# ICT-based innovation of transport: the links with spatial development


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## 1. Introduction

The development of Intelligent Transport Systems (ITS) has taken a leap in the past decade. Under strong influence of new Information and Communication Technology (ICT), industries and scientific institutes have put much effort on developing a range of intelligent applications for vehicles to drive safer, more comfortable, to make more efficient use of current and future infrastructure and to manage fleets more accurately.

Although a large part of this intelligent transportation innovation process is the result of a 'technology push' (Marchau, 2000), policymakers show increasing interest in ITS as a tool for solving traffic and transport problems facing society (e.g. congestion, efficient use of infrastructure, traffic safety). This interest of policymakers is backed by findings of preliminary scientific research, which show that although many uncertainties exist, promising perspectives seem within reach (Marchau & Van der Heijden, 2003).

The fact that ITS has great potential raises new questions on the implementation effects of ITS, which are foreseen in different fields, and are still unclear. These issues are addressed in the new research program BAMADAS (Behavioural Analysis and Modelling for the Design and Implementation of Advanced Driver Assistance Systems [1]). This program consists of six PhD projects from Delft University of Technology and Nijmegen University and started in September 2003. One of the PhD-projects, called SPACE[2], focuses at the long term effect of ITS on spatial development. The focus of this project, although still under construction, will be described in this paper.

The main hypothesis in project SPACE is that ITS-packages will in the long term have significant spatial effects on the location pattern of, in particular, firms. Business activities are assumed to be more sensible to transportation systems than for example family households. The hypothesis is based on two assumptions. First it is assumed that certain ITS applications can contribute to (differences in) accessibility. ITS (in particular traffic control) has proven to

[1] See http://www.bamadas.tbm.tudelft.nl
[2] See http://www.bamadas.tbm.tudelft.nl/Subprojects/SPACE.htm (subsidised by Cornelis Lely Stichting)

be able to improve throughput in transportation networks and consequently to improve access to nearby locations. Secondly, it is assumed that actors, both suppliers and demanders of business locations, regard the differences in quality of transportation systems and their contribution to accessibility of different zones, as important for decisions on the (re)development of these zones as business locations. Demanders of locations are business companies. Suppliers of locations are for instance municipalities and real estate developers.

To study this hypothesis, the study is structured in three parts. The first part aims at specifying a theoretical framework. Some of the underlying thoughts will be described in sections two and three of this paper. The second part of the project consists of a backcasting study, to find out the path of development to be followed regarding the combinations of ITS applications, to improve accessibility. We will call the development of certain combinations of applications 'ITS packages'. Section three and four briefly describe this second part. The final stage consists of a survey study that still has to be elaborated. The current idea is to interview 'suppliers' (municipalities and real estate developers) and 'demanders' (business firms) of locations in a certain area 'what' their spatial behaviour would be 'if' for instance ITS package 'X' would be implemented in this particular urban environment. Evidently, this would require a plausible translation of the ITS packages into imaginable long term changes in the transport system in this region. This stated behaviour measurement is a basis for analysing possible effect of ITS on spatial development.

## 2. Transport and land use: a bad match?

### 2.1 Introduction

From a historic point of view it is clear that technological change of transport has had and will have a significant long-term impact on spatial organisation (see e.g. Filarski, 1999). However, long term as well as short term impacts of changes of the transport system on spatial development appear difficult to predict. Instead of providing answers, much research tends to raise questions (Banister, 2002). Attempts to describe this relationship have been made by traffic engineers (e.g. Mitchell & Rapkin, 1954; Banister (ed), 1995; Wegener, 1995; Transland 2000; Transplus, 2002), while others, mainly economists, (e.g. Lawless & Gore, 1999; Linneker & Spence, 1996, Bruinsma, 1997; Banister & Berechman, 2001), focus more on economic effects of transport. Still another group (e.g. Nederveen 1999; Meurs & Haaijer, 2001; Thorsen & Gitlesen 2002) tries do describe spatial (pre-)conditions for transport use and planning. A common notion in these explorations of the relationship between urban and regional development on the one hand and mobility management on the other, is the notion of 'accessibility'. Therefore, in the next subsection, we explore the importance of accessibility as a factor in the location development.

### 2.2 'Extracting' accessibility

We define 'accessibility' of a business location as '*the number of persons/households per transportation system per class of movement resistance to the business location in relation to other, similar, locations, as perceived by an actor involved in the development of business locations*'[3]. This definition needs some explanation.

[3] Partly based on the definition of Hakkesteegt (1991: 4.7:)

First, a *business location* is a zone where, according to the land use plan, businesses are allowed to settle.

Secondly, a *transportation system* is a means to accommodate a geographical transport of information, freight or passengers from one place to another. At least infrastructure and vehicles are important elements of the transportation system.

Thirdly, the notion of *'movement resistance'* refers to the effort to move information, goods or persons from one geographical position to another. This effort can for example be measured by time, costs, distance and comfort. The importance of the applied indicator is dependent on what is transported. For instance, distance does not matter for the transportation of information. In that case, speed and costs matter. For freight transport costs and time have become dominant for measuring movement resistance (Muilerman, 2001, Runhaar, 2002). In passenger transport comfort, time and reliability have become increasingly important. Hence, distance as such has become less important as compared to the past.

The fourth element to be explained is the phrase: *'in relation to other, similar, locations..'*. Measuring accessibility of a zone in absolute terms has limited information value, since the valuation (and influence on decision making of firms and households) is always related to and dependent on the accessibility of other locations within the search area.

The fifth element includes the accessibility as '*perceived'*. This notion refers to the distinction between 'tangible' and 'less-tangible' accessibility. To explain 'tangible' accessibility we use another definition of accessibility. Hakkesteegt (1986) defines accessibility as *'the possibility that activity spaces can be used by individuals within stated budgets of time, costs and discomfort'* (Hakkesteegt, 1986: 3.4). This implies that for instance ITS can contribute to accessibility if it supports faster, cheaper and more comfortable transport. Basically, several of these impacts can be explored using standard traffic models. Separately, however, it is important to pay attention to the impacts of various developments on the perceived accessibility. Perceptions are often influenced by 'less-tangible' factors, such as for instance image, trust, reliability or flexibility of transport facilities, which are more difficult to be measured. The valuation of accessibility impacts of for example ITS should reckon with both aspects.

## 2.3 The relevance of 'accessibility'

Whether ITS in the long turn will influence accessibility is dependent upon many factors.

A first factor concerns the scale of the company and the size of the transportation system. For example, a retail shop at the edge of a city centre might consider accessibility worse than a shop in the heart of that centre does. Further, many companies only search for a new location in their current region. Others, for instance multinationals, seeking for a location to establish a new European headquarters, may choose between different European regions, like the Milan agglomeration or the Randstad, in the Netherlands. For an investor from the USA, the German border between the Netherlands and Germany is as accessible as Rotterdam. Accessibility is a relative notion and, as has been noted before, is measured and assessed in various ways.

The second factor is the degree of relevance of accessibility for the economic viability of certain business zones. Location theory has a long history in describing the location preferences of businesses. Most of the location theories have been developed by economists

(Lambooy *et al.*, 1997), starting with the older 'classic' theories, as described by Von Thünen (1826)[4] and Weber (1906)[5]. Those theories presumed landlords (in the case of Von Thünen) and industrial companies (in the case of Weber) behaving as a 'homo economicus', which characteristic was totally formed by maximising profit. Later, these classic theories were elaborated by neo-classic location theories, with several changes in the assumptions, for instance from perfect to imperfect competition (see e.g. Hoteling, 1929). Despite the differences, both classic and neo-classic theories considered transportation costs as an important settlement factor for companies. The emphasis on costs and profit shifted away when so-called 'behaviourists' introduced the notion of the 'homo psychologicus'(see e.g. Simon, 1957; 1960). This meant that people were believed to behave as 'satisficers', instead of 'optimisers'. The notion of 'bounded rationality' was introduced. This means that companies accept certain limitations in their choice. In their decision making process, they have to cope with uncertainties and incomplete knowledge.

These 'behavioural' theories where further elaborated with notions as the construction of mental maps, spatial cognition and regional image. The notion of spatial cognition can best be explained as: '*knowledge of spatial entities and consequently of possible locations*' (Lambooy *et al.*, 1997). Spatial cognition is regarded as the bases on which locations are valued. This leads to the other two notions mentioned: mental map and regional image. The former is the image of certain locations or regions. Regional image has a somewhat broader definition, which also contains an element of pre-judgement, personal correct or incorrect information and stereotypes. An example is that people regard Paris as the 'city of romance' and perceive the Ruhr area in Germany as 'dirty'.

Little change has occurred in the last decades regarding the development of location factors in the Netherlands. Lukkes et al (1987) described four factors of increasing importance: accessibility, representation, proximity of clients and the quality of the building in relationship with the price. Later, Atzema & Wever (1994) note that lack of accessibility plays an important role as a *push*-motive for companies. Further, accessibility was the most important *pull*-factor, which included proximity to clients, suppliers, local unlocking and parking lots. More recent, Jansen & Kulik found that (date unknown, after 1999) recurring elements in research are accessibility, parking availability and representation.

As described, companies regard accessibility as one of the main location preferences. An important factor is the difference in the nature of companies and the resulting preferences for different location types. Table 1 is for example based on the overview by Jansen & Kulik (date unknown, but after 1999) on this relationship.

[4] Von Thünen, presented a theory, in which a agricultural business man, who strives for maximization of profits (W), must realise an optimal difference between the given market price (VM) and the sum of production (P) and transport costs (T). In formula: W=VM – (P+T).

[5] Webers' theory (1909) was focussed on the location of industrial businesses. Therefore, he addressed other location factors than Von Thünen did (see Von Thünen, 1826). He called those factors 'standortfaktoren'. Webers´ theory agued that minimization of transportation costs of raw materials (which are site specific, the 'lokalisiertes Material') was the impetus for businesses to locate. He also addressed the importance of labour costs (1909).

| | *Location preferences* |
|---|---|
| **'Stationeries'** | Organisations with a strong preference for locations near pubic transport facilities. Other important factors are: working conditions, such as a nice atmosphere, flexibility of the building and accessibility of the entrée. Representation is of less importance. This group consists of governmental and non-profit organisations. |
| **'Modals'** | 'Modals' need common buildings with standard facilities. Accessibility by car and the presence of parking lots are important. There is no need for representative building, and the proximity of public transport is even less important, whereas the rent price should be as low as possible. Core activities of this group are mainly non-office companies like industries, trade companies and transport organisations. |
| **'Visuals'** | 'Visuals' consider representation and aesthetics very important. Further, the company name or logo needs a prominent position on the outer wall. The image of the building has to congruent with its own product. 'Visuals' are willing to pay relatively high rents. Commercial organisations, service businesses, banks and insurance companies are considered as visuals. |
| **'Ambulatories'** | Most important location factor for ambulatories is accessibility by car. This group provides its services predominantly outside the building, with the building as base. Representation is of less importance as most of the clients are spread throughout the country. Ambulatories are mostly smaller businesses (less than 20 employees) in the services sector: banks and insurance businesses. |
| **'Classicists'** | These users prefer settlements characterised by historical and dignified milieus. They opt for traditional buildings. They settle in city centres, with acceptance of less car accessibility. This group consists of law firms, accountant offices, notaries, brokerages and some governmental institutes, like embassies, for whom representation is of less importance |

Table 1. Location preference of different companies Source: Jansen & Kulik (date unknown)

In addition to these business differences, a classification of locations can be made. Generally a distinction between inner city, city fringe, neighbourhood location, corridor location or transport node is made. The location preferences, described in Table 1 are mainly based on the largest group of office keepers: businesses in services. Main difference between business in services and companies in logistics and transportation is that the former prefers locations with representation, attractiveness, proximity of high educated people, telecommunication services and accessibility by car and public transport. Logistics' providers and transportation companies are[6] more focussed on advanced logistics, which implies: proximity of distribution centres, advanced ICT-facilities, loading and discharging facilities, and multimodal-accessibility by rail-, water- and road infrastructure.

Location theories are mainly focussed on the demands of companies. Suppliers of business locations (e.g. real estate developers) create themselves images on the required accessibility on behave of the potential companies locating in these zones. It seems for instance that 'location policies' of municipalities in the Netherlands, although not anymore explicitly driven by the national government[7], focus implicitly on the proximity of transportation systems. According to Cobb and Elder (Parsons, 1999) this is the result of a process of agenda-setting. To study the impacts of ITS in this process, consequently, requires studying agenda-setting mechanisms. The setting of the agenda is characterised as being of two types: systematic and institutional. The systematic agenda is composed of '*all issues that are*

[6] Results from research done by Van der Heijden & Veeneman (1997) in the West-Brabant region in the Netherlands show that accessibility is most important, although other factors directly related to the location, as living environment, personal contacts and familiarity with location are even so important.

[7] The Fourth Report on Physical Planning Extra (VINEX, 1991: 16-20) formulated an ABC-location policy. A-locations were situated next to road infrastructure, B-locations next to road infrastructure and public transportation and C-locations only next to public transportation. Later in the nineties, the policy was stopped, due to poor results.

*commonly perceived by members of the political community as meriting public attention and as involving matters within the legitimate jurisdiction of existing governmental authority*' (quoted by Parsons, 1999 from Cobb and Elder, 1972: 85). The institutional agenda, on the other hand, is defined as '*that set of items explicitly up for the active consideration of authoritative decision makers*' (quoted by Parsons, 1999 from Cobb and Elder, 1972: 86). So, if an issue appears on the institutional agenda it influences all other issues on the systematic agenda. We assume that the development or renewal of an important (in other words: expensive) public transportation systems, such as ITS, is likely to become an issue for the institutional agenda (e.g. Marchau and Van der Heijden, 1998). If so, other policies like spatial development could become seriously influenced by that.

This brings us to the question: what is the nature of this ITS-development that is assumed to be so important?

## 3 ITS and Accessibility

ITS can be described as '*systems consisting of electronics, communications or information processing used singly or integrated to improve the efficiency or safety of surface transportation*' (Tindemans *et al*, 2003: 2). This notion encompasses a large variety of applications (see e.g. Bishop, 2000; ERTICO, 2002). Van der Heijden and Marchau (2002) give a classification of these applications based on the subsystems related to the so called market model for the transport system (see Table 2). The model is based on a market approach of the transport system. It distinguishes the transport need market, the transport service market and the traffic flow market. This 'market model' learns that the variety in ITS applications is large. Moreover, the goals of these applications differ significantly, depending upon the market. Basically, ITS at the transport need market focuses on substituting physical transport by virtual transport. ITS at the transport service market aims at supporting the (logistical) organisation of transport services, whereas ITS at the traffic market mainly focuses on issues of traffic management and vehicle driving. At this level, ITS applications even go as far as the replacement of human tasks by computer systems to yield automated driving.

Accessibility can be influenced by ITS in two ways. First ITS can be used to bridge distances and influence the volume of physical transport. One can think of for example distance-learning, distance shopping, e-commerce, et cetera. The second level of influence is on the physical transport flows. ITS can influence the actual and perceived accessibility at the traffic market and the transport service market. This second level is in particular our focus of interest. At the level of the traffic market, ITS applications are either in-car for individual support of the driver and based on initiatives taken by the automotive industries, or they are based on dynamic traffic management based on initiatives taken by public road managers.

The development of ITS received increasing attention since the early nineties, since policy makers expect significant efficiency and safety gains of these systems. However, research on the implementation of such systems (see e.g. Van der Heijden and Wiethoff, 1999) indicates that many uncertainties about these expected impacts exist. Moreover, a series of questions can be raised on where and how to implement these systems, whether there exist technical and market obstacles (see e.g. Marchau, 2000), whether there are legal barriers and what role public authorities should play in stimulating and/or guiding these developments.

| Subsystem | policy goals | ITS functionality | possible ITS application |
|---|---|---|---|
| organisation of society | optimise mobility of people, goods and information | | |
| transport need market | reduce unnecessary physical transport | systems for facilitating virtual mobility | electronic commerce;<br>tele-working;<br>tele-education |
| freight and passengers | optimise access to and use of transport system | information supply on transport services;<br><br>booking of services | park and ride information;<br>public transport services information;<br>traffic information on radio, teletext;<br><br>internet booking services |
| transport service market | improve logistical planning (modal split, route choice, time) in favour of safer, cheaper and environment-friendly transport | pre-trip planning support systems<br><br>systems for logistic optimisation | (multi-modal) trip reservation<br>route planning systems<br><br>telecommunication for fleet management and operational control (tracking, tracing);<br>trip matching systems (e.g. carpooling) |
| vehicles | improve driver's comfort, behaviour and vehicle control | smart motor technology<br><br>driver support systems | self-diagnostic engine control systems<br><br>crash recorders;<br>reverse parking aid;<br>tutoring systems;<br>navigation systems;<br>adaptive cruise/speed control;<br>lateral/longitudinal control;<br>co-operative driving; |
| traffic flow market | maximise use of available infrastructure capacity; establish a smooth and safe traffic flow | dynamic traffic management systems | dynamic route information screens;<br>traffic information on radio;<br>differentiated electronic payment;<br>dynamic (directional) lane assignment;<br>ramp metering;<br>speed control (radar detection, cameras);<br>variable message sign;<br>incident detection;<br>aid co-ordination systems |
| physical transport infrastructure | maximise capacity with limited physical extension<br><br>maintain quality | lane optimisation technology<br><br>infrastructure status control systems | dynamic lane configuration adaptation<br><br>surface measurement and deterioration detection |

Table 2*: Indicative relationship between transportation subsystems, policy goals and the variety of ITS applications (Van der Heijden and Marchau, 2002: 26)*

The in-car applications are linked to the basic tasks of the driver. In this focus a distinction can be made between: vehicle control (speed end direction determination), manoeuvring (lateral and longitudinal vehicle positioning in relation to other vehicles) and navigation (route choice). An additional distinction should be made to the extent of technological support of the diver. This refers to the degree of assistance: *Informative* (alarming or advising signals to the driver, who has to decide what to do with the information), *Assisting* (technology influences the vehicle behaviour on parts, but non-overrulable intervention from the system is possible) and *Autonomous* (technology is intelligent and takes over certain driving tasks, without intervention options for the driver). The tendency is to intensify R&D on assisting and autonomous systems. For example, in the Netherlands pilots with automated people movers and freight trucks have been initiated in recent years. The more attention for autonomous driving is intensifying, the more the link with the infrastructure system becomes important and the more the discussion on the transport services level and organisation (the second market) is triggered.

Until recently, hardly any links between in-car systems and infrastructure management were made. Increasingly however, we see thoughts and experiments focusing on the interaction between in-car and infrastructure-based ITS applications. These have for instance been described by Van der Heijden and Marchau (2002) in terms of different transport service levels, summarised in text box 1. These developments, that are hardly to be expected to become reality on a large scale in the next years, are important for the discussion on the long term relationship between transport and spatial development triggered in this paper.

It is expected that higher levels of intelligent transport, based on the integration of ITS systems in infrastructure and in-car, require quite some investments in technological facilities and a dedicated organisation for operational management. For example, sensor technology is required in each road network for real-time data-collection on traffic flows and incident management, real-time tailor-made information should be available on various modalities for travellers, guiding autonomous driving vehicles might require Global Positioning System (GPS) and sensor facilities on dedicated roads, and so on. Particularly when investments in supporting technology and traffic flow management are infrastructure-based, it seems rather plausible that these investments will be selective (that is: not everywhere but related to certain pieces of the transport system). The first reason for that is that budgets, mainly public budgets, are permanently scarce and the possibilities to significantly increase general transport taxes are limited. In contrast, public investments in extra transport service quality for travellers might be legitimised by the possibility to generate extra payments for covering the costs of these services (the consumer directly pays). Secondly, not all infrastructures will be candidate for these applications, but selected parts of road networks will be, because traffic problems (e.g. congestion level) are not the same in all parts of the network and the contribution to the total performance improvement will be a serious criterion for investment. Thirdly, it is plausible that such an infrastructure transition program will be phased in time: new investments will be based on the evaluation on the impacts of former investments (effectiveness, the need for changing the concept): the evolutionary innovation process.

Let us therefore assume that in future the implementation of higher level ITS will follow a pattern of selective adaptation (based on geographical and functional considerations) of the transportation system. Given the pursued goals of ITS (improving safety, throughput in networks and travel comfort) this is assumed to generate competitive advantages for these parts of the transportation network from the perspective of transport performance and attractiveness for travellers.

For example, a dedicated lane for full automated driving inbound a metropolitan area with guaranteed travel time and parking place at the destination might turn out to be more attractive, irrespective the need for reservation of an individual access slot and the need for extra payment for the service, than to accept the present daily peak congestion and uncertainty of finding a parking place.

Text box 1: a future perspective of ITS-based traffic management (Van der Heijden & Marchau, 2002)

A road traffic management approach based on a sequence of six steps, supporting different goals.

AT THE TRANSPORT MARKET:
1. larger temporal-spatial dispersion of travelling,
2. improved multi-modal travelling,

AT THE TRAFFIC MARKET:
3. coordinated use of different road networks,
4. using road capacity with priorities,
5. control of driver behaviour
6. effective response to incidents

The **first** objective is a larger temporal-spatial dispersion of travelling to reduce great fluctuations in use of the road networks in time and space. Dynamic traffic management could start earlier in the process by influencing pre-trip decision making. Road traffic management is interested in influencing the decisions of an individual traveller in various ways: postponing, changing destination, changing mode or changing route plan. ITS helps to collect the necessary real-time traffic data, to perform short-term traffic flow forecasts and to distribute information. In the future, predictability might be improved by unique vehicle identification, the registered scheduling of a trip by the traveller and by road capacity slot reservation.

**Secondly**, freight companies and travellers have quick and easy access to actual and expected network traffic management using the personal intelligent travel assistant (PITA), an on-board computer in vehicles or mobile communication facilities for travellers with wireless access to computers at the traffic information centres. PITA supports both pre-trip as on-trip travel. Important for dynamic traffic management, is the optimal use of available transport capacity (car, train, subway, bus). Systematic data links are made between the road system and public transport to e.g. support Park & Ride (P&R) services. Personal information includes expected travel time and costs.

The **third** objective is the co-ordinated use of different networks. Perceiving and managing all road networks as an integrated system offers better opportunities to inform drivers, to dynamically create alternative routes and to influence traffic light installations for buffering traffic at several places in the network. Therefore, dynamic traffic management technology to the secondary network has been introduced. In that case the traffic manager requires a systematic collection of information about the traffic situation in different parts of the network as well as instruments to influence traffic flows at different networks simultaneously.

A **fourth** objective is using road capacity with priority, which implies a strategy for combining payment with a more active assignment strategy of road capacity. Using the on-board computers or PITA in the car, a slot-reservation system is implemented. Slot management is important for travel quality assurance (mainly guaranteeing an average travel time). Access to the motorway on the on-ramp chosen by the driver is supported by reservation (e.g. up to 15 minutes before use) and electronic vehicle identification. The unique vehicle code is matched at the on-ramp with the reservations to permit entry and to assure electronic payment. Reservations are used for payment for no-shows (normal price plus a penalty).

Control of driver behaviour is the **fifth** objective. The traffic manager has an interest in controlling certain aspects of driver behaviour (speed, lane keeping) to optimise capacity. This becomes especially relevant in the case of the dynamic adjustment of lane width in situations of high traffic density, in order to generate an extra lane temporarily. In addition, in cases of roadwork, slippery conditions or heavy rainfall, speed enforcement is relevant. Hence, electronic support for driver tasks and traffic management decisions should interact more intensively. The ultimate consequence is the application of fully automated driving.

The **final** objective focuses on quickly eliminating traffic disturbances based on incidents or accidents. ITS offer various avenues for that. It starts with improving emergency calls and initiating a quick emergency reaction. This will be linked to the electronic monitoring of the driver status. In the case of illness (e.g. heart attack), drugs or alcohol use, causing dangerous driving behaviour, this system warns the driver or the system takes over the driving tasks and parks the vehicle along the road. This is linked with incident warning at the traffic management centre: camera observations or automatic signalling from a roadway sensor or from the in-vehicle electronic system. In the case of incidents or accidents on the road, the treatment of issues of guilt and liability should no longer (only) require extended police investigation on the spot. Data from a black box in the vehicle make it possible to reconstruct the last minutes of vehicle behaviour before the crash, digital photography and camera registration along the infrastructure enable computer-animated reconstruction afterwards.

## 4. Backcasting ITS' future

In order to specify more plausible ITS applications and combinations that will influence spatial development in the long term, more study has to be done. To measure long-term effects we first need to know what the future of ITS (that is: ITS that increase the perception of accessibility) will look like. There are several scientific approaches to describe the future. A rough distinction can be made between forecasting and backcasting[8] (Robinson, 1990; Dreborg, 1996; Höjer & Mattsson, 2000; Marchau & Van der Heijden, 2003; Van Notten *et al*. 2003). Backcasting is relatively new. In contrast to forecasting, where '*the emphasis is on discovering the underlying structural features of the world that would cause the future to come about*', in backcasting, '*the emphasis…is on determining the freedom of action, in a policy sense, with respect to possible futures*' (Robinson, 1990: 825). We intend to apply a backcasting approach in our study. Backcasting is '*a scenario technique which focuses on presenting solutions to problems that do not seem to be solved, according to conventional scenarios, trends and forecasts*´ (Höjer, 1998: 446). According to Robinson '*the major distinguishing characteristic of backcasting analyses is a concern, not with what futures are likely to happen, but with how desirable futures can be attained'* (1990: 822-823).

There are some reasons for our choice. The first is that currently most of the ITS developments are dependent on the interest of a few private actors. Their current ITS objectives are mainly dominated by in-car applications. A future based on the current situation might lead to an increasing violation of sustainable development, as current trends in the Netherlands (see e.g. the Dutch Advisory Council for Transport, Public Works and Water, 2003) point towards continued expansion in traffic volumes and growing problems related to congestion. Following national and European transport policies, we normatively plea for a 'better' future. However, in that case, national and supranational governments should play a more important role. They could aim for the development of ITS concepts and invest more money in the combinations of applications that solve certain transport problems. The gap between the trend-based forecasted and the normatively desired future is the impetus to use backcasting. In this case we need a future image in which a policy process or 'path' is started regarding possible combinations of ITS applications that could help solving problems regarding accessibility. Figure 1 shows these paths, formulated as 'packages'.

There are also methodological grounds for backcasting. Forecasts depend on the assumptions that have been made regarding the working of the system. These assumptions are often based on historical data, and therefore, often confirm current trends. In case the working of a system basically changes, the assumptions migth not be valid any longer, and the forecast cannot be expected to come true either (Höjer & Mattsson, 2000). ITS might have such a fundamental impact on the working of the system. A second methodological criticism on forecasting is that a forecast, in a public debate, may very well be misunderstood as the truth and thus become self-fulfilling. In case these forecasts have a conserving effect, this might cause a blockade for progress.They can easily strengthen a trend, and thus prevent alternative system developments (Höjer & Mattsson, 2000). Hence, forecasting, in this research, would be a serious source for methodological debate.

[8] A more comprehensive typology of scenarios can be found in Van Notten *et al.* (2003).

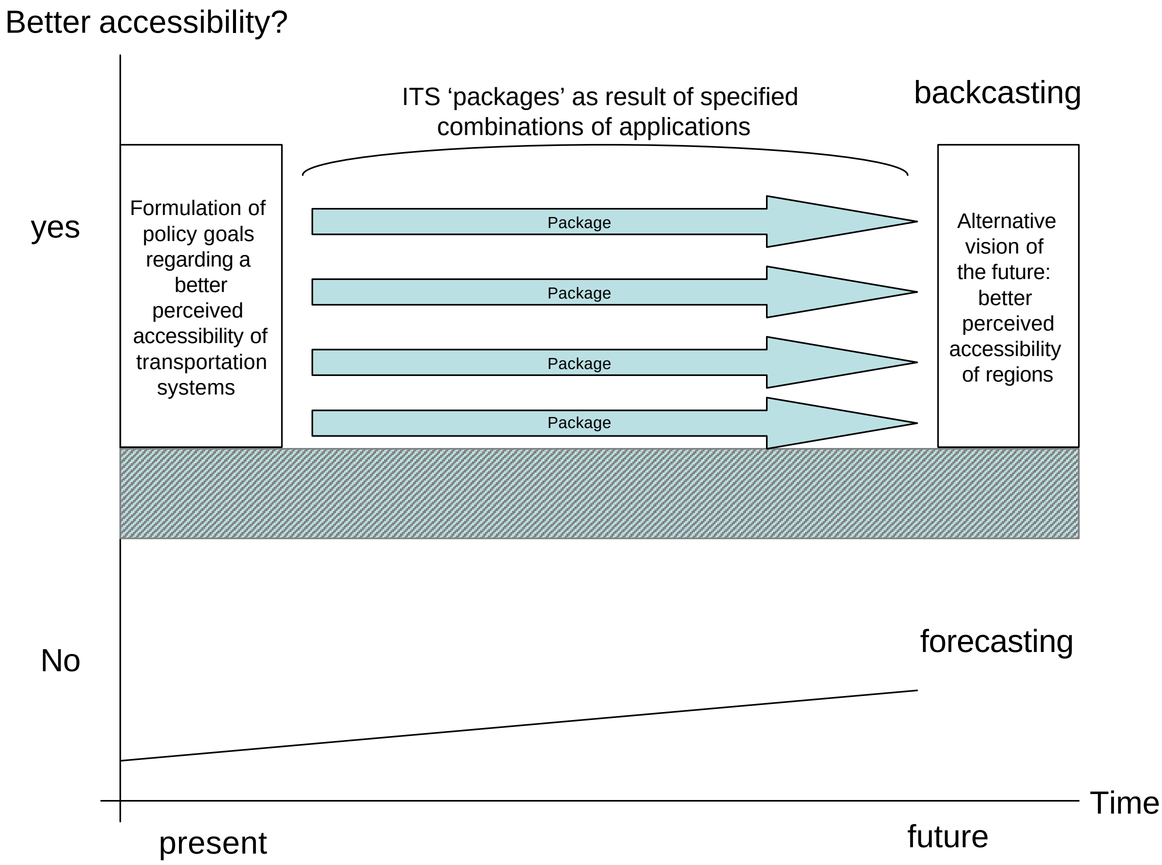


Figure 1. Backcasting as method for alternative future

Figure 1 shows several things. At first, it shows the main difference between forecasting and backcasting. Forecasting studies aim at a future where ITS have hardly any contribution to a better throughput of infrastructure, transportation safety or comfort in public transport. In the backcasting approach the researcher together with policy makers more actively define appealing future images based on ITS. Evidently, these future images are based on public policy goals as formulated regarding the improvement of the transportation system. By using backcasting, the researcher reconstructs the path from the presence to a future image. It is tried to specify the conditions that have to be fulfilled and the actions that have to be taken to contribute to the desired course of development. As argued, our study is interested in the role of 'ITS packages' in this context.

The nature of these packages still have to be specified. To indicate the direction of these ITS packages, one can think of selective promotion by public policies of certain target groups, for instance public transport or business cars or urban freight transport. This might lead to investments in for example all the facilities accommodating high quality public transport, including dedicated lanes, automated vehicles, and top level information supply for travellers. Experiments with such ITS-based approaches in the Dutch cities of Eindhoven and Rotterdam/Capelle aan den IJssel have been described by Argiolu (2002). For freight transport a concept called Combi-Road for a network for full automated freight transport in The Netherlands was already seriously studies (CTT, 1995-1997). Serious thoughts for applying such a freight transport technology in the Dutch urban agglomeration of Enschede-Hengelo are under study (Van der Heijden et al, 2003). Still another possibility is to invest in certain parts of the urban network, for instance the higher level road network accommodating

through traffic or certain inbound/outbound corridors. Both options will lead to the investments in smart and partly dedicated, pieces of infrastructure within the urban agglomeration. A final possibility to be mentioned is to invest in the facilities required for multi-modal chain mobility, linking the car system systematically with public transport facilities. A strong focus may be laid in that context on the performance of the transfer points.
In our study the detailed nature of the backcasting approach has still to be specified. The outline is that different policymakers, scientists and companies involved in the development of ITS answer questions about different 'ITS packages'. Using the backcasting approach, a further elaboration of the packages is made. The Delphi technique has for example been successfully applied in the recent past (Höjer, 1998; Marchau, 2000; Runhaar, 2002), but other methods are possible. A definitive choice will be made in a later stage.

As described in section one, the elaborated ITS packages based on these policy strategies, will function as input for the 'what if' question among actors involved in the development respectively use of business locations. This will be made area-specific, which implies that the elaborated packages will be translated in changes in the transportation system in the study area. The survey will be based on questions such as: 'What if highway 'x' in your region is substituted by a more accessible automated highway system?' A policymaker involved in spatial planning could answer: 'We will develop two more business locations along this new infrastructure'. Another possible answer is: 'I do not see any relevant difference between the situation before and the situation after the substitution'.

## 5. Conclusion

Geographical differences in ITS-based accessibility might result in geographical changes in location patterns. It has been argued that location choices of businesses and actors in the supply side are to a significant degree sensible for perceived differences in accessibility, either in terms of the travel costs (time, money) or in terms of distance. A next step in reasoning is than that these differences in accessibility at a certain moment might lead to gradually changing location choice behaviour of businesses and commuters. These choices will be characterised by a preference for locations that are better accessible by ITS-based transport services as compared to locations that are not. Measured in terms of a long periods (decades), we expect a geographical pattern of (at least certain) business activities that increasingly will match with the geographical pattern of high level ITS applications.

To test the research hypothesis two main studies will be done. The first is a backcasting study to specify the combinations of ITS applications that increase accessibility. The second will be a survey study among actors that influence spatial development. These are 'so-called' demanders and suppliers of locations. Clearly many operational decisions have to be taken for performing these sub-studies. A variety of issues has been mentioned already. Important is that with the exploration of the issue in this paper, and the first attempts to translate them into researchable questions, we made an important step for more systematically studying a challenging issue link technological innovation and spatial development. Evidently, we will report on the progress in future.

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