has been kept constant since 1995. Several large transport projects such as the *Transrapid*, the second Brussels airport and the St. Gotthard base tunnel were abandoned. Heavy taxes on car ownership and petrol brought car ownership down and made public transport almost profitable. Many people, not always voluntarily, moved back into the city; this was good for small cities, but in large metropolitan areas commuting times have become excessive. Fortunately, the introduction of the three-day work week in 2006 has made this more acceptable.

Figure 1. The three component seed scenarios for Environment. Source: Masser et al. (1992).



Region	Index
1 Scandinavia	74.5
2 Benelux	68.8
3 Central Europe	69.2
4 British Isles	74.5
5 West Mediterranean	81.4
6 East Mediterranean	79.1
Total	75.0

Figure 2. Delphi responses to seed scenarios by European region. Source: Masser et al. (1992).

(2) Impacts of the Channel Tunnel

The prospective opening of the Channel Tunnel in conjunction with the emerging European high-speed rail system is stimulating the imagination of national and regional policy makers in north-western Europe. Today, the British Channel with its ferry services presents a major transport barrier to free movement of passengers and goods in Europe. When through the Channel Tunnel this bottleneck will be removed, significant impacts on regional development at either end may be expected. Will the impacts be limited to the regions directly adjacent to the Tunnel exits, or will they be spread out over a larger area? Will they be more pronounced at the British or at the continental end? Will the Channel Tunnel benefit mostly the already highly industrialised and urbanised regions in central Europe and so increase concentration of activities and hence spatial disparities in Europe, or will it tend to equalise the accessibility surface in Europe and hence have a decentralisation effect?

These questions were investigated for the Commission of the European Communities by an international team of experts (ACT et al., 1992). The study was organised in two parallel but interrelated parts: the first included *qualitative* regional analyses based on interviews with regional decision makers in thirteen case study regions, the second applied a *quantitative*

computer model. The MEPLAN transport and regional economic model by Marcial Echenique & Partners was used to estimate the demand for both passengers and freight transport based on a regional input-output model framework, in which the demand for transport and the pattern of regional economic development are influenced by the costs and characteristics of transport. The model provided results for whole area of the EC aggregated into 33 regions. The transport infrastructure available in a specific year was the basis for the estimation of travel costs and times between every pair of zones in that year. This produced a pattern of accessibility which was used to determine the flows of trade and passenger movements between zones, which were transformed into tonnes of freight and number of passengers by mode between each pair of zones. These flows were then assigned to vehicles on the links of the transport networks. Starting with 1986 as the base year, for which the calibration of the parameters of the model was carried out, the model was run at five-year intervals until the year 2001.

Different scenarios were used to represent the effects of the Tunnel either built or not and different levels of development of the rest of the road and rail networks (see Figure 3). Scenario A represented the current network without the Tunnel. Scenarios B (without Tunnel) and B1 (with Tunnel) assumed a limited network development with substantial motorway construction, but only a medium level of rail upgrading. Scenarios C (without Tunnel) and C1 (with Tunnel) assumed an extended network with a substantial number of further new high-speed rail services.

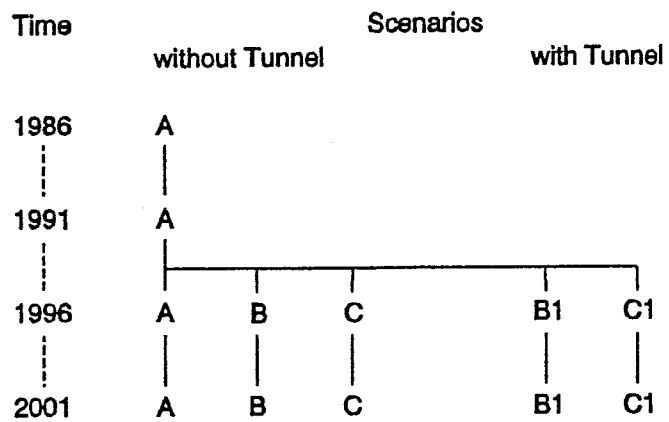


Figure 3. Simulated network scenarios of the Channel Tunnel study. Source: ACT et al. (1992).

Only one example of the results produced by the study can be given here. The effects of the Tunnel on European transport flows are the results of many complex, interacting influences. Therefore the impacts are not confined to the regions close to the Tunnel, nor do they decrease in a simple way with distance from the Tunnel; rather a more complex picture of interaction of travel time, modal characteristics, regional characteristics and orientation to the Tunnel emerges. Six types of regions with different types of impacts emerge (Figure 4):

- *Tunnel competitors with strong impacts:* In these regions close to the Tunnel exits ferry lines will initially lose traffic to the Tunnel, but in the long run will recover due to the overall growth in cross-Channel traffic.

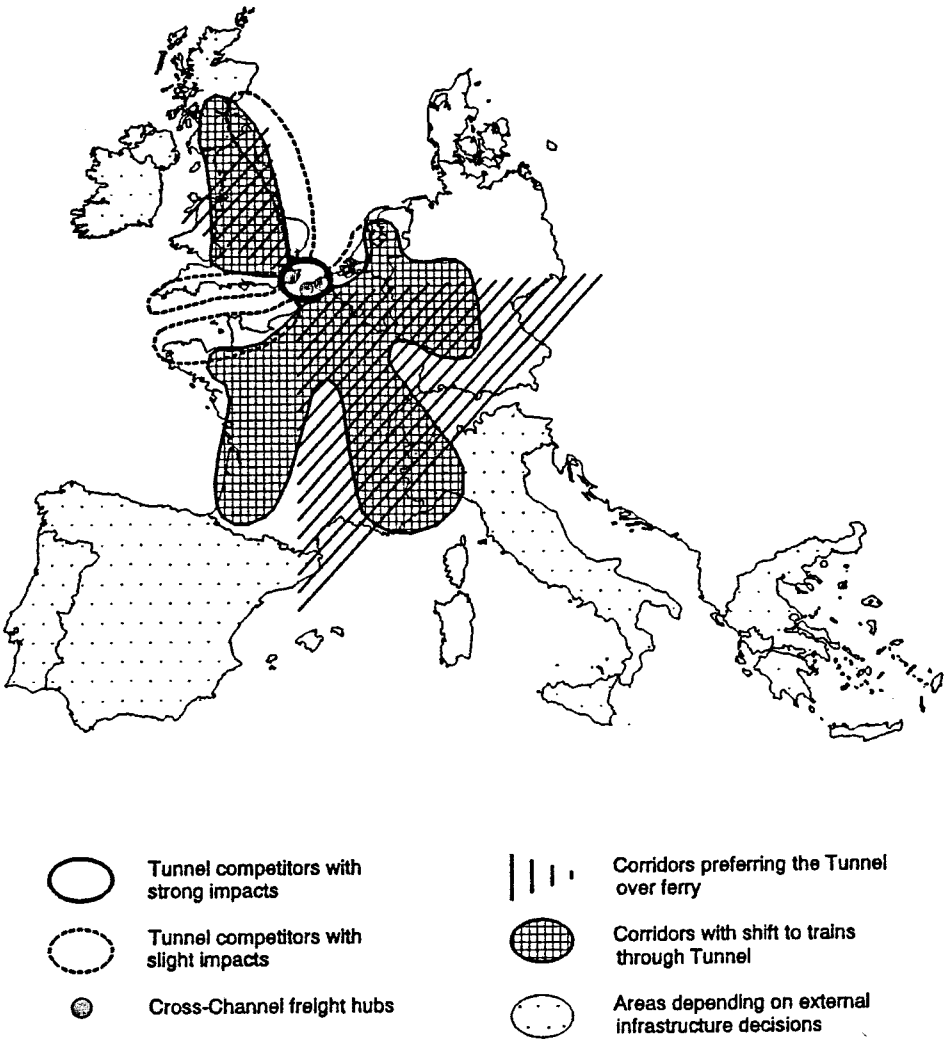


Figure 4. Impacts of the Channel Tunnel on transport flows. Source: ACT et al. (1992).

- *Tunnel competitors with slight impacts:* In coastal regions farther away from the Tunnel ferry lines will only experience light reductions in traffic due to the Tunnel.
- *Cross-Channel freight hubs:* Kent, Nord-Pas-de-Calais and West-Vlaanderen will serve, as today, as main freight hubs between mainland Europe and the UK after the opening of the Tunnel.
- *Corridors preferring the Tunnel over ferry:* Regions in a triangular area along the extended Tunnel axis on both sides of the Channel will prefer the Tunnel over the ferries for cross-Channel road transport.
- *Corridors with shift to trains through Tunnel:* Regions along the future European high-speed rail corridors will see a shift towards rail for cross-Channel passenger transport.
- *Areas depending on external infrastructure decisions:* Regions outside of the influence of the Tunnel depend on infrastructure decisions taken by other countries or the European Community.

In methodological terms, the Channel Tunnel study was innovative in the way it combined the qualitative regional analyses with the quantitative model. The hypotheses generated in the regional analyses were input to the testing and calibration of the model; the data collected for the case studies were similar to those needed for the model; the case studies provided the information which new transport infrastructure was to be examined in the model. In the final phase of the project, the results of the two methodologies were brought together. It was examined where the impacts of the Tunnel on transport flows and regional economic development predicted in the model scenarios were in line or in disagreement with the expectations expressed by the policy makers and experts in the regions. Where there was disagreement, it was discussed whether the model might have lacked essential information or whether the views held in the particular region had been unrealistic.

(3) NO_x Emissions of Road Traffic in the Netherlands

The Second Transport Structure Plan of the Netherlands (Ministry of Transport and Public Works, 1990) is more than a collection of infrastructure plans but covers the whole of transportation policy, encompassing elements which have no land-use implications as well as those with an environmental-planning dimension. It differs from the previous Transport Structure Plan by proposing clear policies and choices based on a realistic financial framework.

To achieve this, the plan contained a section of specific policies linked to four overall strategic goals: improving accessibility, managing mobility, improving environmental amenity and removing obstacles to implementation. For each policy, a target scenario was developed specifying the situation to be achieved by 2010 and the policies to be implemented to achieve that target. As an example here the target scenario for Policy 12, "cutting air pollution", in Category 3, "improving environmental amenity" will be presented. The target scenario for Policy 12 consists of the following objectives:

- emissions of nitrogen oxides and unburned hydrocarbons by road vehicles will be at least 75 percent lower in 2010 than in 1986;
- in the case of private cars emissions of nitrogen oxides and of unburned hydrocarbons per kilometre travelled will be respectively 80 percent and 90 percent lower than in 1986;
- in the case of heavy goods vehicles and buses emissions of these substances per kilometre travelled will be 75 percent lower than in 1986;
- measures to enhance efficiency will limit the growth in the number of lorry movements.

Figure 5 illustrates how much policies such as cleaner engines or mobility management in the case of cars, or energy savings, cleaner engines, more efficient operation, modal shifts and road pricing in the case of lorries are expected to contribute to achieving these objectives. In both scenarios the trend in traffic growth is taken account of, and all reductions start from the higher level of traffic expected for 2010 if no mobility management measures are taken. In both scenarios the targeted reduction is not attained by the measures currently envisaged so that there remains a residual amount of reduction to be achieved after 1995. All policies proposed in the target scenario are discussed in detail with respect to feasibility, public acceptance, chances of enforcement, certainty of impact and financial consequences for both the government and private users.

The target scenarios of the Second Transport Structure Plan have a model character because they inform decision makers and the public about the range, feasibility and likely impacts of policies to arrive at a socially balanced and environmentally sustainable transport system. They are highly informative because they indicate the approximate magnitude of the contribution

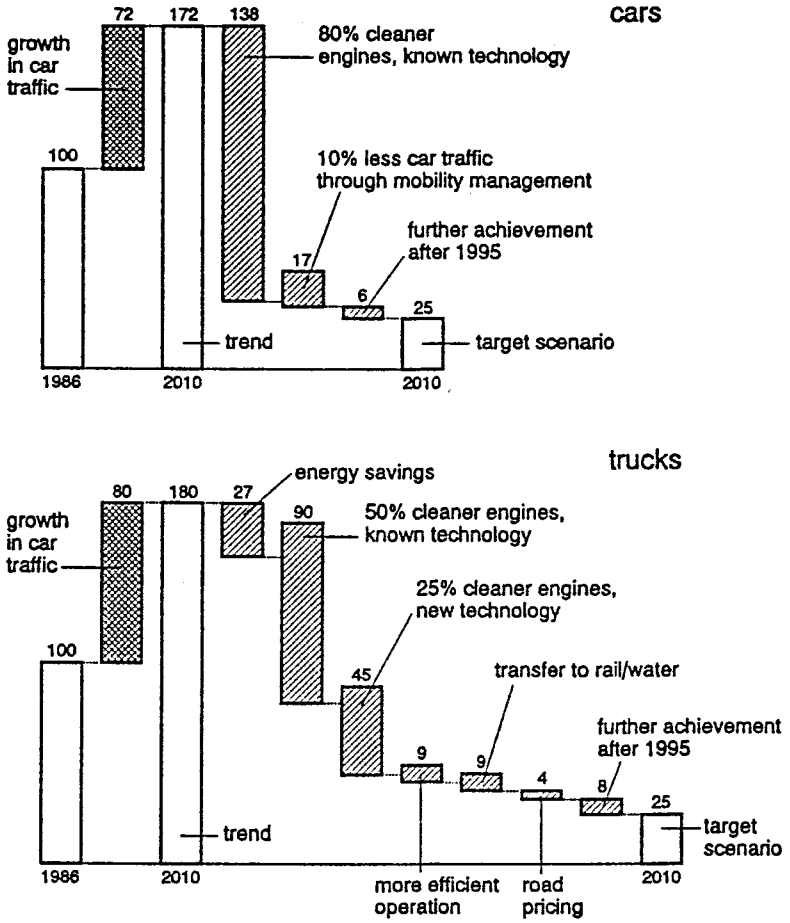


Figure 5. Reduction of NO_x emissions of cars (top) and trucks (bottom). Source: Ministry of Transport and Public Works (1989).

of each type of policy and because they make it clear that there will be no single radical solution to current transport problems, but that a policy-mix consisting of a fine-tuned system of interacting policy measures will be required.

(4) Spatial Development of the Randstad

The fourth example was also taken from the Netherlands. In 1991 the Institute of Spatial Organisation (INRO) of TNO developed three basic alternatives for the spatial development of the Randstad, which were associated with the terms 'freedom', 'equity' and 'quality' (Verroen and Jansen, 1990). The exercise showed that distinct spatial organisations and policy combinations could be designed that corresponded to the objectives expressed by the three terms. The 'freedom' scenario is characterised by polarisation between tertiarised core cities and dispersed residential settlements and increased spatial division of labour and mobility. The 'equity' scenario preserves the 'green heart' of the Randstad at the expense of higher densities in the urban centres and with high-speed traffic corridors between them. The 'quality' scenario, finally, builds on small-scale integration of working and living in self-contained distributed settlements in close contact with nature.

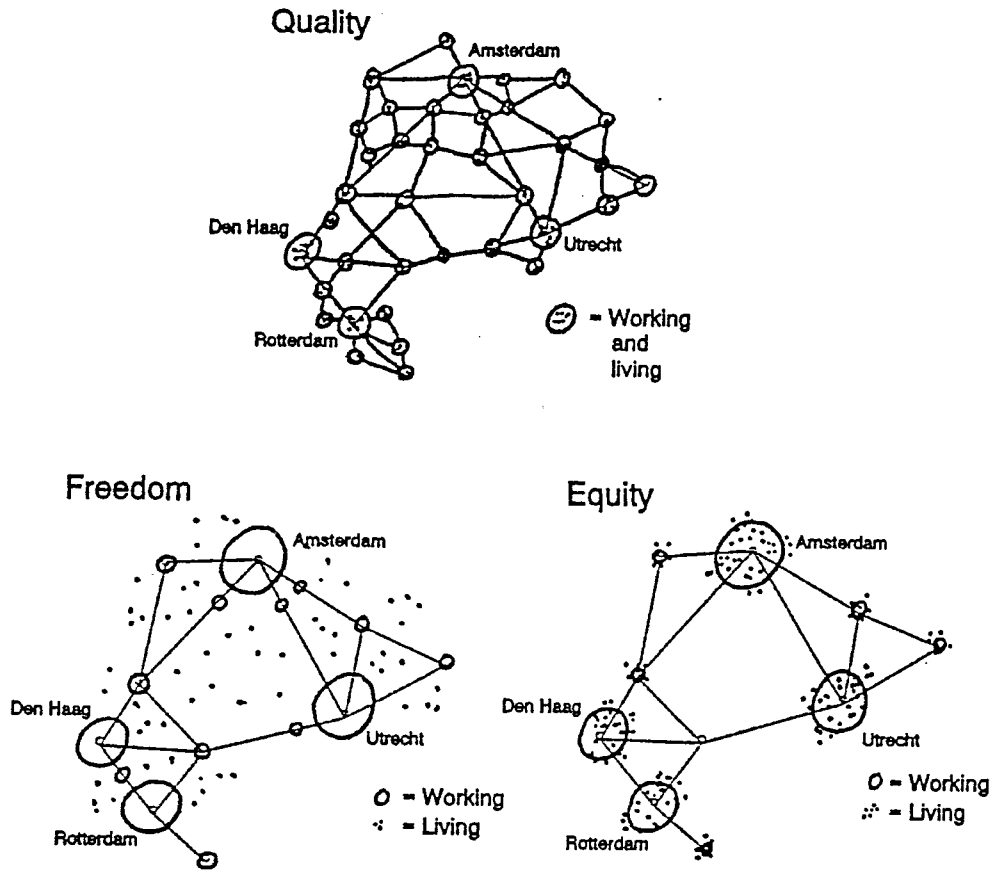


Figure 6. Alternative scenarios for the spatial development of the Randstad. Source: Verroen and Jansen (1990).

Based on the three scenarios, three different policy directions for developing the regional transport system over the next 25 years were proposed. In the 'freedom' scenario, a system of ring motorways and a new central node for high-speed rail connections to Brussels and Cologne emphasises the international connections of the Randstad. In the 'equity' scenario the existing road and rail connections between the urban centres of the Randstad are equally improved. In the 'quality' scenario, no more new roads are built, and in the cities efforts are made to reduce the level of car mobility in favour of new forms of local public transport. The study concluded with qualitative estimates of future trajectories of car ownership, car use, public transport ridership, modal split and car and public transport costs and with some reflections on what the three scenarios would imply for the spatial development of Amsterdam.

The most interesting feature of this scenario exercise is that it goes beyond the textual postulation of general principles or planning objectives by suggesting how these principles or objectives might change the spatial development of regions or cities in concrete terms, i.e. in terms of specific land-use or transport infrastructure decisions. By doing that it is an important contribution to the development of a new type of 'spatial scenarios', which express non-spatial planning objectives in spatial terms. At the same time the experiment demonstrates that today only little is known about the equity and environmental impacts of specific urban forms or configurations of land-use and transport systems.

(5) Local Transport Development Planning

The fifth example illustrates the role of scenarios in a typical transport planning process of German towns today. Between 1987 and 1990 the *Kommunalverband Ruhrgebiet* (Association of Ruhr Area Cities) was commissioned by the city of Unna, a small town with a population of 60.000 at the fringe of the metropolitan area of Dortmund, to prepare an integrated *Verkehrsentwicklungsplan* (transport development plan) for all modes including walking and cycling.

After an intensive process of exploring future options of personal mobility in Unna involving a high degree of public participation, the result was a comprehensive document showing the decision makers three basic alternatives of transport planning for their city (Kommunalverband Ruhrgebiet, 1990). The three alternatives were expressed in the form of scenarios centred around one major assumption or objective:

- *The Mobility Scenario.* The first scenario assumed the continuation of the trend to more car ownership and car use with all negative consequences for traffic safety, neighbourhood quality and environment.
- *The Amenity Scenario.* The second scenario aimed at retarding the trend to more cars in favour of more traffic safety and urban quality of life.
- *The Environment Scenario.* The third scenario aimed at the promotion of sustainable mobility and a virtual stop of road construction.

Table 1 shows the main objectives and design features of the three scenarios. All three contained a basic public transport plan, a city-wide plan of cycling lanes and a minimum programme of measures for traffic management and local street improvement including 30-km speed limits in all residential areas and speed limits on main roads with high levels of pedestrian and bicycle traffic, as well as a programme to reduce traffic accidents at critical junctions.

In addition in each scenario specific measures were proposed in accordance with the general objectives of the scenario, such as specific road improvements, changes in the level of service of public transport or policies regarding parking supply in the inner city. Also for each scenario an approximate assessment of its financial impacts in terms of costs and revenues was provided.

All proposals were laid down in detailed coloured maps showing, in easily understandable symbols, for each neighbourhood the kinds of measures to be expected in each scenario, where necessary supported by coloured artist's sketches of their likely visual appearance. Traffic forecasting and assignment models were used in the process, but played a very small role.

The importance of the use of scenarios in transport development planning lies in their utilisation as communication media in public participation. Through the scenarios citizens could relate the proposed measures in their neighbourhood to the overall objectives of transport development planning for the whole city. This proved to be a great advantage in the ten public hearings on the transport development plan conducted in decentralised locations throughout the city.

However, the Unna experience also shows that the form of presentation of scenarios is crucial; only through the extra effort of presenting the proposed measures in well-designed and clearly understandable maps and artist's sketches can the gap between experts and non-experts be overcome.

Table 1. Transport scenarios for 'Unna 2000'.

Scenario	Objectives	Description
Mobility	Trend extrapolation of urban development	- Optimal transport connections for motorised traffic - Ample parking in CBD - car-dependent lifestyles - Growing action spaces (jobs, education, shopping, recreation) - Public transport residual mode for carless groups
Amenity	Minimisation of negative impacts of transport	- Improved aesthetic integration of motorised traffic - Improved conditions for buses and bicycles - Higher parking charges in the inner city - Improvement of public transport - growing expectations with respect to urban quality of life. - Increasing sensibility for traffic safety
Environment	First steps towards significant reduction of urban traffic	- Optimum public transport supply to increase ridership - Reduction of parking supply in the inner city - Car traffic restraint to improve the ambience of local streets - Improvement of environmental quality - Reduction of land consumption for local roads - Change of values with respect to car ownership, traffic accidents and mobility

Source: Kommunalverband Ruhrgebiet (1990).

(6) Energy Consumption of Urban Travel

Under conditions of growing affluence and low transport costs, market-driven land-use development has led to dispersed settlement patterns associated with high levels of mobility, congestion, pollution and energy consumption. In particular the high energy consumption of transport has become an issue of growing concern. The German government pledged to reduce CO_2 emission from all sources by 30 percent compared with 1987 by 2005. As transport represents a major share of primary energy consumption, serious efforts to lower the energy use of urban transport are necessary to achieve this goal.

Most experts agree that a return to more compact urban development and the promotion of higher densities and mixed land use are the most effective ways to reduce the need for travel and to bring energy consumption of urban transport down (e.g. Newman and Kenworthy, 1989). However, because of the slow turnover of physical stock, land-use policies have only long-term impacts, and high density facilitates, but does not guarantee, short distances (cf. Breheny, 1992). Therefore policies to influence travel behaviour seem to be more efficient to reduce the energy use of urban transport.

To study these issues, an existing land-use/transport model was used to explore possibilities of reducing energy consumption by travel demand management, in particular by changing the cost or speed of travel. The Dortmund model is a model of intraregional location and mobility decisions in the metropolitan area of Dortmund (Webster et al., 1988; Wegener, 1986; Wegener et al., 1991). Three types of scenarios were simulated: scenarios of travel cost changes, scenarios of travel speed changes, and scenarios in which changes of both travel costs and travel speeds were combined.

Table 2. Transport scenarios of CO_2 emission study.

Scenario	*Specification*
Base scenario:	
00	Base scenario.
Travel cost scenarios:	
30	Increase petrol price to 5 DM/l by 2000 and 12 DM/l by 2015, reduce average petrol consumption to 5 l per 100 km by 2015.
32	Increase inner-city parking charges, after 2000 quintupled.
33	Reduce public transport fares, after 2000 free.
35	Increase public transport fares, after 2000 doubled.
37	Increase all transport costs, after 2000 doubled.
Travel speed scenarios:	
40	Make public transport faster (25 %) and reduce headways (50 %) and make cars slower (40 %).
46	Make public transport and cars faster (25 %).
47	Make public transport and cars slower (40 %).
Combination scenarios:	
53	'Promotion of public transport': scenarios 30+32+40.
54	'Reduction of mobility': scenarios 30+32+35+47.

Source: Wegener (1993).

Figure 7 shows the savings in energy use and CO_2 emission by all transport, including busses and trains. It can be seen that significant savings in energy use and CO_2 emission are made only in those scenarios in which the price of petrol price is increased, whereas reductions in speed (Scenarios 40 and 47) have only a slight effect. In all scenarios, despite the continued growth in car ownership and travel distances, total CO_2 emission per capita decreases after 2000 because of higher energy efficiency of cars. However, without intervention the goal to reduce CO_2 emission by 30 percent compared to its 1987 level cannot be achieved.

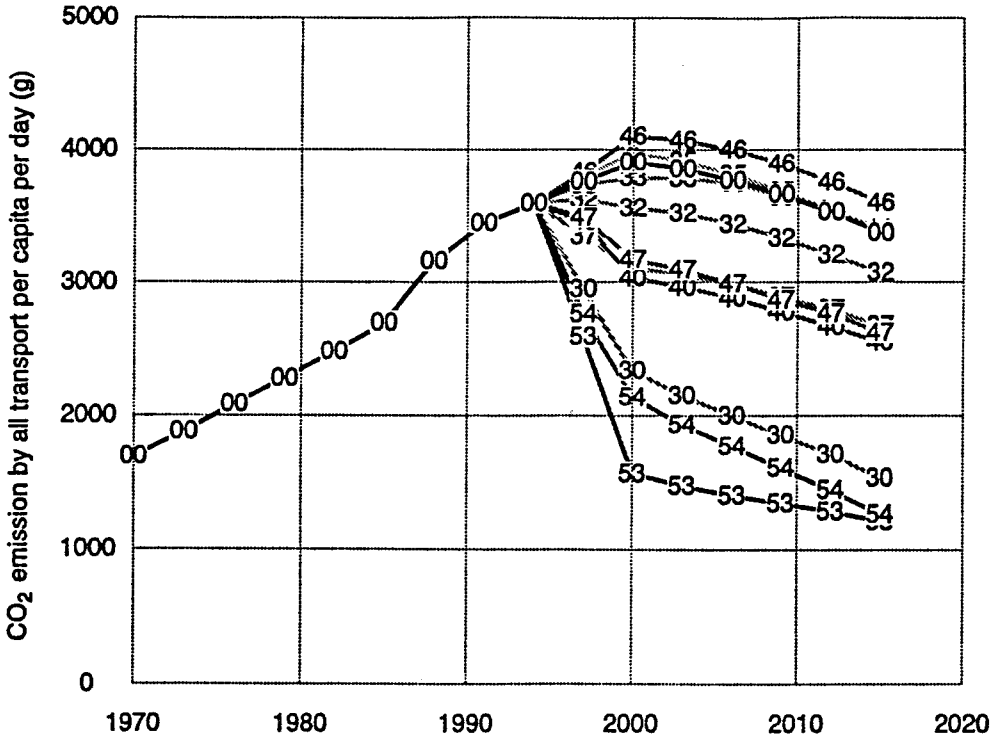


Figure 7. CO_2 emissions by all transport, 1970-2015. Source: Wegener (1993).

This application shows a use of the term scenario which is very close to pure modelling studies. The difference lies in the range of policies that can be investigated, which goes far beyond what traditional transport demand models can handle, and in the dynamic character of the model output, which shows trajectories of any desired system variable over time, including a part of the past and part of the future.

Nevertheless, this use of scenarios, though it scores high in terms of accountability and consistency and takes into account the large range of policy options and changes in the policy environment, shares with pure modelling approaches the difficulty of communicating the results to decision makers and non-experts. Therefore, to develop a more comprehensive methodology integrating the advantages of qualitative scenarios and quantitative models remains a challenge for future methodological research.

(7) A Scenario-Model Interface

An interesting proposal how qualitative scenarios and quantitative models might be combined in a comprehensive unified approach was made by Verroen and Jansen (1991). Their 'Scenario Explorer' (see Figure 8) consists of a computer-based interface in which users can compose their own scenarios by selecting from a menu of possible overall goals and more specific objectives or polices. The user interfaces then transforms this information into values of model variables to be input to a mathematical model - in this case a transport demand model, which shows the transport effects of the specified scenario. These effects undergo an evaluation procedure, the results of which are likely to modify the policy objectives that led to the scenario experiment in the first place. In this way an iterative cycle of learning and experimental improvement is set into motion.

The 'Scenario Explorer' indicates the direction of future research on scenarios in transport planning, yet a caveat is in order. Of course, also in this case the range of scenarios that can be selected and the range of models that can be used is limited by the set of options and models available in the software. The problem remains how the methodology can be updated to respond to new factors, trends, values and conflicts that are certain to arise in the fast-changing field of transport.

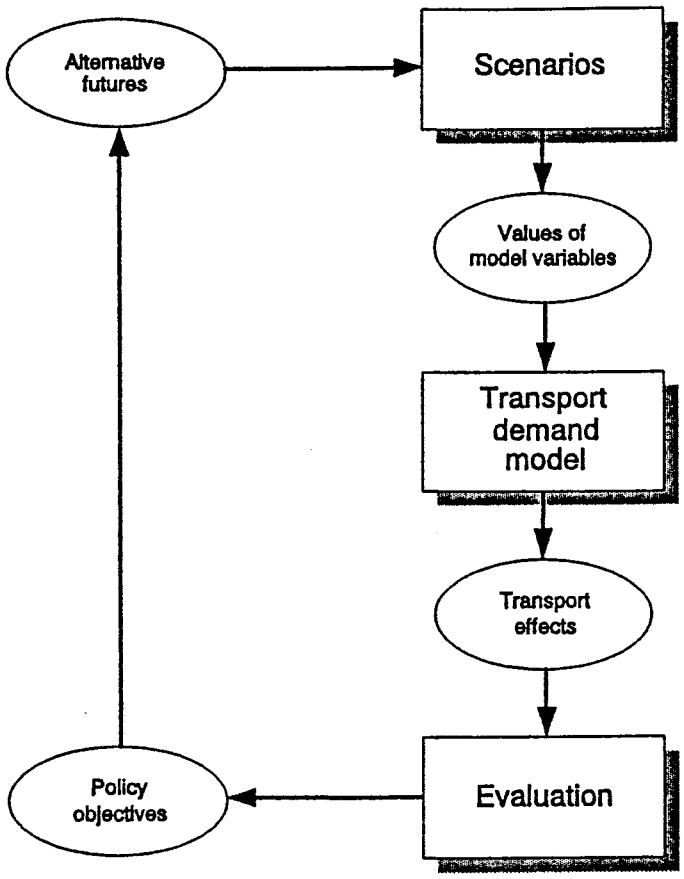


Figure 8. The Scenario Explorer: a scenario-model interface. Source: Verroen and Jansen (1991).

Conclusions

The examples presented in this paper have demonstrated that scenarios are a extremely versatile and useful method for transport planning. Their great advantages, such as their moderate data requirements, their openness for new ideas and their communicative benefits make them in many cases superior to traditional more rigorous and less flexible methods of exploring the future such as mathematical forecasting techniques or models.

However, the examples have also shown that the advantages of scenarios have to be paid for by equally serious weaknesses, such as their lack of objectivity and accountability and their risk of being misused for manipulation. Therefore, to make the best use of the potential of scenarios and avoid their pitfalls, a few rules should be observed when developing scenarios (cf. Kämper and Wagner, 1992):

- Scenarios should be only as comprehensive as necessary, i.e. contain all aspects relevant for the issue under study.
- All values, assumptions and norms and standards underlying a scenario should be made explicit.
- A scenario should be logical, consistent. and coherent, i.e. all elements of a scenario should fit together.
- Scenarios should be concrete and specific, however, pseudo precision should be avoided.
- Qualitative scenarios should be supported by quantitative evidence or model forecasts whenever possible.
- Scenarios should never come alone, i.e. scenario studies should be based on comparison between different scenarios to reduce error.
- Scenarios should be realistic, i.e. contain only assumptions with a significant probability of occurrence.
- Scenarios should be policy-oriented, i.e. should contain explicit and feasible policies.

The use of scenarios in transport planning (and not only in transport planning) is an indication that the traditional planning culture based on rational anticipation of future events is in crisis. A new planning culture appropriate for a time of structural instability and uncertainty has yet to be found. It is therefore difficult to draw a final conclusion about the role of scenarios in transport planning in the future. It may well be that qualitative and discursive modes of decision making will become the norm and displace rationalist methods altogether; in that case scenarios will become even more important than today. However, there may also be a new age of rationality in planning, which will bring back a renaissance of models, more powerful and complex than ever and made feasible by new magnitudes of computer speed and memory. Finally, there may be a synthesis of the two directions, in which scenarios and models will peacefully coexist and interact, both benefiting from new types of communicative computers and new developments in multi-media, computer graphics and geographical information systems.

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