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TOWARDS A MORE FUNDAMENTAL TRANSPORT POLICY: AN INVENTORY OF TRENDS THAT INFLUENCE THE TRANSPORT PATTERNS IN WESTERN EUROPE AND THEIR IMPLICATION FOR POLICY MAKING

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Abstract: The success of transportation is partly a derived effect of the fulfilling of all sorts of needs, varying from economic needs to social needs. The success is also the result of continuous technological innovations. At the same time, the success creates significant negative external effects. Thus, there is a need for a sustainable transport policy that pays attention to the balance between needs and sustainability requirements. So, as transport is the result of a derived demand, it is also needed that there is a better understanding of the societal, economic, and technological trends that will influence the transport patterns and their implication for policy making. This paper presents an inventory of the trends, places these trends in a policy context, and comes forward with recommendations for sustainable policy making for the transport sector in the future. The emphasis will be mainly on experiences in Western Europe. The transferability is briefly discussed.

Key Words: Transport development, Transport policy, Future trends

1. INTRODUCTION

An efficient transport system is a crucial precondition for economic development and an asset in local, regional and international mobility. Free movement of passengers and goods is nowadays considered as an essential precondition for economic development and modern societies. With the integration of the world market, economic growth and higher levels of income, transport has become a major economic sector, which is characterised by quantitative as well as qualitative growth. In the E.U., the transport service industry (including telematics) accounts for about 12 percent of GNP (European Commission, 2001). For some of its Member States, like the Netherlands, the contribution of transportation to the GNP is estimated to be around 16 percent. For the U.S. and Japan it was estimated to be between 4 and 6 percent (OECD, 1993 and 1994), but the share definitely increased. It can be stated that the significance of transportation goes even beyond these proportions, while no economic activity can flourish without transportation activities.

The benefits of transport, however, come at a high price. No mode of motorised transport is environmentally friendly. Some modes of transport, notably rail and inland waterways, have lower impacts than others, such as road and air. It is not clear how the performance will develop in the (near) future. Therefore it is important to understand the dominant trends that will shape our future. In this paper the authors assess these future trends on the basis of literature study and interviews with stakeholders.

In the following section (2) the position of transport will be described, with a special emphasis on the 'derived' character. Section 3 deals with the societal and economic trends in Western Europe. In Section 4, attention is paid to the impacts of these trends on the technological developments that manifests. Section 5 deals with the new and emerging trends of sustainable development. Finally, in Section 6, conclusions are drawn.

2. TRANSPORT AS A DERIVED DEMAND

Transport is a fascinating phenomenon in society of all times. Since the ancient times fast and efficient transport is connected with connotations as economic prosperity, social desire and welfare, with a lot of positive (side)-effects. In the early days, animal power played a dominant role in travelling; camels, mules, and horses were frequently used until nineteen's century. But in modern times the combustion engine took over and our Western society became almost 100% dependent on fossil fuels. What remains are the symbols such as the measuring of the power of engines in terms of 'horsepower', but the transport sector is today a high tech sector with a strong innovative capacity (Ongkittikul 2003).

The evolution of transportation has always been closely connected to technological development. New transport technologies have been vital for economic development. In fact, they have been so influential that economic historians have termed whole periods of economic development after various transport infrastructures, e.g. the `age of canals' in the first half of the 19$^{th}$ century, or the `railway and coal era', the expansion of which ended with the Great Depression in the 1930s. (Geerlings 1999). But understanding the developments in the transport sector can't be explained by a 'techno centric' analysis. Of course there is a direct relation between the technological development and the transport performance. But this development goes hand-in-hand wit a changes in society. A complex equation has to be solved in order to curb the demand for transport. Transport is in almost every case a derived effect to fulfil certain needs. Economic growth will almost automatically generate greater needs for mobility of goods, but there is also a strong demand created for passenger transport, due to income growth (Zahavi 1981), but also needs such as education, social visits, recreation, etc. Looking back we observe that passenger transport growth in Europe with 2.8 % per year and freight transport by 2.4 % per year (Korver and Harrell 1999). Consequently the success of transport refers to the changes in society (production and consumption), individual needs and the opportunities offered by technology. And as transport is a derived effect, to understand the future development is crucial to get some idea about the potential future trends and developments.

3. SOCIETAL AND ECONOMIC TRENDS

The development of the transport sector is highly depending on societal changes. In the following section we address the expected developments of the modernization process in our

society, where some major changes are taking place (Van Ast 1998). Most eye-catching are globalisation, internationalisation and rationalization. These trends have a significant impact on the way mobility will develop. In the following we make a distinction between two perspectives: the viewpoint of public policy and of economic dynamics.

3.1 Societal and Policy Perspectives

Individualisation. We observe in Western Europe a dominant development that is called individualisation. It includes on the one hand a fragmentation of society, with changing standards and values, and on the other hand an increasing social awakening. The availability of an exponentially increasing quantity of information and knowledge causes rapid developments. In turn, these new dynamics in society lead to a continuous demand for faster and more flexible modes of transport.

Societal segregation. The rapid developments in West European society are causing an increasing number of people that can be identified as `drop outs'. The gap between this group and the rest of society is more active in production and consumption will widen. Particularly in relation to the time and money budget passengers have available, we will see that mobility will be more strongly connected to social status.

New institutions. New (sometimes `one-issue') groups of variable composition may be formed. Existing structures and institutions that are incapable of meeting the pluriform societal demands may lose ground. New organisations and groups in society may gradually replace the old ones causing the political decision (-making) process to become more complex. For instance, the European integration creates more cross-borders transport.

New roles of the government. Acting from its position as a director, the government could increasingly attempt to facilitate and support societal and economic development. This requires a consistent, effective and integrated government. This tendency can be called the "horizontalisation of governance" and refers to the less important role of the command and control paradigm that allows the government agencies to determine from a hierarchical position what citizens should do. In modern society, citizens participate in the decision-making process in a more or less horizontal position compared to agencies. The process of deregulation and privatisation affects the positions of the public sectors in regulation the transport services. The outcomes so far is worsen public transport services which results in a declining use of public transport.

Re-regulation. Attempts to influence public opinion are becoming more complex due to the fragmentation of society (see individualisation), the governmental steering in society, however, does not decrease, because social behaviour remains largely predictable. The increasing concern for social well-being means that deregulation is being replaced by re-regulation. Because of these new types of, partly horizontally-, partly vertically-oriented, instruments are being deployed. At this moment, it is not clear how this trend will affect the transport demand. However, the declining use of public transport may signal to the government that re-regulation may be an option to tackle this undesired development.

3.2 Economic Trends

The economisation of our society could be seen as a trend in itself, everything has a price nowadays, and for every decision the financial profit seems to be the most important factor.

Because common economic thinking does not imply the long-term effects and the non-financial consequences, most environmental factors are not adequately taken into account.

International cooperation. While retaining national responsibilities, the international and regional political cooperation could be reinforced. Increasing diversity of interests in large institutions like the E.U. may make decision-making processes more complicated and cause a growth in bilateral cooperation (in an attempt) to reach practical solutions. This has a very strong effect on the increase of global trade patterns.

New global regional network developments. In addition to the globalisation trend there is a rapid growth in the regional orientation of economic activities. A new structure of mutually dependent worldwide and regional networks is developing. These networks generate positions of power by linking competence, a process in which knowledge and `economy of touch' (see Chapter 4) play an important role. This has enormous consequences for multinationals and the way business is performed. But is also effects the increase in demand for transport services

New economic centres. Unbalanced rapid growth of the world population and liberalisation of economies could cause the development of new economic centres like China, Korea, India and Latin America. This regional concentration of production and trade may stimulate ongoing specialisation. Here too, however the Asian tiger will growth, the development of the demand for transport will affect Western Europe as well.

Regionalisation specialisation/clustering economic centres. After the primary tooling of materials in the source areas, semi-manufactured products are processed into final products in different regions. This process of concentration is facilitated by ongoing computerisation and a better production management. This causes a growth of the (global) intra-company and intra - supply chain - supplies of semi-manufactured products and an increase in the regional final products trade. As soon as the scaling-down benefits can permit, expansion of the production capacity may take place in the new economic centres, a process that could be coupled with ongoing centralisation of (financial) management in the `home-based' countries. Logistic systems and ICT plays a crucial role in this process.

Industrial eco-systems. Production activities show a growing connection with technology, economy and environment. New industrial activities are being geared to the developing network structure of global and regional economies. Multinationals are changing into trans-multinationals and new combinations of industrial eco-systems in the shape of clusters aimed at small-scale activities with an emphasis on added value are developing. The idea is that the good application of this philosophy will lead by the end of the day to the decline in the demand of transport.

Re-orientation of R&D activities. The yield of R&D activities for the hardware element of products has strongly diminished due to the rapid copying of developed products which, in international competition, may quickly lead to diminishing margins. Consequently, strategic R&D research could be placed in new institutions (public-private partnership). The government's role could mainly become a facilitating one (`not picking winners') for universities and institutes with respect to technological research. Expectations are that R&D is a matter of short-term priority for companies, but that the results of the R&D will be increasingly used for long-term strategic planning. Supporting its own national interests may be an important part of the government's role. As these are knowledge-based activities, the effects on freight transport will be minimal.

Outplacement R&D activities. As a result of economically favourable circumstances, new industrial activities may be established in the regions. The first alternatives in the field of energy and technology could also take place there. New concentrations of R&D activities may arise in these regions to be able to anticipate the specific demands of the growing outlet. This mainly concerns R&D activities that are aimed at the final stage of product development. In 15 to 20 years, the dominant position of the new economic centres could be established.

Overall it can be concluded that Western Europe is in a phase of transition now. However the future trends are complex and the exact effects cannot be measured yet, it is clear that the trends will absolutely create more demand for transport. This conclusion can be drawn on the basis of historical evidence (see Zahavi 1981), but evidence can also be found from the assessment of the societal- and economic trends and an appraisal of the effects of these trends on the demand.

4. TECHNOLOGICAL TRENDS

It is also clear that the growth of transport will generate sincere negative effects (such as congestion, emission, accidents). But since the transport sector can be characterized as a dynamic sector, it is expected that some of these effects can be addressed by technological innovation. However a 'technological fix' will never be envisaged (Geerlings 1999), technology can contribute a more dynamic economic development but also to fight the external effects. I the following a quick scan of the technologies will be presented.

4.1 Transport Flows Concepts

In the past, we acknowledged transport in a somewhat narrow definition that mostly deals with physical movement (both people and goods). Nowadays, technology has been involved in widening the meaning of transport. Remarkably, the development of information and communication technology (ICT) has played a vital role in shaping (and also shaking) the role of transport in the society. In order to understand this evolving system, we propose the concepts of transport flows as follows.

Transport consists of two flows: physical flow and information flow. The physical flow represents the traditional transport concepts. This flow could be either passenger (people) or freight (goods). The main important elements of this flow are transport infrastructure and vehicle. For the information flow, we can consider this flow in twofold; complement and substitution. Complement is ICT that helps or improves transport service such as travel information systems, real-time traffic information, or vehicle scheduling. Substitution is ICT that replace or reduce the physical transport needs such as telecommuting or teleworking. Figure 1 shows the transport flows concept.

The concept of transport flow aims to examine the importance of technological development in the transport sector. These trends reflect the fact that there are different paths in technological developments. The first path consists of the technological development that intends for transport industry only, such as the development of an alternative fuel vehicle and the magnetic levitation (Maglev) technology. Secondly, there is a path of information and communication technology. The development of this path benefits from the advance research and development in the communication industry while the transport industry is not likely to be able to develop the technology per se.

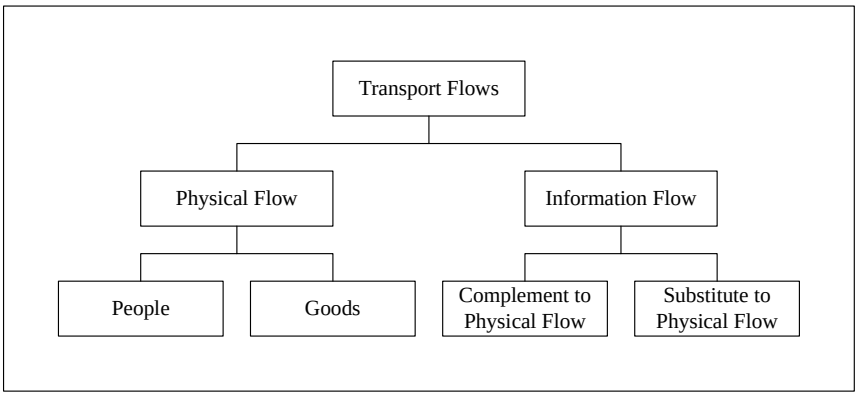

Figure 1. Transport Flow Concept

This section assesses several aspects of the trend of technology in the transport field. The assessed aspects include mobility, congestion, and environmental pollution. It also extends to determine factors that influence successful technologies and its barriers to implementation.

4.2 Decomposition of Technological Involvement in Transport

This section is mainly dealing with the physical flow. However, the information flow may also help in some areas, especially where it complements with physical flow. Technology is involved in many aspects of transport systems. This composition can be applied to both passenger and freight transport.

As mentioned above, technology takes part in various aspects in transport. To examine the effect of technology, it is useful to decompose the technological composition of the transport system. This decomposition is called transport mode concept which is proposed by Zwaneveld et al. (1999). This concept is to consider transport into three components: propulsion system (PS); vehicle concept (VC); and transport concept (TC). Then the transport mode concept is introduced to cope with three previous items (PS, VC and TC). The definitions and some of the relationships between terms are given in Figure 2.

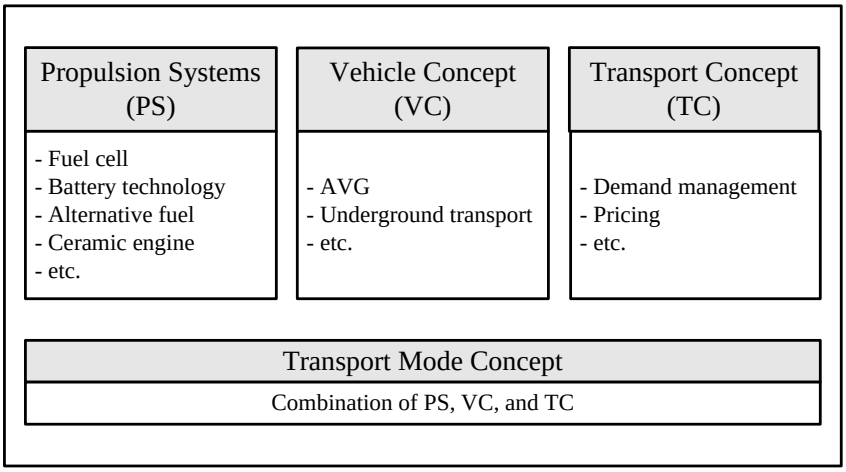

Figure 2. Transport mode concept (Zwaneveld et al. 1999)

In each system, there are several potential technologies that could make an impact to the system. Each system has its own path of technological development. The propulsion system concerns on the fuel and technology that is used for the movement of the vehicle. As far as

the vehicle concept is concerned, both the vehicle and infrastructure are developing. The transport concept goes beyond the individual vehicle. This concept concerns the aspects of organising and facilitating the system. Finally the transport mode concept evolves all concepts that mention above and takes into account the individual behaviour to manage and control mobility of the system.

4.3 Fuel and Propulsion Technology

The development of fuel technology is an important trend in transport technology. In the past fuel and propulsion technology improve the performance of transport system in term of speed. If we see the development of the transport system, in any modes, the speed is gradually increasing. One of the key elements is the propulsion system. For example, in railway, the change from coal engine to diesel engine increased the railway speed. However, each mode has its capacity to increase such speed. Undoubtedly, automobiles have reached their maximum practical speed (150 kph at max) due to a safety reason. Further concerns are the environmental impacts from each propulsion system. Recently, the issue of environment becomes more important to the society. As the transport is one of the sources of pollution, the fuel and propulsion technology have tended to improve the environmental performance of transport systems, especially in the automobile sector.

An important development in this category is the alternative fuel vehicles. There are several fuel technologies that are in the development period now, such as fuel cell (FC) technology and bio-diesel. Clearly, the engine replacement is not relevant to the mobility and congestion issue, i.e. the use of alternative fuel vehicles is neither reducing nor increasing the level of congestion. What it does affect is the environmental aspects. Gwilliam and Geerlings (1992) observe four alternative fuels, namely hydrocarbon fuels, biofuels, hydrogen, and electric propulsion (fuel cells). These technologies have promising means toward more environmental friendly transport systems with substantial reductions of all environmental impacts, however, the introduction of such technologies is only in a long-term perspective. Indeed, more than a decade of this report, the significant implementation is not yet found in this field.

The list of potential fuel and propulsion technologies is as follows:

- Advanced conventional propulsion systems
- Improve internal combustion engines
- Improve tailpipe emissions treatment technologies
- New propulsion systems
- Electric vehicles
- Hybrid electric vehicles
- Advanced conventional fuels
- Fuel quality improvements
- Alternative fuels
- Compressed natural gas (CNG)
- Liquid petroleum gas (LPG)
- Hydrogen
- Fuel cell
- Battery

Helmreich and Leiss (2000) indicate two important technologies in the field of fuel and propulsion technologies that could make a major contribution in the future namely fuel cell

technology and hybrid propulsion. Firstly, ***fuel cell propulsion*** may be based upon several different fuel and technology combinations, depending upon rate of technological development, fuel availability and infrastructure development. There is uncertainty over the impacts that may be expected from each of these combinations. Full life-cycle analysis is required to fully appreciate the contributions of fuel production and distribution on resource use and greenhouse gas emissions. There is less doubt that fuel cells will lead to very significant improvements (>90%) in local emissions of key pollutant species. Fuel cell technologies are expected to be significant in almost all scenarios and with many different vehicle and transport technologies. They are expected to have the most positive impacts on greenhouse gas emissions and air quality, and will deliver improvements to nuisance (mainly urban traffic noise). Fuel cells are expected to show a 50% improvement in fuel efficiency in 2030 compared to conventional petrol in 1995. Fuel cell technologies still require a lot of R&D to become more economically viable, and to guarantee equity in transport access.

Secondly, ***hybrid propulsion*** is also expected to play a significant role in the medium term, and to become an important core technology connected to fuel cell deployment (Ongkittikul and Geerlings, 2004). Whilst enabling significant reductions in resource use and therefore greenhouse gas reductions, hybrid drive technology (for all-purpose cars, buses and possibly freight vehicles) will allow zero emission operation of these vehicles within urban areas, where air quality improvements are of the highest priority. Nuisance impacts will also see remarkable improvements in slow-speed urban operations.

In sum, the propulsion technology is unlikely to contribute to the mobility and congestion problems per se, i.e. reduce the congestion level. But if we consider the external effects of congestion such as pollution and noise, this technology can be helpful in this matter. Two technological trends could be identified. The first path is that the conventional propulsion system is adopted. This can be seen as a short-term path that would dominate the propulsion system in the next five years (or so). The second path is the new propulsion system. This is a sort of technological break through in the long term (10-15 years). However, there is uncertainty that whether which technology could be dominate the market. The wide range of technologies, such as fuel cell and hydrogen technologies, will become available in the future.

4.4 Vehicle and Infrastructure Technology

The vehicle and infrastructure have a close relationship. The development of vehicle design, in some instances, bases upon the infrastructure it associated. Clearly the infrastructure is a main determinant of the spatial development. Thus the issue of technological development in the infrastructure component should also concern the standardisation of the system. In general, the vehicle and infrastructure technologies can be considered in two modes namely road and rail systems.

There are several potential technologies that we would like to examine in this section; which is automated vehicle guidance (AVG), the magnetic levitation (Maglev) technology, and underground logistic system (ULG).

AVG is the system that helps the vehicle to manoeuvre automatically in a provided path. This system has the potential of increasing the road capacity. This system, theoretically, reduces a distance between vehicles and a possibility to reduce the lane width. Hence, a direct impact of congestion reduction can be expected. Furthermore, it also increases the comfort of driving, especially in congested areas. Drivers become able to use their in-vehicle time for other

activities as well. However, given the improvement in a driving comfort, this system may stimulate car use, especially in congested circumstances. This may increase congestion. For environmental aspects, the impacts of this system to the environment are mainly associated with the level of congestion. As mentioned above that this system could both reduce and increase the congestion, the outcome cannot be certain. However, if we assume that this system makes traffic flows smoothly, higher energy saving is possible, which consequently resulting in the reduction of pollution. In addition, this technology may also bring about the better comfort to the driver.

Maglev technology is non-contact vehicles using magnetic levitation, guidance and propulsion. The key element for this system is high speed and it is comparable with high-speed train in several aspects. Furthermore, Maglev has; high acceleration and deceleration, high payload, low energy consumption, low emission and noise (see Geerlings (1999) for more detail). With respect to congestion and mobility issues, Maglev may not affect directly to the system since it is dealing with long distance travel. However, it could be used to construct regional versions of the system that suits very well in the corridor area where the high capacity and efficiency link is needed.

The underground logistic system (ULG) is a completely new concept of transport with it is own infrastructure and that offers an alternative to road and rail freight transport (Heyma et al. 2000). It potentially reduces the congestion in urban area because it replaces short distance road transport. Furthermore, its environmental impacts seem to be minimal compare to a conventional heavy goods vehicle because it uses electric propulsion.

Helmreich and Leiss (2000) identify three promising concepts in the field of vehicle and infrastructure technologies namely: all-purpose car, personal rapid transit, and road train.

All-purpose car*:* The all-purpose car (APCAR) in its various forms satisfies essentially all requirements of individual mobility including urban, long-distance, business, lei-sure/fun, etc. applications. This includes more specialised variants such as all-terrain vehicles, sports cars, and multi-person vehicles. The all-purpose car is expected to show the most significant impact improvements. Reduction of air quality impacts is expected through slow turnover of the fleet to advanced conventional diesel turbine engines.

New systems for personal rapid transit*:* This concept refers to light rail and people mover systems that are usually associated with urban transport. Research on new systems for personal rapid transit has been done over the last years already. It could benefit from a better knowledge transfer, based also on the assessment of pilots and demos, but the main problem for such new systems must be seen in financial barriers and in a mismatch with the dominant public transport technologies.

Road trains: A road vehicle used specifically to carry heavy goods on medium to long distances. This includes the road train vehicle (for long-distance, high capacity freight movement) as well as designs for freight intermodality. Moreover, the similar concept also applies for passenger transport called Autoshuttle.

In sum, the vehicle concept is more promising means than the propulsion system with respect to the mobility and congestion problems. Furthermore, the new development also trends to be an environmental friendly one due to the global trend toward a sustainability society. A major barrier in implementing the technologies mentioned above is an investment problem. As each

technology relied heavily on the infrastructure, the costs of both infrastructure and vehicle are very high. This means the area-wide implementation needs considerable diffusion period. Furthermore, some regulations are also needed to organise the new systems and also, in some instances, to accelerate the technology diffusion.

4.5 Transport Demand Management Trends

This demand management issue is about transport concept and transport mode concept (see Fgure 2). The concept is dealing with the transport demand management issue. Elements of this are, for example, parking facilities, supply system, and pricing concepts. In this report, two examples are selected; as they are promising trends, namely demand responsive concept and road charging.

The demand responsive concept offers an individual public transport that supplies the service upon request. The size of vehicle tends to small and it likely works in an urban area. This concept could increase the mobility and, as higher occupancy than private car, it could also reduce the congestion. Technology is very important to make this system successful, such as ICT and AGV. As the pattern of demand will rely on each individual, the ICT will help to minimise the operational route. AGV can also improve the service quality in term of speed and capacity of the system.

Congestion charging is a pricing measure aiming to reduce travel demand in congested periods and areas. In this case, the technology is not a main subject, but it is a tool that makes this scheme possible. There is an example using ICT in the congestion-charging scheme in London, UK. According to Derek Turner, boss of the capital's street management department, the scheme reduced traffic in the area by 20% and delays cut by nearly 30% (Economist 2003). Clearly it reduces congestion and increases mobility. Furthermore, as the congestion decreased, the pollution level is also decreased. However, in many countries, the congestion scheme was delayed or even rejected due to the public (un)acceptance.

The potential traffic management systems are as follows (Helmreich and Leiss 2000):

- Urban and motorway traffic control
- Incident management
- HOV and reversible lane management
- Parking management and speed enforcement
- Weigh-in-motion systems
- Surveillance: network and probe vehicle
- Emissions and environmental monitoring
- Automatic train protection, control and operation
- Dynamic route planning and guidance

In sum, technology takes part in the transport concepts in various levels. For some instances, technology plays a leading role in the introduction of the concept. Sometimes, technology plays an accelerated part to simulate the scheme. One element that should be mentioned is that the uncertainty in technology and in the public interest may influence the scheme. At the same time individual needs and transport demand have elements of autonomous processes. As has been stated before, they are partly the result of technology potential, but in their turn they result in innovations in transport modes.

4.6 Information and Communication Technology

The information and communication technology (ICT) plays a role in transport sector in twofold. Firstly, it helps the physical transport to operate smoothly. For example, the real time travel information, which builds on the state-of-the-art of ICT, helps passengers in reducing travel time. Secondly, ICT can substitute the transport demand. For example, in the past, the letter can be substituted by the telephone call. Recently the telecommuting becomes more plausible in an information age these days.

In general, in the complementary to the physical flows category, ICT involves in transport section in twofold. Firstly, it helps the operation and management of transport networks (in all modes), such as railway-signalised system, area-wide traffic control, and variable massage signs. Secondly, it gives information and guidance to the users such as a travel information system.

One ICT, which is implemented in several areas already, is travel information and trip planning system. This technology also extends to the recent transport trend in the multi-modal issue. This multimodal travel information provides information over several modes of travel which can be beneficial to both the traveller and service provider (Helmreich and Leiss 2000). Another ICT that will be implemented in the near future is the smart card technology. A smart card is a cashless fares system that substitutes cash, ticket, and tariff information. The user has to register and to cancel. A smart card can hold information on current balance, transaction history and user profile. The use of smart cards is increasing. Smart cards offer the option of totally anonymous usage for applications such as Autonomous Route Guidance, driver information and congestion charging, and public transport fare collection.

The potential technologies are listed below (Helmreich and Leiss 2000):

- Operations management systems
    - Location systems
    - Improved remote vehicle condition and use monitoring
- Information infrastructure
    - Smart card infrastructure
    - Satellite navigation

Instead of transporting people, it is possible to avoid making trip by using other means to fulfil the desired activities. This is an idea of the transporting information substituting the travel demand. The advanced Internet technology makes this idea plausible through the telecommuting approach (Mokhtarian and Salomon 1997). Telecommuting is an approach to reduce the actual travel and subsequently reduce the transport externalities. In some works, people can work in their residential places or at the location that close to their home, and use the Internet as a mean of communication with other colleagues. This measure can directly reduce the congestion problem and therefore the environmental pollution from transport is decreased. However, it should be noted that this measure has a limitation that limited type of works could apply this measure. Furthermore, although there is no scientific work supports the argument, it is likely that the time that people can save from this telecommuting is going to be spent in travelling for other purpose instead. Thus, travel demand may maintain at the same level.

In summary it can be stated that there is growing attention on the role of technology in society. We observe a certain fascination and technological optimism. Technology is seen as the key to a number

of different problems. This opinion is often expressed when society confronts 'new' problems, such as environmental problems or limitations in energy supply. Technological solutions can be politically preferable as they involve the least amount of government intervention and restriction.

5. SUSTAINABILITY TRENDS

A new and emerging concern is the state-of-the-environment and end quality of life in society. This concern is reflected in the concept of sustainable development. It is difficult to give a clear and unambiguous definition of sustainability. As a result of the view expressed in the Brundtland Committee's Report, it can be stated that sustainable development should be interpreted as a process of change in which the economic, social and ecological aspects (the `sustainable triangle') play an important part and which, preferably by using synergy, should be in harmony. In this study, the emphasis is on the necessity to incorporate the environmental aspects in the project assessment, particularly stressing that a reduction of CO_2-emissions must have priority. Here, emission standards are important instruments, for these can subsequently be used in formulating heuristics (the direction of search for technological innovations).

Sustainable development distinguishes several, sometimes seemingly opposing, goals, which makes it a very difficult task to find synergy within these different goals. Especially in matters where finding the right balance between ecological and economic aspects is concerned, development in harmony with sustainability will be more difficult to put into operation. The development of the transportation sector and all its external effects shows that this optimum situation rarely occurs. It is expected that the environmental interest will increase in importance, and will have implications for the transport sector. In the following an overview of the trends is presented.

5.1 The Sustainability Trends

Environmental problems. All indicators on pollution, harm and exhaustion of the environment suggest that the impacts may continue to increase. In the new economies, this could become manifest by a strong growth in the use of materials and the emission of waste into air and water. In Western countries pollution could increase as a result of increasing consumption. The reduction in the emissions of CO_2 and the competition for the use of space could become a bottleneck to an increasing extent.

Dematerialisation of physical goods. The use of technology and its derived possibilities for central production and supply chains may cause a decline of economies of scale. In addition to this, there is a trend towards dematerialisation caused by the expected scarcity of some resources. This could lead to a decline in the amount of materials and energy per product unit. At the end of the day, this could result in a drastic reduction in the possibility to re-use materials by the waste sector. At the same time the producers of `material-intensive products', like car manufacturers may develop into managers of materials and resources, whose aim will be to control the total production column of materials from extraction, via manufacturing to waste-management by closing the life-cycle. Immaterial activities (e.g. the service industry and entertainment and amusement) may gain importance.

Increasing importance of resource management. The international exchange of secondary materials may increase as a result of the necessity to close physical cycles. Trade and management of secondary materials will be less dependent on time and will be directed by the

materials manager.

Environmental regulation. The international environmental consciousness may create a broader basis for a specific policy to control environmental pollution. The transportation sector could develop into one of the most important sectors of policy measures, because the direct nuisance of intensifying pollution and congestion will not only affect the environmental quality but also the economic performance of regions (as is shown already in California and heavily congested Bangkok). In addition to fighting direct nuisance (sound, congestion, etc.) by a policy aimed at effects, a further policy aimed at sources could be developed. In the choice of technology versus influencing behaviour as a pretext for policy measures the balance may tip towards the first category.

Fossil fuel economy. In spite of the increase in energy requirements and the rise of alternative energy, the supply of fossil fuels should be able to meet the need for a considerable length of time. The increasing environmental burden caused by the extraction and use of fossil fuels may lead to technological efforts to apply alternative forms of energy. Because of social pressure, these efforts are likely to be largely concentrated in the US, Japan and Western Europe.

Alternative energy. Alternative energy may be applied in different forms. The most likely forms are wind, water and solar energy, biomass and hydrogen, which primarily use electricity as an energy carrier. The industry could cause a breakthrough by way of technological innovations for existing systems. A real breakthrough, however, may be affected by policy and (economic) scarcity and not just by technological innovations.

In summary it can be stated that there is general accordance regarding the fact that the process of innovation and implementation is influenced by a large number of factors and is subject to great uncertainties and risks. Sustainability requirements are the latest development in this development. The realisation of innovations therefore demands the kind of technology that must satisfy enormous demands, and needs to be focused on presenting in the clearest possible manner those risks that occur during the innovation process, because they can so easily transform themselves into barriers.

6. CONCLUSIONS

6.1 The Potentials of Different Technologies in the Transport Sector

Firstly, the development of the propulsion system solely is not likely to help the mobility and the congestion. Its main contribution is in the improvement of environmental effects from transport. As the society concerns more in a sustainability issue, the environmental-friendly means of transport become more important. Secondly, the infrastructure still plays a prominent role in the transport sector. Both AVG and Maglev need the development of infrastructure and the capacity of the system is also relying on the expansion of the infrastructure. Thirdly, ICT plays an increasingly important role in the transport sector. One important remark is that the effect of ICT is mixed, both positive and negative as it could help to reduce the congestion as well as to increase the congestion. Finally, government intervention is crucial. Once we can determine which technology is the chosen one, government intervention should be used in order to accelerate the diffusion of the technology. For example, the catalytic converter is now compulsory to every car due to the strict policy regulation from many governments.

On the basis of the developments described in the previous sections, it is possible to assess of the chances of success for the implementation of policy development on technological innovations in the transport sector. From a historical perspective it is justified to expect that the present trends of increasing mobility will continue in qualitative as well as in quantitative terms. The highest growth rates will occur in rapidly developing economies with the highest GDP/ capita rates. This is partly due to an increasing demand for faster and more flexible modes of transport (especially air and to a lesser extent road transport). The largest growth of demand in absolute terms will occur, despite some deceleration, in China and India as large representatives of the `fast growing' economies. For these regions a shift from collective to individual (road) transport will be anticipated.

Freight transport is expected to show a decline in the amount of bulk goods transported, in favour of containerised and high value goods. The globalisation of the world economy means that the flows of transported goods will have an increasing international dimension. Sea borne transport is expected to be a dominant mode of transport in this context, while air transport is increasing its share.

6.2 Is a one-sided positive attitude of technology the correct one?

What is the role technology actually play in practice? As stated in the previous section, technology is seen as the key to a number of different problems. But from a sustainable perspective we are quite skeptical of this technology optimism. We see that, on the basis of the trends described in section 3, technology development plays a driving force in four seemingly counterproductive trends (Nijkamp et al. 2000).

- technology plays a role in the present trend of a modal shift from less polluting modes of transport towards more polluting modes, is partly due to technological innovations,
- improvements of the environmental performance by technological means is threatened to erode due to the strong autonomous growth of the transport sector, there is no prospect of a short term technological fix.
- consequently it is expected that the government will have to intervene to assure the collective interest,
- and finally we see that many present technological improvements are directed in the wrong way. Technological features like the turbo-charger, inter-cooler, etc. are aimed at improving the performance of the car (faster acceleration, heavier and larger cars, etc.) rather than providing a more environmentally friendly character.

In general, it can be observed that technological innovations evolve regularly from R&D processes, but their implementation encounters considerable difficulty. This especially applies to the transportation sector which has many examples of innovations that either have never been implemented or have caused undesired side-effects after implementation. An important factor causing this phenomenon is the fact that an insufficient amount of both insights and information reaches the decision makers. A well-organised technology policy (e.g. by establishing multidisciplinary teams that cooperate internationally) can contribute to the *ex-ante* steering of technology dynamics.

6.3 Some Considerations for ‘Sustainable Transport R&D Policy Making’

Consequently, the need for a policy based on sustainable development has to be of a more stringent character. However, the environmental concern will not become a `one-issue topic' that puts a dominant constraint on a further growth of transportation. The challenge will be to find a field of common interests that stimulates economic growth and environmental interests. It is

expected that technology is the key to bring these ostensibly contrasting interests together in a way that that a `win-win' situation can be reached.

In this context it is the expectation that the technologies that turn out to be most successful will be those that address the energy aspects and the related (global) impact of the CO_2 emissions, providing of course that they fulfil the needs for transportation.

From the governmental perspective new institutions are under development to respond to the new challenges which spring from the combination of the increased environmental awareness in the Western countries, the need to convert from defence towards civil projects (especially in the U.S.) and the energy policy of the developed economies. New networks are being constructed in which governments play an active role in facilitating projects. The PNGV (U.S.) and the Task Force on The Car of the Future (E.U. and Japan) are good illustrations of this re-orientation and the more pro-active attitude of the government. For multi-national enterprises, it will be a challenge to meet the new requirements. Global alliancing, due to increasing competition, means that the production capacity is based in new economic centres with cheap labour costs. At the same time, new regional networks will develop with a clustering of `high-level' activities in the home-based countries. This regional specialisation will stimulate R&D activities.

The need for (more) sustainable development will put extra policy emphasis on R&D activities that address energy requirements. Potential areas of technological breakthrough will be alternative sources of energy, new transportation concepts and new transport management systems. Due to their long-term trajectory, the high costs and risks, etc., these types of innovation are referred to as mega-technological innovations.

Technology provides many possibilities to reduce the impact of transportation on the environment. However, its development and implementation involve several different complexities and, in relation to this, great uncertainties and risks. Therefore, implementation requires a clear strategy and a multidisciplinary approach. Important parts of a technology development strategy should be: a) distinguishing the right level of analysis (the transportation system as a whole, the level of modalities, etc.); b) implementation within the transportation sector; c) insight into the development of technological innovations and finally; d) the role of the several different actors in the innovation process.

Although the observations are the result of a study in Western Europe, it could be expected that they have value on a global scale as well. This is of importance, since at present there are no initiatives undertaken that bring together a strategy on the new global regional network development and the effect on transport. A conclusion that can be drawn is that for a successful policy on research, development and implementation of technological innovations is a pre-condition that new (sustainability-sound) requirements of future transportation are taken into considerations. Indeed, these considerations of sustainability should also apply, where possible, to current transport projects planned for implementation in the future.

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