Transport, economy and air pollution in the 21st century

H.J. van Zuylen

Transport Research Center (AVV), P.O.Box 1031, 3000 BA Rotterdam, The Netherlands

1. INTRODUCTION

1.1. Looking into the future

The 20th century might be characterized as the century of diminishing distances and growing transport speed. The growth of distances travelled, travel speed and traffic volumes can be considered as a combined effect of technology, economy, social structures and national and international efforts to build more infrastructure with higher standards. The predictions of the future of the 20th century, made at the end of the last century or in the first decades of this century do not cover to a reasonable extent the real developments which have taken place. We should not expect that our expectations of what will happen in the next century will be more accurate or reliable. We can just do some wishful thinking, quantify our hopes and fears, extrapolate present growth processes, but we cannot expect that our views on the next century will be accurate, complete and relevant. Reviewing forecasts made in the nineteen-forties until the sixties for the second half of our century shows, that many forecasts were reliable, but that the emphasis in the many forecasted phenomena was seldom accurate: so even if we are able to forecast what will happen in the next decades, we will not be able to estimate whether the predicted trends will be important for the future of the world or that they will be accompanied by other, new trends which will overshadow the predicted ones. It is easier

to look backwards and to (re)write history as a comprehensible, causal chain of events than to look ahead and do the same for the future. If we look forward, we can only see what we already know: extrapolation of the past. Really new developments can be identified, but their relevance and impact can not yet be assessed.

1.2. Creating the future

Air pollution due to transport is a technology-induced problem. It is reasonable to expect that technological innovation will be the first appropriate means to deal with the problem. However, technology is not an issue isolated from society. Technology is embedded in the society. Technology cannot be changed without taking into account what the reactions of the society will be. The time is yet not completely over when innovations came out of the laboratories, were brought to the market and became successful - or failed, without a careful consideration of its possible impacts. Most innovations are feasible and successful due to the fact that they satisfy certain apparent or hidden needs of users, match the existing infrastructure, have no conflicts with existing laws or division of competencies between relevant actors, match the existing preferences and habits. The innovation process is complex and forecasts are usually inaccurate and unreliable. The innovation process, as it is seen by many scientists, has a chaotic, unpredictable character: small factors apparently seem to determine the direction of the development process. It is already difficult to explain the process '*ex post*'. An '*ex ante*' prediction of success or failure is in most cases unrealistic.

1.3. Policies for the future

The role of governments in the innovation process is changing. The assumption that society can be constructed, planned, manipulated, changed to demand appears to be false. The dynamics of change processes is too complex to be fully understood, many factors which determine the dynamics cannot be controlled. Uncertainties can be coped with by using other approaches: scenario-development to get more grip on the - uncontrollable - influence factors, a more open steering concept with feed back and frequent readjustment of the steering and an approach where the government takes the role of facilitator, arranging the conditions for the innovation processes instead of steering the process. The

new roles and approaches of the government require different skills and different structures in decision making.

Recently, in The Netherlands a project has been set up to develop option for a technology policy for transport [Slomovic et al. 1997]. The project INIT (Innovation Inland Transport Technology) identified about 15 innovation concepts which, according to expert views, will contribute to the policy objectives regarding accessibility and environment and which are feasible on a relative short term. For each innovation concept a preliminary survey has been done with focussing on *picture* (what are the characteristics of the concepts), *problems* (which problems will be solved by the concept) and *promises* (what will the concept contribute to the policy goals). Furthermore, the stakeholders have been listed and analyzed, the national and international initiatives which have a relation with the concept are enumerated. The strategy and necessary policy actions have been defined depending on the maturity of the technologies, the stakeholders and the existing R&D programs. The recommendations of INIT are now in a decision making phase and should lead to a coherent policy for the Ministry of Transport with respect to innovations. Most of this paper is based on the work done in INIT [INIT 1997].

1.4. Content of the paper

In section 2 the outlook on air pollution from transportation in The Netherlands is given. In section 3 the character of the transport system in relation with social and economic activities will be shortly discussed. In the approach of transport as a system, several ways can be found to solve the air pollution problem. Many of them involve technological innovations. In section 4 the character of the innovation process will be described and the possible roles of a government will be discussed. Section 5 describes how the innovations which are seen as promising and feasible, can be implemented in co-makership between private and public stakeholders. Chapter 6 gives the conclusions.

2. TRENDS AND SCENARIOS FOR AIR POLLUTION FROM TRANSPORT

In 1990, the Dutch Minister of Transport, Public Works and Water Management and the Minister of Housing, Physical Planning, and Environment published a policy statement on transport called *The Second Transport Structure Plan* (hereafter SVV-II, the Dutch acronym for *Tweede Structuurschema Verkeer en Vervoer*), which was approved by the Dutch government [Ministerie van Verkeer en Waterstaat 1992, Van de Hoorn 1993]. The SVV-II describes the current and foreseen problems associated with transport in The Netherlands and lists the goals and targets set by the government, as well as a wide range of measures and policy instruments proposed for reaching the goals. Although technology developments play an important role in the presented measures and instruments, the SVV-II paid no special attention to technology as a phenomenon in itself.

The SVV-II distinguishes three main problem areas:

- Economic centers are in danger of becoming inaccessible, and the national position of The Netherlands as a transport and distribution center is in jeopardy.
- Pollution continues to worsen: transport damages the environment through air pollution, noise nuisance and the fragmentation of the countryside.
- Road safety is deterioratinging after years of improvement.

The targets for 2010 have been made specific and quantitative in the Structure Plan. Recently, a similar exercise has been done for the OECD project on Environmental Sustainable Transport (EST) [van Wee et al. 1996]. Six quantitative criteria were given, where for The Netherlands these criteria have been extended with four additional ones. The criteria for SVV-II and EST which apply to air quality are given in table 1.

Table 1

Air quality criteria for SVV-II and EST

Component	SVV-II: Reduction between 1986 and 2010 (%)	EST: Reduction between 1990 and 2030 (%)
CO_2	10	80
NO_x	75 (cars) - 80 (commercial vehicles)	90
VOC (volatile organic compounds)	75	90
PM_{10}		90

Since the SVV-II was written, however, it became increasingly clear that the ambitious targets for many policy goals cannot be reached without an extra policy impulse. An assessment has been made of the intermediate situation and an estimation based on two scenarios. The most optimistic scenario with respect to economic growth was called the European Renaissance Scenario (ER) [Centraal Planbureau 1992], which assumes a dynamic, technological development, economic integration of Europe and a strategic role for the government as a co-ordinating mechanism. The second scenario, the Global Shift Scenario (GS) assumes a dynamic technological development, a free market, a stagnation in the European integration and an economic growth in Europe which is less than in Asia and North America. In the next two figures the estimated development of car kilometers and CO_2 emissions are given as estimated for two economic scenarios.

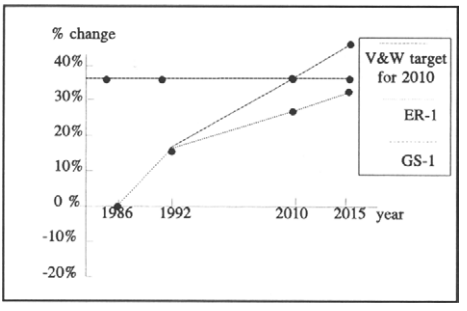

Figure 1 Observed and estimated development of car kilometers between 1986 and 2015

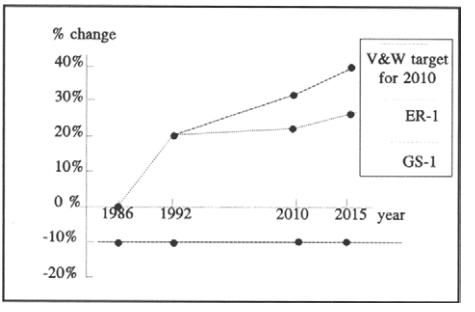

Figure 2 The expected development of emissions of CO_2

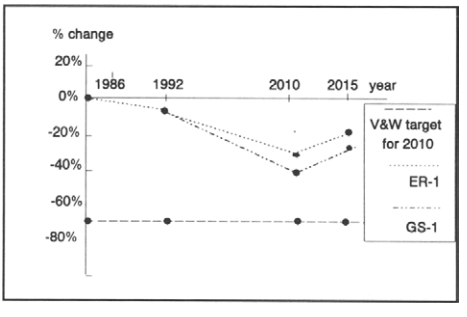

Figure 3 Percentage change in NO_x emissions from road traffic from 1986

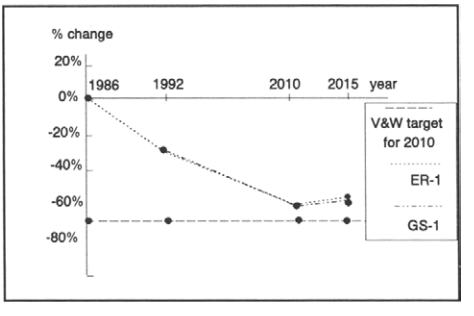

Figure 4 Percentage change in VOC emissions from road traffic from 1986

Preliminary studies suggested that part of this extra policy impulse could come from technology policy for traffic and transport. In the EST study [Van Wee et al. 1996] a detailed investigation has been made in which the impact technological innovations are compared with strictly restrained transport demand. This study shows, that the *Business As Usual* scenario does not lead to a situation which satisfies the requirements. A second scenario, in which technological innovations are supposed to be introduced, such as fuel cells, hydrogen and electrical and hybrid traction, shows sufficient reduction of emission to reach the targets for 2010 and 2030. A third scenario is the capacity constraint scenario. In this scenario it is assumed that the transport demand has been significantly reduced. Large changes in the society are needed, including a more efficient organization of transport, reduction of distances between production and consumption location,

elimination of commuting and car travel, except for special services. The economic growth will be changed significantly from the present trend, because production has to be done more localized. A fourth scenario has been developed in the EST study, in which a mix has been made of technological innovations and the reduction of transport demand. Here less extreme assumptions had to be made, while the objectives still could be achieved.

The EST scenario study contains many assumptions which all represent uncertainties. However, the high technology scenario and also the fourth scenario show that extrapolation of the present economic grow does not necessarily conflict with high standards for air quality. The problem is, however, the realization of the necessary innovations, i.e. the changes in technologies and structures and culture in society and institutes the role politics has to play. INIT [Slomovic et al. 1997, INIT 1997] has developed policy options for the development and implementation of technological innovations which will help to achieve the necessary improvements in the transport system. In order to clarify the possibilities to improve the environmental impact of transport, a short discussion is given of the transport system. In this discussion it will become clear that technological innovations have more possibilities than just improving the direct source of pollution: the propulsion system of vehicles. Technology can also help to modify modal choice, facilitate intermodal transport and reduce transport demand.

3. THE TRANSPORT AND TRAFFIC SYSTEM

3.1. A systems view

Transport is a derived demand, where social and economical activities lead to the demand for mobility. In figure 1 a conceptual scheme is given of the transport system. Most environmental problems are located in the transport means part of the system, where vehicles give emissions, noise and risks. The directions for solutions can be on any level: e.g. demand reduction, alternatives for existing transport modes and improvement of the existing modes. The link between economy and transport is mainly that a growth of economic activities induces transport demand. Qualitative changes in the

economy have also an important impact. For instance, the stimulation of recycling creates new transport patterns. Also changing logistic concepts and geographical shifts in economic activities have an impact on transport demand. Another influence of the economy on transport is, that a growing economy generates higher incomes which result in a higher travel demand.

An important factor which influences transport demand is regional planning. The geography of economic and social activities determines for a great deal the demand of transport. Optimization of the location of industries with respect to each other and of residential areas with respect to working places, cultural centers and recreation areas determine the distance for transport and often also the quantitative transport demand. Most important for transport demand are cultural patterns: habits, preferences and values determine the needs for transport, especially transport of people.

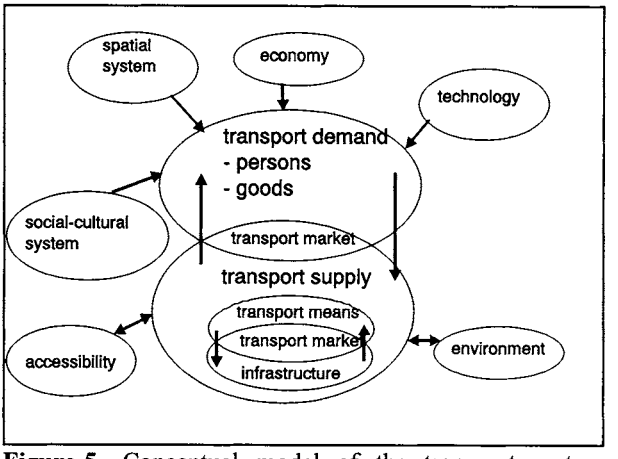

Figure 5 Conceptual model of the transport system [INIT 1997]

The environmental problems such as air pollution are caused at the transport means level of the transport system: vehicles and the way vehicles are used. The most obvious and logical solution is to develop clean engines and to manage traffic in such a way, that environmental problems are not caused at sensitive locations such as residential areas. However, it is often more effective to look also at the higher levels of the system. In The Netherlands the vision on the future of the transport system, in which both the

environmental goals as well as the goals with respect to accessibility are realized, can be summarized as follows [INIT 1997]:

1. The demand for transport is restricted by making transport more expensive, provide alternatives for transport of people by stimulating tele-activities and improved land use patterns.
2. The character of the transport system is modified gradually into a service structure: transport is a integrated service from door to door, where the choice of route and vehicle is of less concern the ownership of vehicles is separated from its use. The choice of routes and vehicles is subjected to limitations, especial in urban areas, and the costs structure is such that the choices lead to a social acceptable situation.
3. The transport service is optimized such that a better utilization of vehicles and infra-structure can be realized. This implies that intermodal transport becomes normal: the mode which is the most cost-effective is chosen and interchanges between modes are no longer costly and give no unnecessary delays.
4. The transport chain has become transparent: for the supplier and user of transport services all the necessary information is accurate and complete to make the necessary decisions and to control the transport process.
5. The different links and nodes in the transport chain have been improved such that the infrastructure is utilized as good as possible and vehicles are efficient, safe and clean.

3.2. The concepts

In INIT the approach has been to investigate the potential of technology on all levels of the transport system, i.e. for innovation of vehicle traction as well as for demand reduction. INIT has identified 14 innovations which have the possibilities to contribute to the vision of the future. The innovations have a technological character and are assessed by experts as being feasible. The innovations are given as *concepts*: descriptions of a design or elaboration of an available set of measures and (technological) resources for a specific area of traffic and transport in the future. Concepts are more then just applied technologies. They bring technological innovations and changes in society and economic structures in relation with functions of the transport system.

The technology concepts that are formulated in INIT are technologically evident: they

are no uncertain, creative inventions but applications of existing technologies and technologies which can be developed on a short term. They have been formed on the basis of discussions with experts about the technological possibilities and have grown into coherent future scenarios. They pose new challenges for society and the government. They hold promise, but sometimes bear risks as well; promise in terms of more efficient, safer and cleaner transport, risks in the context of, for example, changing economic relationships - some existing organizations will disappear or get a completely different role, and the rate of technological development in relation to social change - how much technological change can the society absorb in a few decades.

There are three categories of concepts:

1. tele-activities:

The use of information technology facilitates several activities where physical presence is no longer necessary: tele-working, tele-learning, tele-shopping etc. There are many possibilities to reduce physical transport. However, until now the applications are too limited to show a significant impact on transport and traffic. Further stimulation of experiments and removal of barriers may develop the full potential of this concept. The risk exists, that tele-activities will induce new transport demand, just as has happened with the telephone.

2. integrated goods transport chain:

Several concepts can help to facilitate (inter-modal) transport chains. The concepts apply to the infrastructure, vehicles, organization of transport, intermodal terminals and organizational issues:

- intermodal market linking system, an information system which links supply and demand for transport, supports the optimization of transport chains and provides the necessary information to follow goods along the transport chain,
- transhipment terminals, the optimization of intermodal nodes, such that costs and transshipment delays are reduced,
- integrated intermodal packaging infrastructure: standardized packaging and transport

units which are suited for different modes - also new modes like underground transport -and satisfy the requirements of producers, retailers, carriers and forwarders; the concept includes all the manufacturing and logistics to optimize the use of the standard units,

- underground (urban) haulage system, a new transport mode which eliminates the need for surface transport in sensitive areas, such as town centers, an improves the quality of life in those areas,
- automatic vehicle guidance, which will automate a part of the transport chain, reduce the costs, improve the utilization of vehicles and infrastructure,
- integration of inland shipping and coastal shipping: by technological innovations in ship building, waterborne transport in certain important transport niches can be made more competitive with respect to road transport,
- high-speed waterborne transport, using high frequency connections, fast transshipments and high-speed ships,
- improved designs for lorries/vans, which make them more suited for use in urban environments, cleaner and safer.

3. integrated passenger transport chain:

The separation between individual, private transport and collective transport has to become subordinate to the concept of the door-to-door transport service. Just as nobody is interested in the question whether the connection for a telephone call is made by a copper wire, glass fibre or wireless, the choice of vehicle, mode and route should in the future be determined by considerations like efficiency and social acceptability, without reducing the speed, efficiency and comfort of the trip. The transport system should be reliable, efficient and safe. Ownership of vehicles will no longer determine the preference for the use of a transport mode. Concepts which will support this vision of the future of passenger transport are:

- a fully integrated (public) passenger transport system
- a dynamic traffic management system
- a dynamic information system
- automatic vehicle guidance

- modular vehicles
- propulsion and fuel

The first concept primarily ensures the integration of different means of transport and connections between modes of transport. The goal is to achieve organizational improvement, supported by technological innovations.
A dynamic traffic management system ensures optimum utilization of existing infrastructure. A dynamic information system makes it possible to make transport choices on the basis of all the information available at any given time and supports the integrated passenger transport system.

4. THE VIEW ON INNOVATION

4.1. The innovation process

Technological innovations in the transport system are necessary. However, the direction of the innovation process is uncertain and difficult to steer. In the beginning of the innovation process everything is uncertain, there are plenty possibilities to steer the innovation process but there is little guidance for decisions in which direction to steer the process. As the innovation process goes on, the impact of the innovations and its possibilities become more clear. However, the possibilities to change the direction become less. Many forces have an influence on the innovation process. These forces work often in an independent, incoherent way. Cooperation between these forces is in most cases by accident.

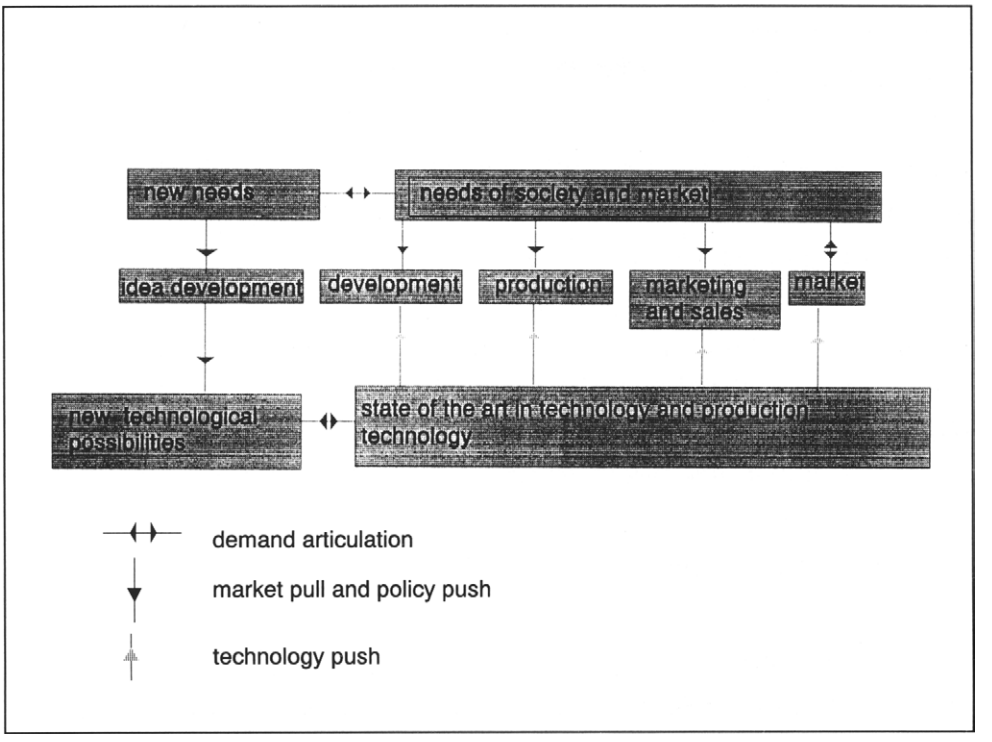

Figure 6 A model of the innovation process

The ways in which the government can have influence on the innovation process are:

- stimulating research and development by subsidies and research programs,
- facilitating the market uptake of innovation e.g. by tax measures, subsidizing the replacement of outdated equipment,
- strategic niche management: small niche markets are created where innovations can grow, build up the necessary infrastructure and networks without facing the competition of existing products,
- demand articulation, clarifying what the needs for innovation are and giving guidance to the industry indicating which directions will have the support of the government
- being an advanced buyer of new products,
- building networks of stakeholders to stimulate co-operation and removing barriers
- removing legal barriers,
- national and international co-ordination of innovation activities

- enforcing technologies by legal prescriptions,
- covenants between government and trade and industry.

In some cases the government can have different roles in the innovation process. Since the government is owner of the infrastructure and most governments have their own research and development organizations, the government is sometimes even found in the role of developer.

4.2. Strategies

In INIT the roles and strategy for the government in the innovation process have been determined for each concept, contingent with the maturity of the technology, the relation between stakeholders and their involvement in the innovation process and with the existing innovation programs. Some innovations are already in a mature state, many are already supported by initiatives of the government. Such initiatives should not be changed, unless more co-ordination is needed or the present initiatives are too limited in scope. Examples of such innovations are the *Dynamic Traffic Management System* and the *Travel Information System.*

Other innovations need technologies which are in a mature state and the innovation process and impact of the innovation is already reasonably clear. Such innovations require a kind of *Constructive Technology Assessment* [Rip et al. 1995]: stakeholders should come together, form a network and should identify their own goals with respect to the innovation. The government has to try and find a way to 'polarize' the different goals: the interests of the different stakeholders is taken into account and the goals which facilitate or fortify the common policy goals are supported. The process of the acceptance of a common shared goal, the growth of common understanding and the adjustment of different activities is first of all necessary. Examples of concepts that have to be dealt with in this way are:

- an intermodal market linking system
- terminal technology
- integrated intermodal packaging infrastructure
- an underground (urban) haulage system
- integration of inland and coastal shipping

- a fully integrated (public) passenger transport system.

The content of these concepts might change significantly during the development process. Little has been fixed yet and the future is still uncertain, which gives many possibilities for adjustment.

Finally there is the class of long-term innovations, which need several decades to be fully developed. Examples are *Fully automated vehicle guidance* and *Modular vehicles*. The approach for these concepts is, that an *Awareness Technology Assessment* [Smits and Leyten 1988] is executed, an analysis of possibilities, advantages and disadvantages, risks and opportunities, a map is made of stakeholders and a discussion is started whether such innovations are needed and what should be done to make a maximum profit out of the concept.

An analysis of the transport system is a precondition for an effective strategy. Experimental learning is a good approach supplementary to this analysis. Demonstration projects, pilots and niches are excellent ways to investigate the full potential of concepts, to find limitations and barriers.

4.3. Co-makership

Innovations in the transport system cannot be imposed, enforced or just left over to the market. The forces of the market have to be used to promote the innovations, but unfortunately many of these forces work in opposite directions. Market forces often lead to *social dilemmas*: short term, individual interests create a locked-in situation where optimization of other stakeholders become restricted or even impossible and the whole community ends in a worse condition than in the situation that some top-down, global optimization had been done and individual freedom of choice had been limited. Solving the social dilemma is a task for all stakeholders, but a government often has to take the initiative to change the structure of the market. The government is in most cases not able to steer the innovation process, but it is possible to change the characteristics of the dynamics of the process in such a way, that the innovation moves towards an attractive situation and will not be locked-in in a social undesirable state [van Zuylen 1995].

Innovations should be tailored to the specific application area. New technologies should contribute to the solution of existing problems and should be applied such, that they fit

in existing patterns of behavior, competencies and equilibrium of power distribution. For example, in logistics several innovations will only be possible if they are introduced in collaboration with the stakeholders. The term 'acceptance is too weak to describe this aspect of innovation. The term 'co-makership' is more appropriate.

The practical approach proposed by INIT is, that for each concept a public-private organization is set up to develop implementation plans. These plans should be executed in collaboration between government, research and trade and industry, in order to get a guarantee of quality of the plan and a maximum support of the stakeholders. The co-ordination between concepts and the goals for the different concepts will be the care of a steering group according to a multi-echelon structure [Jantsch 1972].

The initial activities of these organizations should be to identify the stakeholders, to analyze the processes in which the concepts should play a role, look for existing initiatives which can support the development and introduction of the concepts. During this process it is possible and likely that the original concepts undergo an evolution and will be tailored to existing needs and problems of the stakeholders. This phase will be analytic as well as creative: analyzing subsystems of the transport system and creating new directions of solutions.

The next phase should focus on actions: *research* to reduce uncertainties, *development* of technologies, *pilots* and *demonstration projects*. In the following implementation phase the barriers have to be identified and removed and starting problems have to be solved. Suitable strategies are tax measures, legislation and strategic niche management. There has to be a coordination between actions of public and private stakeholders. Just as with goals, also action should be 'polarized': actions which work nearly in the same direction have to be fine-tuned and coordinated and conflicting actions have to be prevented. The basis for this 'polarization' is a good common understanding of all stakeholders [Eden en Vangen 1995].

This approach proposed by INIT for the innovation process is relatively new for the domain of technology policy in transport. It requires new skills and - at least for The Netherlands - new ways of co-operation between government, local authorities and private stakeholders. The dynamics of the innovation process in the transport system is not well understood yet. Research and experiments will be necessary to find effective

ways for implementing innovations.

6. CONCLUSIONS

Transport has a negative impact on the environment. Without appropriate measures the pollution caused by transport will be unacceptable. The present situation has to be improved and the growth of transport demand have to be dealt with in such a way, that technological improvements of vehicles are not overshadowed by increased demand.

Transport is a derived demand where economy, the spatial system and social activities are determining factors. Choice behavior in often sub-optimal from the point of view of policy goals. Social dilemmas make market forces work in the direction of locked-in situations, where possibilities for optimization become very limited.

Several technological innovations have been identified, which can help to reduce the environmental impact of transport. Some innovations work on the level of the propulsion system, others have influence on the choice behavior, reduce transport demand, create new choices and make environmental friendly transport modes more attractive. Scenario studies show, that conflicts between economic growth and environmental quality can be solved.

Technological innovations have to be implemented very carefully. Transport is an organic system. Implementation of 'strange' technologies is difficult and often impossible due to repulsion reactions. Careful fine-tuning of the primary processes, identification of opportunities for innovation and 'polarization' of the goals and actions of the different stakeholders can lead to successful adaption of new technologies.

The approach which is proposed is based on co-makership in the innovation policy, where government, provincial and local authorities coordinate their strategies, private stakeholders are involved and share the responsibility for the implementation plans. The uncertainties in the dynamics of innovations and the emergence of new problems and technologies will be dealt with by monitoring the implementation process, executing technology surveys and periodic replanning.

INIT has recognized the fact that technological innovations have international

dimensions. First of all is the automotive industry a worldwide complex that cannot easily be influenced by one single country. Furthermore, the competence of international organizations such as the European Union might be more suited to develop and implement an effective technology policy. There are many international activities in research and development which fit in the innovation concepts described in this paper. Duplication of these efforts is a waste of resources. Therefore, for each concept the international dimensions have been investigated and the implementation programs have to be set up in collaboration with existing international initiatives.

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