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ABSTRACT

Current trends in transport indicate that the system is moving away from a sustainable development (e.g., due to rising CO_2-emissions) and that major changes in technology, public policy as well as in the behaviour of individuals are necessary to make the transport system more compatible with environmental sustainability. This provokes the need for assessing a set of future images for transport in relation to the environment. In this paper reference and expert scenarios, which can act as a judgement framework for a sustainable transport system, are constructed on the basis of the recently developed 'spider model'. Based on a set of distinct characteristics of a transport system, represented by eight axes in the spatial, institutional, economic and social-psychological field, an evaluation framework is constructed, which visualizes the driving forces that largely influence the future of the transport system. There are several directions in which these factors may develop, and each of them will separately or in combination lead to entirely different transport systems. In this way, many scenarios can be constructed by connecting points on the successive axes. Such scenarios may range from market-oriented to regulatory pictures; the first may lead to a transport system in which individual, the second in which collective modes of transport dominate.

Next, expected and desired scenarios are constructed by means of opinions of Dutch transport experts, which have been investigated by means of a nation-wide survey. The expected scenario indicates that many current trends will continue, while the transport system is largely the same as the current one. The desired scenario on the other hand, gives a more collective system, in which also many new modes are operating. The conclusion is that there are many roads for achieving a sustainable transport system, but that whatever road will be chosen, this road will be hard to follow.

1 INTRODUCTION

Current trends in transport show a worldwide rise in mobility and an ongoing modal shift towards the private car and airplane. Consequently, the negative extemalities caused by transport, such as visual, stench and noise annoyance, spatial segmentation of landscapes, and the emissions of harmful gases generating smog and various kinds of greenhouse effects are likely to increase and to lead to environmentally unsustainable conditions (Nijkamp, 1994). As a result large changes seem unavoidable which makes future changes in the transport system necessary (Thord, 1993).

In general, extemalities caused by transport may be reduced by using four options: improvement (technical, managerial) of vehicles, introduction of more sustainable transport technologies and of new transport modes, a modal shift towards cleaner (mostly collective) transport modes and a reduction of the total mobility leve1 (Enquete-Kommission, 1994).

It is clear that the fust option leads to the least resistance in society and to the lowest necessary changes in individual transport behaviour. However, current expected improvements in the private car and airplane are not expected to reduce the externalities to such an extent that one could speak of a 'sustainable' transport system, mainly because improvements are simultaneously compensated by growing mobility rates (Gwilliam and Geerlings, 1994). Therefore, altemative options have to be considered as well. It seems plausible however, that none of the above mentioned four options will separately lead to a sufficiently favourable impact on environmental quality conditions.

Therefore, it is feasible to investigate a blend of all options in order to attain a more sustainable transport system. For example, in the long run several new technologies may be introduced, which may largely reduce the extemalities of transport (Rienstra et al., 1995). The same result may hold for a drastic modal shift and for a reduction in mobility levels. In practice, various mixed options may thus be introduced, which will have different impacts in many - also non-environmental - fields, therefore trade-offs have to be made.

In order to analyze the potential of such mixed options the construction of scenarios is an interesting and promising methodological approach (see also Swahn et al., 1994). There are several ways of constructing scenarios: they may be intuitive, a literary product (mostly historic), idealistic, qualitative expert assessments or an instrument for quantitative forecasts (Svidén, 1989). Two complementary methods may be distinguished; the first one is forecasting in which the existing situation is taken as a starting point for exploring the future. The second one is backcasting in which first the situation in the reference year is given, and next the necessary policy measures and developments to reach this situation are described (Steen, 1994).

In the present paper two kinds of scenarios will be presented as a vehicle for exploring environmentally sustainable situations in the transport sector. First, two intuitive reference scenarios, which describe extreme developments in several fields related to transport and the environment, will be developed. Next, a new type of scenarios based on expert opinions will be constructed. These opinions

are gathered and assessed by means of a structured questionnaire which has been sent to hundreds of Dutch transportation experts. Both the reference and expert scenarios have been discussed in an intemational workshop, too. Like in the Masser et al. (1992) study, several questions have been asked about expected and desired developments which may influence the future of transport; hence an expected and a desired scenario may be constructed. In the Masser et al. study, various packages of futures are designed and presented, while in our study each relevant aspect has been questioned separately. The advantage of this approach is that in this way scenarios may be constructed by combining different groups from one sample; this also offers the opportunity to investigate in more detail possible inconsistencies in opinion among different segments of one sample.

The paper is built up as follows. First an introduction will be given to the methodology used - the so-called spider model - for the scenario construction. Next the reference scenarios - a market-oriented and a regulatory one - are constructed. Then the expert based scenarios are described, while finally some conclusions are drawn. We restrict ourselves to passenger transport in Western Europe, while the time horizon chosen is 2030. For a more detailed analysis as well as for a description and underpinning of the questionnaire we refer to Nijkamp et al. (1995).

2 METHODOLOGY USED: THE SPIDER MODEL

2.1 Introduction to the Spider Model

Many driving factors are important for the future of transport. They may be found in several scientific disciplines and may relate in particular to spatial, institutional, economic and social/psychological aspects. In the scenarios designed the resulting future transport system is supposed to be a consequence of forces and developments in the above mentioned fields. The most important future developments in these fields may be studied by using a multi-criteria analysis, which is visualised by means of a spider model (see Figure 1). Multi-criteria analysis is a method to grasp, classify and analyze different scenarios by means of explicitly formulated criteria (which are put on the axes of the spider). The advantage of this analysis is that the individual assessment criteria do not have to be measured in a single quantitative unit; they may be qualitative in nature (e.g.,rank order) (cf. Voogd, 1983).

2.2 The Spider Factors as Eight Diict Dimensions

For each of the four relevant scientific fields distinguished in our study two axes are drawn in the spider, which are the most important factors influencing the future of transport and the transportation technologies used. On the first axis, possible developments *in the* future European *spatial organisation are* mapped. At the one extreme (interior) side of this axis we fmd the so-called chains and zones model which is a result of a non-interventionist policy and trends which lead to a diffuse spatial structure; at the other extreme the concentration and specialisation model is depicted which tends to favour a concentra-

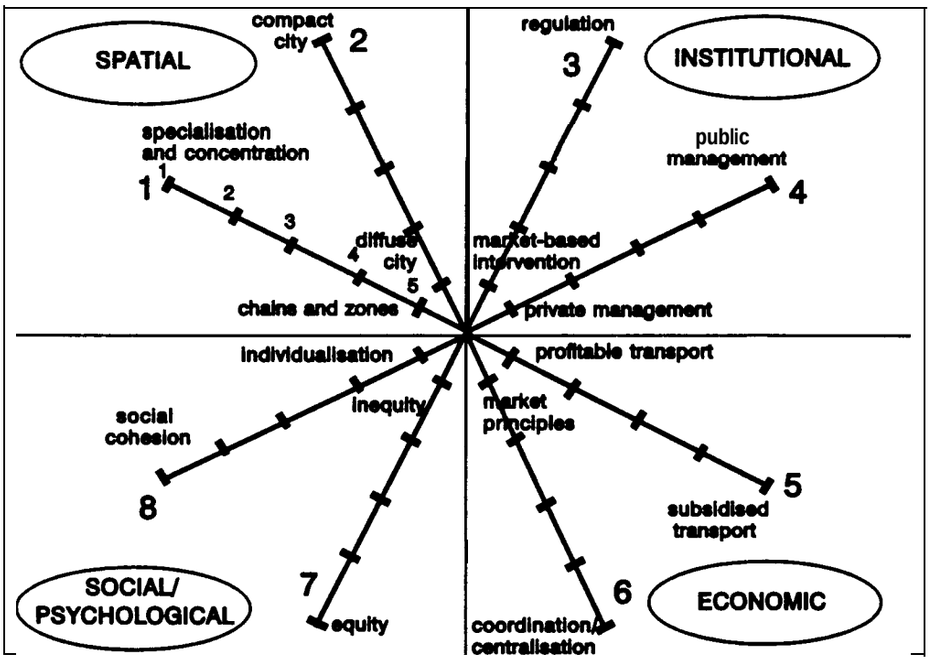

Figure 1 The spider model for depicting the driving forces of future transport systems

tion of activities and population in urban areas and in the economic core zone as a result of a dedicated spatial-economic policy (cf. RPD, 1991). The second axis in the spatial organisation is mainly concemed with urban patterns; it describes the important dichotomy between spatial dispersion and concentration. Thus, on the extreme sides of the second axis we have depicted the diffuse city (as a result of free market forces) and the compact city (as a result of explicit urban policy efforts) (see als0 Wegener, 1995).

In *the institutional part (axes 3* and *4) we* investigate the controlling and managerial systems for sustainable mobility. On the third axis the degree of government intervention in the transport market is depicted; the contrasting ways are regulation versus market-based measures. The management of transport modes and infrastructure is found on the next axis, where the two extreme ways in which this may be organized - purely public or private - are presented. In this context, public transport means that the ownership as well as the operation of the transport companies are the sole responsibility of the govemment (or governmental agencies) .

Another important driving force sterns from the *economic field*, and is depicted in the axes 5 and 6. The fifth axis concerns the feasibility of transport as the required profitability of transport modes is an important factor for the future of transport. The main question in this case is whether the govemment wants to subsidise transport or whether transport modes should be operated on a

commercial basis; in this way also private financing of infrastructure may be attractive. This warrants the extreme cases of profitable versus subsidised transport on axis 5. The next extremes - to be found on axis 6 - are the introduction of market principles in the economy versus coordination by the government (which may lead to some form of a centralised govemment). This consideration is important for future economic growth, regional development, the construction of infrastructure towards peripheral regions etc.

Finally *socio-psychological factors are* important (see also Levy-Leboyer and Duron, 1991). On the seventh axis equity is confronted with inequity. Non-intervention may favour inequity in society (for example, an uneven income distribution, uneven chances for individuals, e.g. travelling, education), while on the other hand much public governance may emphasize equity measures (social security , discounts on travelling costs etc.). Finally, the eighth axis reflects individualisation versus social cohesion, which is important from the viewpoint of the leve1 of freedom of individuals (versus social control), including related developments (e.g., demographic, educational), which may have again consequences for transport.

All above mentioned four fields (represented each by two axes) have important impacts on the leve1 of transport demand, the price leve1 of transport and the modes used, and hence may be regarded as the main force fields for the development of transport systems technology .

The order of items on each of the eight axes is such that the interior points are more associated with non-intervention strategies (e.g., market-forces, liberal attitudes etc.), whereas the exterior points reflect the result of policy interventions (e.g., land use planning, control strategies, regulatory measures etc.).

2.3 The Construction of the Scenarios

A transport system can now be represented and assessed by a combination of 8 points on the successive axes of the spider model. This is a meaningful visualisation of the main characteristics and driving forces of such a system, as a confrontation of different 'spiders' (concerned with different driving forces) will immediately pinpoint the most important underlying factors. It should be recognized that the size of the area formed by linking the 8 points on all axes has no meaning, as (1) the information on the axes has only a qualitative (and not a cardinal) meaning and (2) the size of the resulting area is also dependent on the order in which the axes are positioned in the spider.

One may wonder why technological developments have not been included as driving forces in the spider model. This would certainly have been possible (e.g., by making a distinction between Schumpeterian types of technological changes and govemment-instigated types). However, in the present study, technological advances in the transport sector are regarded as endogenous developments (i.e., responses) to the underlying four major driving forces. Thus, in our approach transportation technology is not 'manna from heaven', but a result of systemic forces. Consequently , in the present study a typology of various technological options in the transport sector is made, while next each of these options can be evaluated by means of the elements from the spider model.

It should be noted that the extreme points on each axis have only a qualitative meaning; they do not represent numerical information, but only a rank order (in terms of more or less). This is also important for scenario design, as the opinions of experts are more concemed with statements on which transport systems options and underlying forces are more or less likely than on precise assessments of all consequences of such options. It is possible - or even likely - that in practice the expected future developments will be less extreme. In that case a shrinkage of the axes may take place in order to describe such actual developments. Clearly , the second and fourth point represent developments which are closer to the extremes, whereas the centra1 point (3) indicates an intermediate (neutral) development.

Compound scenarios can now be composed, by taking a point on every axis and linking these points. In this way a great many of scenarios can in theory be designed. The reference scenarios are constructed in such a way that they form the inner and outer circle of the spider. They mainly serve as a frame of reference. The expert scenarios will probably combine points at the axes which are positioned more at the middle of the axes. The scenario design itself will now be further discussed in Section 3.

3 REFERENCE SCENARIOS

3.1 The Market-Oriented (Interior) Scenario

3.1.1 Iutroduction

In the market-oriented scenario it is assumed that all spider variables will develop according to the inner circle of the spider model (see Figure 2).

It is assumed that spatial pattems evolve with a low leve1 of concentration (density), while the public policy is mainly market-oriented and is focused on deregulation and on reducing its direct influence on society and the economy . As a result public intervention in the economy is as smal1 as possible, while the necessary (especially environmental) policy measures are largely market-oriented. We will now describe in more detail the foreseeable developments associated with the interior scenario.

3.1.2 Spider factors iu the market-oriented scenario

Spatial factors

The spatial organisation in the year 2030 is the starting point of this scenario. A shift will take place out of the cities and the core zone towards 'green' rural and partly peripheral regions, which are becoming favourite places for living and working, because of higher valued living conditions (the suburbanisation trend). Because of mobility price increases, in genera1 only the higher income classes will be able to move to these areas. Governments will attempt not to interfere, because every individual is supposed to be free in choosing his or her place of living. At the same time the trend towards footloose companies will continue, as these firms follow the highly educated working force. This will especially be true

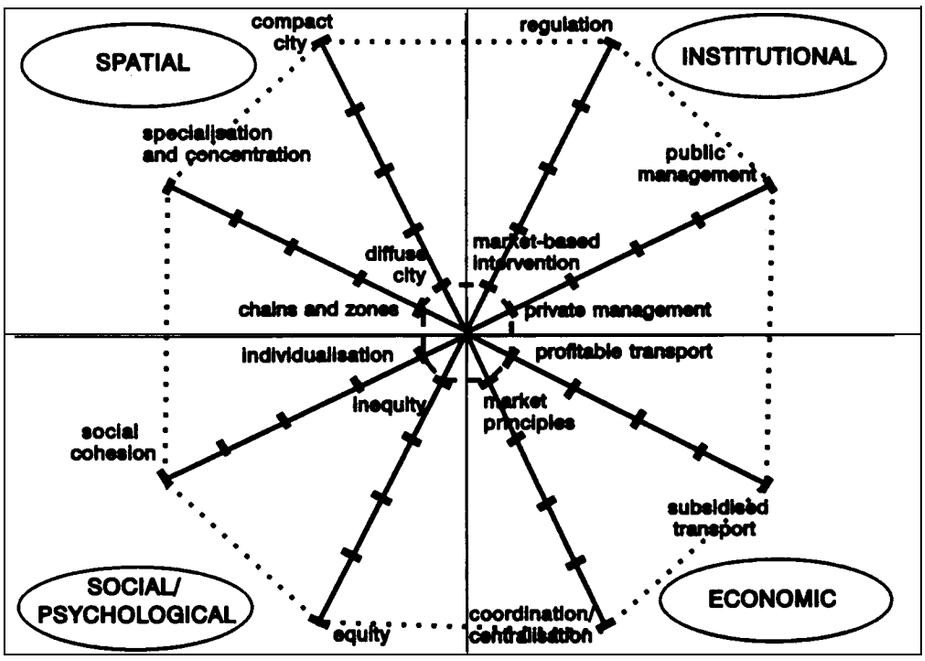

Figure 2 *The reference scenarios*
Legend ------ market-oriented scenario
..... **regulatory** scenario

for the most **dynamic** sectors in the **economy**.

As a **result** the peripheral and **rural** regions around large urban **areas** tend to become highly **competitive,** despite the abolisbment of regional support **programmes**. Therefore, a diffuse spatial organisation - according to the chains and zones model - **will** occur in **all** countries in Europe. The resulting transport **demand** reflects a **pattern** characterized by **many** low density criss-cross links.

The same trends **will** occur at the urban level. **Every** region has one or more cities, which are the **main** centres of population and **economic** activities. **Because** of the **higher** transport **costs** regions have become more self-supplying, while they have **also** become **rather powerful** because of devolution trends.

The urban organisation which is evolving has **also** a diffuse **structure**. The population of most cities will not grow. The **size** of households **will** decline further, therefore more dwellings are needed to house **the** smaller families. People **who can afford** it **will** move towards 'green' suburbs. The same **holds true** for **many** services like **shopping** malls etc. **Also companies will** follow this trend, because of the poor **and** expensive accessibility of the urban centres. People in the lower **income** classes **however,** stayed behind in the old city centres.

Institutional factors

The devolution trends will largely continue. Organisations like the UN, OECD and the Worldbank will not get more power, whereas national states become relatively more powerful. There is one major exception, however. The global environmental problems (e.g., the greenhouse effect, depletion of the ozone layer, acid rain) cannot be solved at the national level, because individuals and countries are caught in the social dilemma of 'free rider' behaviour. Therefore, a strict environmental policy will be agreed upon all over the world, while evasion from this policy is not possible. An example is a global CO_2 tax, which will increase, for example, the price of conventional fuels to a large extent. As a result, fiscal revenues are to a significant extent based on environmental taxes.

Also a reversal in the European integration policy will occur; as a result the regional support and agricultural subsidies will largely be abolished. Most emphasis will be put on the competitiveness of countries and regions, which will reinforce the trends towards govemments 'stepping back'. Therefore, there is no active housing and physical-spatial policy, while also social security systems will have been drastically reduced in size and coverage.

Also the transport sector will be no main policy field anymore. Infrastructure and the exploitation and operation of networks will be largely privatised. As a result, for example, user charges (by, for instance road pricing) will be introduced at a large scale. When demand is not sufficient, the infrastructure will simply be closed.

Economic factors

The European economy will develop in a relatively positive direction, because of the introduction of more market principles and incentives. Therefore, the European economy will become more competitive compared to other trade blocks. Because of the high mobility costs, trade growth will largely diminish. Despite this, a large share of the population may still afford to live in rural areas, because of high economic growth and rising incomes.

Regional economic growth will exhibit more dispersed patterns because of the diffuse spatial development. Therefore, the economy in the core regions will develop in a relatively negative direction, whereas the opposite holds for peripheral and rural regions.

Policies will be aiming at intemalizing environmental costs by increasing the price of conventional fuels, for example, by implementing a CO_2 tax, but also by introducing levies on noise, visual and stench annoyance etc. The variable costs of transport will also increase because of the privatisation of the infrastructure. All public transport will become also privatised, while only basic safety standards will have to be met. All transport has become profitable in this way, in the sense that all users pay for all costs (included social costs).

Social and psychological factors

There will be a widespread agreement in society that the environment has to be protected, which will make global measures possible, despite the desintegration of the world community . At the sarne time, the individualisation trend will

become more perseverant. Therefore, evasion problems will likely occur, which will make market-based measures more necessary. This trend will also lead to a smaller household size, which will increase housing needs and therefore reinforce geographical diffision trends.

Social security systems will be largely privatised and minimised; the same holds for all kinds of public subsidies and govemment support. A strong socio-economic segmentation in society will come about; for example, the income distribution will become much more skew. Therefore, also mobility and housing possibilities may develop much more uneven.

Intuitively , society can be divided in three income classes: the fust class is that of the rich people (20% of the population). They own a private car (based on new fuels) and are not restricted by the high mobility costs; therefore they can afford to live in highly valued natura1 areas.

The middle class accounts for about 60% of the population. They can afford a private car, but they are restricted by the high variable transport costs. This class will mostly live in suburbs and rural regions. Teleworking will become more common, which will reduce mobility needs.

Finally , the lowest income class (20%) will mostly consist of unemployed people, living in old quarters of cities. For their travel needs they depend on either car rentals or (more likely) collective modes, because they cannot afford to own a private car.

Next, we will explore the consequences of this interior scenario for the transport system.

3.1.3 The transport system in the market-oriented scenario

Long distance transport

Because of the diffuse spatial organisation many low demand criss-cross transport links will emerge. The taxes and user charges will make mobility much more expensive. The environmental taxes will be so high that conventional fuels are to a large extent not used anymore, and will be replaced by new alternative fuels, such as hydrogen.

Infrastructure will be largely privatised, and will be planned, constructed and operated by the private sector. The same holds for collective modes, which will be exploited on a commercial basis. Because of the low density of demand on many links, the use of collective systems will largely diminish.

Individual modes will generally be the most efficient ones; therefore, the high and medium income classes will own a private car. Telematics systems will be introduced for many transport applications, while on the main links route guidance will become common practice. This will increase the capacity of the infrastructure significantly .

Surface infrastructure will be strongly taxed because of the high environmental extemalities, therefore it will become attractive to construct subterranean transport links for long distances. The same holds for existing highways, which will be reconstructed as subterranean infrastructure or otherwise closed. This strategy will be less attractive for conventional rail infrastructure, therefore a significant part of traditional rail infrastructure will be closed.

As a result, only at high density links High Speed Trains (HST) and Maglev trains will be in operation. This will especially be the case between large cities where high density links do exist. A bus system will be set up towards other cities, which are mainly used by people who do not own a car. On very long distances new LH_2 airplanes may offer an expensive but environmentally-benign service.

In the beginning of the next century mobility growth will be sometimes negative, because of the new environmental taxes. Later on new technologies may be introduced which become cheaper too. Therefore, mobility will start to grow again from 2010 onwards. The modal split on long distances will change in favour of the private car. The share of this mode will be about 90%, with all cars driving on new environmentally more friendly fuels.

Urban level

Parallel to the above mentioned long distance transport trend, also the cities developed towards a diffuse spatial organisation, while the population will not grow to a large extent. Many public transport links will not be profitable anymore, therefore several public transport links will be closed. An extensive bus system will be set up for people who do not own private cars.

Private cars based on electricity and new fuels will be the main mode of urban transport in 2030, while on shorter distances also the bicycle will be an important mode in suitable cities. Only at high density links collective modes will offer a service. A great deal of infrastructure will be constructed as subterranean infrastructure, while electronic user charges will be levied everywhere.

Because of the shift out of the cities, urban mobility will decrease in the beginning of the next century, after which it will stabilize. The modal split of the private car will be approximately 70%, while collective modes will have a modal share of about 30%.

3.2 The Regulatory (Exterior) Scenario

3.2.1 Introduction

The starting point of the regulatory scenario is a strong concern of the govemment for land use and transportation planning from the viewpoint of sustainable development. This means a priority for a concentrated spatial organisation at the European and urban level. It is assumed that the government uses mainly regulatory measures to influence the economy and society and also the transport market. A main reason for this orientation is also the political emphasis on achieving equity in society.

This scenario forms the outer circle of the spider model and is in this way the opposite of the market-oriented one (see Figure 2).

3.2.2 Spider factors in the regulatory scenario

Spatial factors

In the year 2030 the suburbanisation trend will largely be reversed and a shift back towards the cities and tbe core zone will occur. This is one of the results of a strict spatial and land use policy, which aims at concentrating activities in the urban and some otber specific dedicated areas in the economic heartland of the country and Europe.

Leading economic activities will be found in a few metropolises - London, Paris, Frankfurt, Milan and Barcelona - which house a large population (10-20 million) and are the main economic centres in Europe. Many head offices of intemational companies, junctions of HST/Maglev connections and large mainports will be found here. This trend will be reinforced because (goods) transport tends to become inefficient and expensive, which will make companies less footloose .

In tbe next leve1 of tbe spatial organisation so-called europoles are found, which are relatively large cities (1-5 million) in Europe with a sufficiently high degree of specialisation and economic potential. They are often oriented towards the metropolises, but house also many independent activities themselves. Next, smaller cities will be found in European space in wbich regional activities are concentrated. So a hierarchical spatial structure will occur.

These developments will have negative impacts on rural and peripheral regions. The population will decrease significantly, while also agriculture will shift to areas in the vicinity of cities. This trend will be reinforced by policies to make natura1 reserves of many agricultural regions.

At the urban leve1 the compact city concept, with a concentration of economic activities and population in the city centre and some subcentres, will emerge as a result of a strict housing and industrial policy. It is very attractive to live near the nodes of collective transport, because otherwise travelling becomes inefficient and very time consuming.

In old districts of the city people live who cannot afford housing in the more expensive suburban centres. In these areas low quality housing is available; every destination in these places can be reached by public transport, however.

Institutional factors

The devolution trends will be reversed by 2030; as a result there will be much more emphasis on equity in public policy. Most emphasis will be put on regulatory measures, because then no distinction is made between people. The EU will develop into a centralist organisation with a lot of influence. Strict and obliged environmental, spatial and transport policies will be introduced for example. Also many protectionist measures were introduced to safeguard the European economy and to make it easier to introduce regulatory measures to achieve sustainability goals.

In socio-economic policy also much emphasis on equity will take place. Social security systems will be extended and govemment interventions will be expanded to ahnost all sectors in the economy .

Also the transport sector will be regulated to a large extent. Collective modes will be publicly owned, while the maximum amount of car kilometres per person will be restricted, e.g., based on a quota system as a result of a fixed environmental utility space for transport. Therefore, collective modes will become dominant, and their infrastructure will be largely expanded. Their companies are publicly owned and will grow into bureaucratic organisations, which will be operating at big losses. These will be covered by the govemment, a policy which is accepted because of the emphasis on equity .

Economie factors

European economic growth will lag behind that in other trade blocks, because most attention was paid to equity and regulation of the economy. Therefore, economic efficiency measures and incentives were largely abolished. Also taxes have been raised significantly.

The EU will introduce a strict spatial policy in which activities will be concentrated in the core zone and cities. Therefore, population and economic growth will be concentrated in this zone. To keep the other regions populated however, subsidies will be given to the rural population to live there. Their activities are largely regulated, in order to safeguard the natural value of these regions.

Transport will be running at big losses. Because of equity reasons the prices for the collective modes will be kept low, while also many unprofitable links will be maintained. To regulate car use, restrictions like a maximum amount of car kilometres per person will be introduced, therefore there will be no need to price the road infrastructure by means of user charge principles.

Socialandpsychologicalfactors

The low economic growth, together with the growing emphasis on equity, will reverse the individualisation trend. Regulations will be accepted as the best way to protect the environment therefore. Evasion will not be possible because of the growing social cohesion. The size of households will again grow, also as a result of the scarcity of space because of the spatial concentration trends.

Equity will be the key topic of public policy. Social security systems will be expanded, while subsidies and public support will increase everywhere. Therefore social inequity will largely decrease.

Three income classes may be distinguished. The class of rich people (approx. 5% of the population) will live mostly outside the cities in high quality housing areas. When they need it (for work or privacy reasons) they are allowed to own a private car, driving on new fuels.

About 90% of the population belongs to the middle class. They mainly live in compact centres and subcentres of the cities. For their transport needs collective modes will be used, which they can easily afford because of the low prices. Sometimes, private cars will be rented, but there is only a limited amount of kilometres per person available.

The last 5% of the population consists of unemployed people living outside the city centres. They depend for their transport needs on lower quality collective modes, and can mostly not afford renting cars.

3.2.3 The transport system in the regulatory scenario

Long distance transport

By the year 2030 a radial transport system will emerge at the European scale level, with high density links between the metropolises and from the metropolises to the europoles. Car use will to a large extent be regulated, and therefore collective modes will dominate the scene. This trend will be supported by a strong policy aiming at spatial concentration and the regulation of car use. Road infrastructure investments will be drastically reduced, in favour of new investments in rail infrastructure. Because of lack of space this new rail infrastructure will often be constructed as a subterranean network.

On the links between the large metropolises subterranean high speed shuttles will offer a high frequency and a high quality service. Between the other metropolises and the links towards the europoles High Speed Trains and Maglevs will be operated, which form the backbone of the transport system. Smaller cities are also connected by other fast trains, which are however slower than the High Speed Trains. The connections with the smaller living and working areas will be realized by an extensive network of conventional trains, subways and light rail. In this way all Europe is covered by a high quality collective mode network. This system offers a high frequency and a good service at low prices, so that almost everyone can afford travelling. The system is subsidised to a large extent out of public funds. Air transport will be strictly reduced on links where other modes are available. At various long distances LH $_2$ airplanes will offer a service.

In the next decade mobility growth will be negative because of the regulations on car use. When new collective infrastructure is constructed however, mobility will rise again, albeit at a lower growth rate because of a stabilising population and the spatial concentration.

The modal split will change in favour of collective modes: approx. 80% will be covered by these modes, while about 20% is used by private cars (approx. 15% rented and 5 % privately owned).

Urban level

Also in tbe cities a radial system will emerge, with the crowded city centre as the centra1 terminal where the transport flows come together. The main corridors are leading to other compact subcentres. The central transport nodes are the HST/Maglev/shuttle stations or the other conventional main train stations. Private car use is strongly discouraged, while investments in road infrastructure will be drastically reduced. Walking and cycling have • in various cities • become the main modes for short distances.

The backbone of the transport network will then consist of subways and light rail connections, while on shorter distances also people-movers will offer a high quality and frequent service. At the nodes of this system low quality modes like buses and trams will still be in operation and they will operate on a relatively dense network. There is also a wide spread possibility to rent bicycles there. The low quality housing areas are covered by a network of buses and trams too. The density of the network and the low tariffs will make the public transport system largely unprofitable, and therefore these modes will be largely subsidised. Private

cars are only used to reach recreational areas or to transport heavy goods. Because of the low price, the mobility leve1 will not be restricted by the price but by limitations (travel time, destination etc.).

In the fust decade of the next century the mobility leve1 will decrease because of the restrictive measures for car use. Later on the mobility will start to rise again, as a result of the concentration of economic and population growth in the cities. The modal share of the private car (electric and altemative fuels) will diminish to 15%, while collective modes may account for 85% of the modal split.

4 EXPERT-BASED SCENARIOS

4.1 Introduction

After the extensive description of the two imaginary reference scenarios, we will now turn to actual scenario design based on expert opinion. We will first give some concise background information.

In fall 1994 a questionnaire has been sent to hundreds of previous and current participants in the biggest annual conference on transportation research in the Netherlands, the so called 'Colloquium Vervoersplanologisch Speurwerk (CVS)' . The survey contained an array of questions about the various key fields covered by the elements of the spider model, as well as about the viability and desirability of several modes which are at present under development. The response rate of the survey was 36% (n = 27 1).

The questions were consistently subdivided into 'expected' and 'desired' answers, in order to separate factual information and subjective value statements of these experts. This will allow US to identify the tension between reality and wish. Therefore an expected and a desired scenario can be constructed, which are presented and described in the remainder of this paper. Rather than describing the statistical results of this scenario experiment, we will depict the resulting spatial, societal and transport pattems in future by way of interpretative analysis. The resulting scenarios are presented in the remainder of this paper. The scenarios may be drawn in the spider model as presented in Figure 3.

It should be noted that we give here only an aggregate interpretative picture; for each subgroup of respondents (depending on age, gemier, scientific background or current profession) such results may be somewhat different.

4.2 The Expected Scenario

4.2.1 Introduction

At first sight the expected scenario is largely an extrapolation of current trends, although several behaviourial changes and policy measures may occur. These are not as big and severe as in the desired situation, however. Therefore, also the resulting transport system does not differ significantly from what is at present. The spider factors and the resulting transport system are discussed in more detail in the next sections.

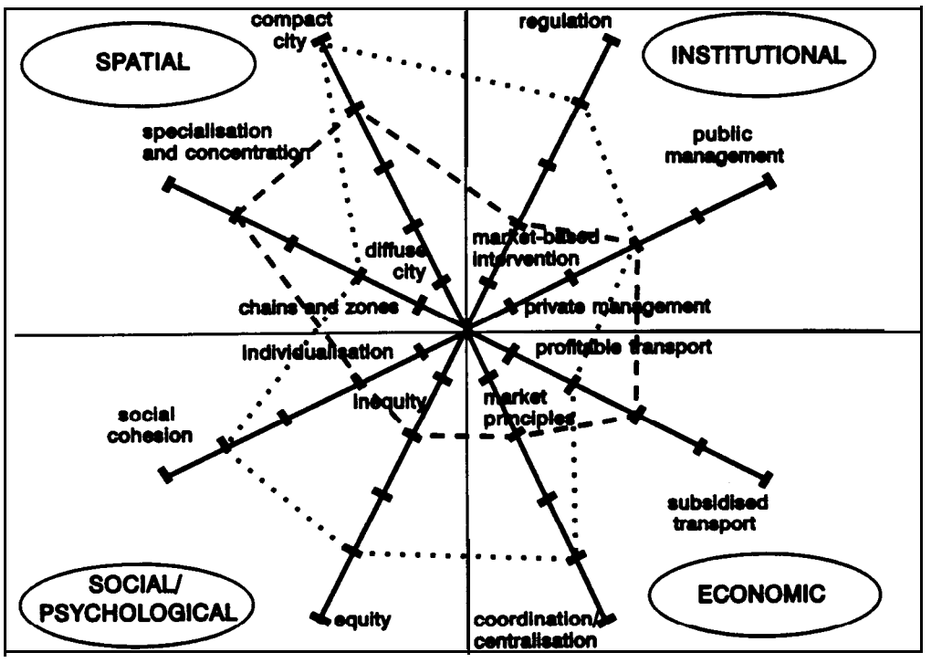

Figure 3 *The expert scenarios*
Legend ---- expected developments
..... desired developments

4.2.2 Spider factors in the expected scenario

Spatial factors

The spatial policy is mainly expected to focus on concentrating activities and population in big urban areas in order to increase the competitiveness of collective modes, which may result in lower extemalities. The suburbanisation trend will largely be reversed. Especially richer groups however, do not want to move towards the cities; they will either stay in the more suburban and rural areas. Therefore, a moderate concentration occurs, especially in the core regions where economic and population growth are the highest.

Several metropolises appear to be very attractive for living and working. These are however less dominant than in the regulatory scenario because of two reasons. First, the spatial policy will not be entirely successful, and therefore several activities will remain in the cities. Second, the intensity of European integration will largely decline, so that much support will be given to the capital and other big cities in the national states. In almost every country at least one europolis will be found. Also the smaller cities will appear to be important for the economy.

The cities tend to develop towards a moderate compact spatial structure too, as a result of the public policy pursued. The people tend to be living in centres

and several subcentres of cities, because there affordable housing is more available. Several housing problems may occur however, because of the smaller size of households and because of the high prices of scarce space. Therefore, also a large share of the population lives in old living quarters outside the city centres. People who can afford it tend to move from the city centres to green suburbs . Therefore, the compact spatial policy is not likely to become fully successful.

Institutional factors

In genera1 the devolution trends tend to continue, although the influence of the govemment is still rather significant, especially in the spatial and land use field. Most policies however, will be aiming at measures to keep the national economy competitive with other European countries, with other trade blocks and with the 'low wage countries' . As a result the integration of the European Union may largely stop, since the population has still a strong desire to be govemed by national states. At several fields where cooperation is favourable for all countries (trade policy, environment) the EU will gain more influence, however.

Also transport will remain the main responsibility of the national governments. At the European level, strict standards for emission levels for private cars were introduced, while the same holds for telematics standards.

The railway companies will be made more independent of the national govemments, although these govemments will stil1 be mainly responsible for the construction of infrastructure. The profitability of the railway companies will be rather high for long distance transport. For the other sectors however, the profitability is fairly low, so that the railway system is stil1 largely subsidised. The same accounts for car transport, as road pricing for example will not be introduced at a large scale, but only on the most congested links. Public policy will focus mainly at improving current car transport and on the introduction of electric cars in urban transport.

Economic factors

The European countries will by the year 2030 largely have integrated their markets, but further cooperation is not likely to be achieved. The competition between countries and other trade blocks tends to have a negative impact on mutual coordination; environmental policies, for example, are probably not centrally introduced and accepted because of frequent 'free rider' behaviour of various countries .

The European funds for the rural and peripheral regions will largely be abolished, while at the same time a shift towards the core zone of individual countries will be probable. Therefore, the core regions develop relatively positively, while the peripheral and rural regions will face a period of relative decline.

The govemment is largely expected to withdraw from the transport market, especially from transport on the longer distances. There tends to be much resistance in society against closing public transport links, and therefore the regional and urban transport system may still be subsidised to a large extent. Road pricing will not be largely introduced on road infrastructure, while also

other measures to restrict car use were not introduced at a large scale. As a result the private car will stil1 be the dominant mode of transport.

Social/psychological factors

The individualisation trend in society tends to continue at the current pace. As a result, a society with more and smaller households is likely to occur. Social cohesion may therefore be further reduced, which will increase evasion behaviour. Behaviourial changes will therefore not be big enough to change the transport system to a large extent. The individualisation may also partly obstruct the spatial policy of the govemment. The same holds for measures aiming at reducing car use and stimulating a shift towards collective modes.

At the same time social security systems may be abolished; the same will hold for many subsidies, for example, in public transport. Also taxes will be lowered to improve the competitiveness of the national economies.

Three income classes may be distinguished. The class of rich people (15 % of the population) can afford to live outside the cities and in green suburbs. They will own a private car used for most transport needs.

About 75% belongs to the middle class, which mainly lives in the centres and subcentres of the cities. They own a private car, which is powered by conventional fuels or by electricity . The latter will be relatively cheaper because of mass production of the batteries, while there will also be govemment support for this mode. The low driving range is likely to be a problem however. Therefore, the electric car will probably not become the dominant mode. Collective modes will be more attractive on dense transport links, which is often the case between the compact city centres.

The lowest income class at last, accounts for some 10% of the population. This class will mainly live in the old living quarters, where housing is cheap but of low quality. They often cannot afford a private car. High quality nodes (HST and main train stations) may be rather remote, and can only be reached by low quality modes like bus and tram. Their mobility possibilities tend to be largely reduced, therefore.

4.2.3 The transport system in the expected scenario

Long distance transport

In general, by the year 2030 a radial transport system will occur with rather high density links between the metropolises and mutually between the metropolises and europoles . On these links high quality HST-trains will offer a frequent service, and they will be mainly used for transport between compact city centres.

Most people will use private cars for transport which are driven by conventional fuels, however. The engines have become much more economical, therefore the emissions of harmful gases will be reduced sign.ificantly. On very long distances airplanes will offer a service. Their use will become rather expensive because of tax increases, while the HST will become an important competitor. Subterranean transport will appear to be very expensive, while most people still have to overcome psychological barriers for travelling in long tunnels.

For cormections with the smaller cities also slower trains will be in operation; the same holds for the main regional links. On these links the private car is also the dominant mode, however.

Mobility growth will largely continue, although it will be lower than in the 1990s because of the changes in the spatial organisation. Infrastructure investments will not rise dramatically. Road infrastructure capacity tends to be increased by using telematics, while public budgets are likely to be insufficient for large scale investments in collective mode infrastructure.

The modal split at longer distances will remain in favour of the private car, which will account for about 70% of transport demand. Collective modes will account for 30% of the modal split; their modal share between metropolises and europoles will however be relatively high with about 50%.

Urban transport

Also in the cities a radial transport system is likely be established. The main links will be those between the city centre and various subcentres as a result of the moderate compact spatial structure. These links will mainly be served by metro and light rail connections. Also buses and trams are stil1 in operation, but their importance will decrease because of cuts in subsidies.

In most cases however, electric and conventional fuel cars will be used for transport, especially when destinations are not in easy reach of high quality collective modes. Their use will be made somewhat less attractive however, by raising the parking fees.

Mobility growth in cities will be rather low because of the new spatial structures. A continuing population growth however, may cause some new mobility growth About 60% of the modal share will be covered by the private car (30% conventional and 30% electric), while 40% will be served by collective modes.

The overall conclusion is thus that the expected scenario is a modified trend extrapolation where new technologies, new policy orientations and new styles of living have only a moderate impact on transport systems in the future.

4.3 The Desired Scenario

4.3.1 Introduction

We will now turn to the elements of the desired scenario. In the survey the same questions as for expected developments were also asked for the desired ones. 'Desired' in this case means developments which are to be desired for the society as a whole and not only for the transport system. Therefore it is also possible to construct a comprehensive desired scenario. The analysis of these answers shows that individual behaviour should change much more, while several dedicated policy measures and new technologies should be introduced to a much larger extent. The resulting spider scenario is presented in Figure 3. First the spider factors will be discussed in more detail, then the resulting transport system will be analyzed.

4.3.2 The spider factors in the desired scenario

Spatial factors

According to the experts, in Europe a policy should be established in which an equal regional economic development is a main objective. As a result activities and population should shift out of the core zone towards more peripheral and rural regions. Especially the main regional cities will then become much more important. As a result one may not speak of a hierarchical spatial organisation, although the number of inhabitants largely differs per city and region.

In long distance transport govemment policy should focus more on a modal shift towards collective modes, despite the above discussed deconcentration. Activities and population should therefore be more concentrated around nodes of the collective transport system. In this way a spatial organisation may emerge like the chains and zones model, witb somewhat more concentration in cities. One might therefore speak of a moderate diffuse organisation.

Also at the urban leve1 the public policy should be aiming at a modal shift towards collective modes. Therefore, the compact city concept should be implemented more, with a strong concentration around the main nodes of the collective transport system (see als0 the regulatory scenario).

Institutional factors

In general, the influence of the govemment in many fields of society and tbe economy should be increased in order to redress social and environmental extemalities. The EU should develop as the most important authority in the environmental field. It should introduce more compulsory standards and targets, while also the regional support programmes should be extended. Liiewise the regional authorities should become much more important because of the subsidiarity principle .

Much emphasis in policy should be put on equity . Therefore, regulation may be accepted to be the best way for reducing transport extemalities. Because of evasion problems however, also market-based measures should be considered.

A strict environmental policy should be introduced, implemented and respected at the European level. For example, in the transport system many standards and regulations should be introduced, which make a shift from conventional towards new fuels more attractive.

Also for transport the EU should become the most important authority, while the urban and regional authorities should mainly be responsible for the regional and urban modes. The EU should also initiate a large scale investment programme in collective mode infrastructure. This network should cover all main transport links.

The railway companies should be more independent of public influence, although they may stil1 be publicly owned. This may be possible if the government undertakes the responsibility for the infrastructure and its costs. The profitability should drastically increase, because of the policy measures to make car use more expensive and the necessary huge investments. Especially the efficiency of railway companies should largely be increased. Road pricing may next be introduced to a large extent, so that investments in road infrastructure

will also become profitable. As a result the transport sector as a whole should be operated on a cost covering basis.

Economic factors

Much more coordination and centralisation may be necessary in society and economy, which may however have a negative impact on economic growth. This should be accepted however, because of equity reasons (both regionally and individually). As a result the European position in the world economy may however become relatively less important.

Because of the regional support and the policy to achieve an equal regional development, a shift out of the core regions towards the other regions is needed. This development may be stimulated by a proper spatial and land use policy and regional support programmes. As a result the economic position of regions will converge .

The govemment should also intervene more in the transport market and should oblige railway companies to cover all transport links. At the same time large price increases should be avoided in order to stimulate public transport use. As a result, the profitability of the railways may increase, because of the restrictions on car use, an increased efficiency and a concentration of population in compact city centres.

On most road networks some form of road pricing systems should be introduced, which should discourage car use and increase the profitability of the transport sector as a whole.

Social and psychological factors

It should increasingly be accepted in society that the individualisation and its impacts cannot continue, because of the great many negative consequences for the environment and the welfare of individuals. Therefore, the individualisation trend should be reversed. It should be widely accepted that environmental measures are necessary; for example, car use should be restricted and collective mode use should be stimulated. Equity may become a main objective of public policy . As a result, regional support has to be increased, while als0 the social security systems should not be abolished.

Three income classes may be distinguished. The class of rich people (10% of the population) can still afford to live outside the compact cities in 'green areas'. They own a car - powered by new fuels or electricity -, which is often used for reaching nodes of the collective transport system.

About 80% of the population belongs to the middle class, which lives mainly in compact city centres. They often do not own a private car, because of its high costs and the scarce space in these centres. When they need a car, it can easily be rented, however.

The lowest class at last (10% of the population) lives mostly in the older living quarters of cities. These can only be reached by low quality nodes like bus or tram. This class depends ahnost entirely on collective modes for their transport needs, which decreases their mobility possibilities largely. Nevertheless, these services might to be guaranteed by the govemment.

4.3.3 The transport system in the desired scenario

Long distance transport

In general, a transport system should emerge with many criss-cross links between the larger cities. These links are covered by an extensive network of HST and fast train links.

Private car use should be largely reduced on long distances. Only at low density links, cars, driving on new fuels, might be used. Road pricing has to be introduced on the main transport links. Very long distances where no HST links are available may be covered by LH $_2$ airplanes, which may ahnost entirely replace the services of conventional planes.

Also the main regional links should be served by trains and on the smaller distances by metro/light rail systems. Here again cars may be used for low density links and to reach public transport nodes (especially by the richest class).

Mobility growth should be negative after the introduction of the measures aiming at a reduction of car use. When much new infrastructure will be constructed for collective modes, the mobility may grow again, mainly because of the more diffuse spatial organisation.

The modal split should in any case change in favour of collective modes, which account for some 75% of travel demand. Especially because of the relatively high share in regional traffic the private car (driving on new fuels) may have a total market share of 20%, while the LH $_2$ airplane may have a share of 5%.

Urban transport

In the cities a radial transport system should come into being, with high density links between a compact city centre and its subcentres. These links are served by metro and light rail systems, which should form the backbone of the urban transport system.

At the short distances walking and cycling should be strongly encouraged, because collective modes are not efficient on short distances. Sometimes however, people-movers may offer a high quality service at very high density links.

From the nodes (terminals) of the metro/light rail systems to the final destination trams and buses may offer a complementary service. At the end nodes of the metro systems parking places should be constructed, which may also be used by the richer classes living outside the urban areas.

Mobility growth should become negative as soon as car use is restricted. Later on however, the mobility may start to rise again, because of the accompanying economic growth. About 75% of transport should in the year 2030 be covered by collective modes, while 25% may be covered by the private car (driving on new fuels or electricity).

5 CONCLUSIONS

Changing the transport system in order to make it environmentally more sustainable appears to have significant impacts in many fields. The life of individuals may be affected, for example, by intervening in their choice where to live, but also the freedom to choose their way of travelling. It should be noticed however, that the existing transport system is to a large extent the result of developments in other fields. Changes in the emphasis on equity or a reversal of the individualisation trend, for example, will be largely independent of transport motives, as is shown by past developments. Govemments in democratic countries will usually follow these trends and hence may show no (major) intentions to intervene. In this context also cultural aspects do play a role. In the United States, for example, intervention by the govemment tends to face more resistance than in most European countries.

Given the need for a structural reduction of the contribution of transport to global environmental problems, it may be clear however that several choices have to be made about the future of our transport system and its use. In our study these choices have been presented in an extreme way in two reference scenarios. For the current transport system the basic choice concerns either improving the existing transport system which is mainly based on individual modes of transport (by introducing new fuels, increasing fuel efficiency etc.) or introducing a more or less collective transport system in order to replace (part of) the current transport system (see als0 Rienstra et al., 1995).

As might be expected beforehand, the scenarios based on expert opinions are not that extreme, but reflect more realism. In our opinion however, especially the expert-based expected scenario is rather conservative. In fact, this scenario is largely an extrapolation of current trends, so it is questionable whether it will lead to a sufficient reduction of extemalities. It appears, for example, that new technologies are not expected to play a major role in future, while public policy is not expected to introduce the necessary policy measures for reaching environmental targets.

In the expert-based desired scenario the rather traditional choice is made that collective modes should dominate the transport scene, while the private car is only to be used as a feeder system for this collective system. According to most experts, government policy should aim at achieving such a collective transport system. A striking fmding is that most experts - irrespective of age, gender, discipline or professional background - largely agree on both scenarios; the variance in answers between the subgroups was smaller than expected beforehand.

The final conclusions may be that in the expected situation in the year 2030 environmental goals may not be attainable at all, while in the desired situation much more government intervention and subsequent changes in individual behaviour and the transport technology used are necessary . In conclusion, based on our application of the spider scenario model, it appears that many roads to an environmentally more benign transport system are possible, but that irrespective of the road chosen, it will be a hard one to follow. Environmentally sustainable mobility is stil1 more a challenge than a realistic and deliberate policy choice.

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