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# Urban land use changes and ICT-based innovation of public transport

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## Abstract

R&D in Intelligent Transport Systems (ITS) develops fast. Applications focus on all levels of the transport system: driver behaviour, infrastructure, traffic management and travel choices. Smart combinations of these applications in coherent ITS concepts will be the challenge for the future. Applied to urban systems, it is assumed that different ITS concepts will work out different with respect to urban patterns of economic activities. So far this possible impacts has hardly been a subject of research. This paper elaborates on the first step of a project that researches on this relationship. In the paper attention is paid to the possible distinctions between ITS concepts. An illustration of such a concept, designed for public transport in a city in the Netherlands, is briefly described.

Key words: ITS concepts, urban areas, public transport

## 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 infrastructure and to manage fleets more accurately. 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 [1]. The range of ITS

applications is wide (see e.g. [2]). ITS applications are being developed for public transport, private vehicles, commercial vehicles and infrastructure. Their functional aims strongly differ accordingly.

From a scientific point of view ITS applications seem to hold many keys to innovate the performance of the transport system [3]. Consequently, ITS receives much interest from governmental bodies since ITS could contribute significantly to transport policy goals. However, many uncertainties exist [4]. One of the uncertainties concerns the spatial impacts of ITS. An interesting question for instance is whether the spatial distribution of firm locations will change in case ITS are deployed at a large scale. This is the main research question of a sub project of the Dutch BAMADAS<sup>1</sup> research program. The answer to this question depends upon the behaviour of many actors. We are mainly interested in the actors that influence location choices in service industries. Theory indicates that these decisions are strongly based on the trade-off between the attractiveness and the costs of a location. Attractiveness at its turn is to a substantial degree influenced by the accessibility and/or image of a location [5] and much research has been done regarding this relationship. In contrast, hardly research has been published on the influence of ITS on accessibility and location image.

This paper explores the possible influence of ITS in public transport on urban structure changes. Our study is still in an early stage of research. The exploration, partly described in this paper, is a basis for empirical data collection and research in 2004 and 2005. In section 2 we explore some long-term ITS applications that are considered important for future innovations in the urban transport system. A next step is the combination of ITS applications into coherent packages. We call them possible ITS implementation scenarios. This step is described in section 3. In section 4 an example of the implementation of such a concept in the Netherlands will be described briefly. Finally, in section 5 the paper will be concluded.

## 2 ITS developments

As mentioned, ITS encompasses a large variety of applications. ITS systems cover, among others:

- (a) systems supporting the driver in controlling his/her vehicle and performing driving tasks more effectively (Advanced Driver Assistance Systems: ADAS),
- (b) systems supporting the traveller in finding an optimal mode and route (Advance Traveller Information Systems: ATIS) and

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<sup>1</sup> BAMADAS is an acronym for Behavioural Analysis and Modelling for the Design and Implementation of Advanced Driver Assistance Systems. The program started in 2002. BAMADAS consists of five PhD projects and one post-doc project. The subprojects focus on implementation issues of ADAS by studying driver behaviour, traffic performance, infrastructure design, spatial implications, and legislation and tort reliability.

(c) systems supporting an optimal traffic management (Advanced Traffic Management Systems: ATMS).

In [6] a structured view of ITS services is presented, which forms the basis for the overview in Table 1. The transport system is conceptualised in terms of seven subsystems: four subsystems comprising the transport system's physical features (infrastructure, vehicles, goods or passengers and spatial and economic organisation) and three markets representing the interactions between the transport system's process characteristics. The three markets are labelled as the mobility market, the transport market and the traffic market.

<b>Subsystem</b>	<b>ITS functionality</b>	<b>Examples ITS application</b>
Mobility <u>market</u>	Systems for facilitating Virtual mobility	Electronic commerce; tele-working; tele-education
Freight and Passengers	Information regarding transport services; booking services (ATIS)	Park and ride information; PT services information; traffic information on radio, teletext; internet booking services
Transport service <u>Market</u>	Pre-trip planning support systems (ATIS) Systems for logistic optimisation (ATIS)	Trip reservation and route planning systems; Telecommunications for fleet management; trip matching systems
Vehicles	Smart Motor Technology (ADAS) Driver support systems (ADAS)	Self-diagnostic engine control systems, crash recorders. Reverse parking aid; navigation systems; adaptive cruise/speed control; lateral and longitudinal control; co-operative driving; intersection collisions warning
Traffic flow <u>market</u>	Dynamic traffic management systems (ATMS)	dynamic route information screens; traffic information on radio; differentiated electronic payment; dynamic lane assignment; ramp metering; speed control (radar detection, cameras); incident detection;
Physical transport infrastructure	Lane optimisation technology; infrastructure status control systems (ATMS)	dynamic lane configuration adaptation; deterioration detection

Table 1: Relationship between transportation subsystems, ITS functionality and selected ITS applications [3, p.26]

As compared to the present situation a much higher service level in transportation is within reach on the long term by integrating different ADAS with ATMS and ATIS. Often, an evolutionary development of this integration process is

expected. Fully automated driving (Fig. 1) is often considered as the final stage of this development. Although such a concept is not plausible to become reality on a large scale in the near future [7], its potentials are sufficient great to keep them within the scope of future research.

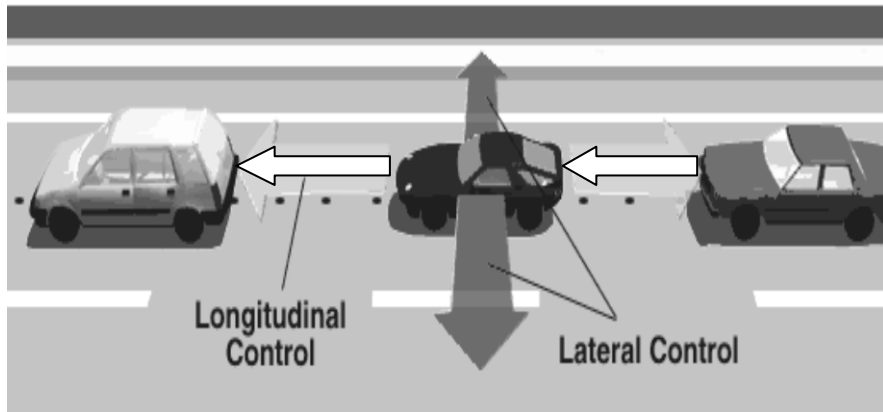


Figure 1: concept of automated highway

Contrary to the technological development of ADAS, ATMS and ATIS systems in transportation have largely matured [8]. ATIS are for example systems that inform drivers or passengers about different aspects of the trip. Examples of such systems are Variable Message Signs (VMS) and Personal Intelligent Travel Assistant (PITA). VMS systems inform drivers on motorways about congestion or incidents and perhaps alternative routes. ATMS systems mainly focus at improving traffic management. Examples are ramp metering and speed regulation.

The course of the R&D and implementation of these applications is difficult to predict because of large uncertainties in technological development, the market potential for this type of services, the spatial impacts and institutional requirements [4]. Consequently, in practice, examples of (full) integration of ADAS, ATMS and ATIS are rare. Section three describes a way to integrate the three subsystems into both plausible and promising concepts for the future.

### 3. ITS-concepts for urban areas

The question rises what plausible functional combinations (so-called “packages”) of ADAS, ATIS and ATMS are (“ITS-concepts”) to be implemented in transport systems. We are primarily interested in the emergence of these innovations in urban areas, due to our interest in the effects on accessibility of locations. We make two basic assumptions in the process of specifying such ITS-concepts:

- (a) the ongoing combination of (sub)systems of ADAS, ATIS and ATMS within the transport system will continue in the future, and
- (b) public investments in ITS-supporting facilities (such as adaptation of infrastructure or implementing road-side technology) will be selective with regard to where and when to invest.

Marchau [7] applied an inductive approach for constructing ADAS concepts in particular, building on the so-called morphological analysis. This implies:

- (a) the identification of basic variables constituting the variety of concepts;
- (b) the specification of values of these variables, and
- (c) the evaluation of all possible combinations of these values.

We followed this procedure in our study too for constructing more general ITS-concepts. Given the systems view presented in the previous section, ITS-concepts all have in common that they pay attention to at least the following five variables.

The first variable is *functionality*. Each ITS-concept will choose for a certain mix of applications from the categories of ADAS, ATIS or ATMS. We assume different goals to be pursued. One major goal is typically focused on the improvement of driver behaviour, in order to improve safety and comfort. This refers to a primary interest in ADAS, supplemented with applications from ATIS and ATMS. An alternative goal is to pursue significant efficiency gains in travelling (less travel time losses, perhaps modal shift). This leads to a primary interest in ATIS, possibly supplemented with applications from ADAS and ATMS. Finally, a third competing goal is to significantly optimise network capacity. Hence, this implies a primary focus on ATMS applications for flow management, supplemented with applications in the field of ADAS and ATIS.

The second variable of ITS-concepts is based on a distinction in focus between *private or public road services*. This is significant because of primary responsibility for investments and market considerations. In case of ITS for private car system, R&D investments mainly come from automotive industries. In case of a focus on public transport, much of the R&D costs come from public budgets. The third variable concerns the *target groups of users*. In our study we focus on either individual or collective transport (respectively cars, taxis and busses). The fourth variable refers to the level of *automation* in the context of driver support, which is very important for the nature and the level of investments in the supporting infrastructure. A distinction is made in terms of three categories. The first is *Informative ITS* (real time travel information, signals to car drivers, et cetera). Basically the addressed person has to decide what to do with the information. The second category is *Assisting ITS*: applied ITS systems take over some driving tasks (and perhaps even some travel planning tasks (like seat or parking lot reservation), but intervention by the traveller remains possible. Finally, we know the category of *Autonomous ITS* (system takes over certain driving tasks, without intervention options for the driver). Finally, the fifth variable concerns the *geographical scale* of application, implying a spatial variable. ITS-concepts can be implemented within activity areas, on connecting network links or on motorways. Activity areas are for example residential areas,

business areas and city centre. Links within networks refer to infrastructure facilities that connect these activities. Motorways refer to infrastructure networks that connect large urban areas and are used for longer distance traffic flows. For the Netherlands, this distinction can be interpreted as follows: (a) roads in activity areas with a maximum speed of 30 – 50 km/h; (b) connecting network links with a maximum speed of 50 – 90 km/h; (c) motorways with a maximum speed ranging from 90 – 120 km/h.

The possible variation in variables of ITS concepts is summarised in Table 2.

Variables	Values		
	(1)	(2)	(3)
<i>Functionality</i>	driver support	traveller support	traffic optimisation
<i>Modality</i>	car driving	public transport	
<i>User number</i>	Individual	Collective	
<i>Automation</i>	Informative	Assisting	automation
<i>Geo. scale</i>	activity areas	Connecting links	motorways

Table 2. Dimensions and values of ITS implementation strategies

Based on these variables and values, a set of possible ITS-concepts can be constructed. Taking into account the state-of-the-art described in recent literature, not all combinations are functionally consistent. This has been elaborated in another paper [5]. Let us give some examples.

It seems not very likely that concepts of full automation will be implemented at the level of all geographical scales, hence for all road networks, in the next future. That would require too many public investments in supporting technological and infrastructure facilities. Therefore, we exclude this combination and limit this option to motorways. Next, it is more likely that the combination of public transport services and single use (taxi, people mover, personal transit system) will occur within activity areas and possibly between these areas, than as a regular service at motorways.

Although various combinations appear to be not plausible in the near future, given technological developments and related investment requirements, many possible combinations of variable values are left. Therefore, further elimination steps have to be made, using other criteria for elimination, to arrive at the preferred 3 to 5 ITS concepts, enabling further in-depth research. These steps have been described in [5] noticing that these steps and their outcomes will be tested and validated in a separate research activity, using the opinions of experts, later this year. In this paper, we limit this part of the approach to some preliminary outcomes. From the analysis we envisage various plausible urban ITS-developments, that are assumed to have discriminatory effects on location preferences of economic service activities.

By example, we specified 3 hypothetical ITS concepts: two for car driving and one for public transport. They have been briefly typified in Table 3. Concept 1 presents a focus on automated car driving at motorways, aimed at optimising network use and network throughput. Concept 2 elaborates on supportive ITS for car drivers on secondary roads within urban areas. The aim here is primarily

creating safety. Concept 3 presents a focus on automated driving of busses for public transport on dedicated lanes within the urban area. This concept aims at improving service level (frequency, comfort, and reliability).

<b>Application field</b>	<b>Goal: comfortable and safe driving on motorways based on automated driving support</b>
ADAS	- self-diagnostic engine control systems - crash recorders; - dynamic route navigation systems - autopilot:
ATIS	- traffic information on radio, teletext; internet booking services - trip reservation and route planning systems
ATMS	- differentiated electronic payment - dynamic (directional) lane assignment; - ramp metering; - speed control (radar detection, cameras); - incident detection; aid co-ordination systems

Table 3a. Ingredients of ITS-concept I

<b>Applications</b>	<b>Goal: car driver support in inner-urban areas, based on assisting and informative ITS applications</b>
ADAS	- intersection collision warning - intelligent speed adaptation - reverse parking aid - passenger warning systems
ATIS	- park and ride information - route navigation systems
ATMS	- intersection collision warning - differentiated electronic payment - speed control (radar detection, cameras)

Table 3b. Ingredients of ITS-concept II

<b>Applications</b>	<b>Goal: high level urban public transport services, based on automation of driving on dedicated lanes and high level information provision</b>
ADAS	- Autopilot
ATIS	- personal Intelligent Transport Assistant (PITA) - trip reservation (passenger based technology)
ATMS	- intersection collision warning - electronic payment (passenger based) - tracking and tracing system (GPS based)

Table 3c. Ingredients of ITS-concept III

It is stressed that the ITS-concepts described in Table 3 are only examples of possible developments. For further research it is important to validate them and to translate these concepts into spatial images: what does it mean for a specific urban region? Which parts of the road network will change? What will be the changes in the performance of the transport network (in terms of efficiency in capacity use, throughput through the network, modal shift, et cetera). These questions are subject of further study in our project.

#### 4. Example: Phileas Public Transport concept



The Phileas project is situated in the urban region of Eindhoven, in the south-eastern part of The Netherlands. In the early nineties, the municipality expressed the ambition to create a real innovative concept for urban public transport. An important motive was the deteriorating economic circumstances in this region, in particular in the sector of automotive and electronics industries. Using substantial amounts of subsidies from the Ministry of Economic Affairs, a project was started to develop a new concept for an extended bus, using semi-automated driving facilities, clean propulsion technology (electricity) and a very low noise emission level. Because of the option for automated driving, the construction of a dedicated bus lane was considered necessary. The concept is called Phileas. The operational phase of the first part of the network is expected to start in April 2004. It concerns a route of about 15 km. linking Eindhoven airport with the main intercity rail station and the main economic and shopping city centre in the region. Somewhat later, as soon as the construction of the infrastructure has been finished, a link to a suburban town will be taken into operations. In the future, extension of the network is expected to the northern suburban villages. Figure 2 gives an impression of the high-tech bus.



Figure 2: Phileas bus in Eindhoven, the Netherlands

A number of elements is of great interest with respect to this Phileas concept (Argioli, 2002). First, the developers have tried to link the automatic driving vehicle with a dynamic travel information system. This is considered important for providing the traveller with most accurate and up-to-date information on the public transport service in the bus, on mobile phone, the internet and at each station. Secondly, the design of the dedicated lane very much took the human scale as starting point. This implies a focus on attractive details (trees, easy access to stations, possibilities for parking bicycles, streetlights, et cetera). The idea is that this will make the use of the system more attractive. Thirdly, a flanking policy has been developed with regard to traditional parking in the inner city. For example the prices of parking have significantly increased and the number of parking lots significantly decreased. Fourthly, although the driving technology in the bus enable automated driving, it is considered important for considerations of safety to have a chauffeur on the bus for control. Evidently, this negatively influences the cost-benefit ratio of the operations

significantly. Finally, it is noted that the route with the dedicated lane has been chosen because of its support of an economic corridor development. Actually, within this corridor four more important economic activity centres (nodes) can be distinguished. In the future extended network, this number will increase. It has already been noticed that certain economic nodes have expressed their interest to be linked to the network.

In sum, the Phileas public transport concept is based on the most advanced level of ICT at different levels of the concept: the vehicle control, the traffic control and the travel information control. As such, it will be very interesting to follow what the impacts will be on urban transport. The first signals indicate that at least in terms of spatial development, Phileas might have some recognisable impacts on economic centre development within the urban area. This might imply some significant economic benefits in favour of the city of Eindhoven. This is in particular of interest since it is quite evident that the costs of the development and implementation of Phileas are high and full coverage by revenues must be seriously doubted.

## **5. Conclusions**

In this paper we explored the possible future application of ITS in urban regions. More than in the past, when ITS was strongly associated with instruments of dynamic traffic management, the ITS concepts to come are based on selectively linking in-vehicle advanced driver assistance applications with real-time travel information services and traffic management concepts. One example has been described: the Phileas public transport concept in the urban region of Eindhoven. Another Dutch example, not described here because of space limitations, is the operational people mover connection of about 1 km. between a subway and an economic business area in the region of Rotterdam. Evidently, there still exists a lot of uncertainty about which functional mix of applications from the three scopes will be most plausible to be implemented. In the context of that, an important question is whether the distinguishing variables we mentioned (based on results from other studies) will be the most discriminatory variables in the future. We expect that economic, political, institutional and spatial considerations will influence the course of this future development. However, whatever may happen in terms of this development, it is an interesting issue to find out how these possible developments might influence location patterns of economic activities. Will improvements of accessibility and location image due to ITS concepts change the landscape of accessibility to locations and at its turn preferences among offices? Will policies on transport technology innovation and urban economic development be more than ever integrated? And if so, should not we elaborate new theories on location choice behaviour and concepts for urban transport management? These questions are the main drives of the next step in our research. Consequently, for this moment we have more questions than

answers. In the next future however, we hope to report on further results of our inquiries.

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