Office location choice behaviour and Intelligent Transport Systems

Raffael Argioli
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Office location choice behaviour and Intelligent Transport Systems

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van de Managementwetenschappen

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Preface

Like every writer of a book that has experienced more emotions than enjoyment alone, I am obliged to right a preface. So I can thank people, for the strangest reasons. Before doing so, I would like to first look at my motivation for doing this PhD.

After my study in spatial planning in 2002 I had the impression that my intellectual river would suddenly turn to dust if I had to start working in the planning practice. Therefore, during the heyday of my studies in spatial planning I started wondering what I could do to keep the river running. On the faculty website I noticed the possibility to follow a Masters degree. I went to talk about this with my tutors Andreas Faludi and Barrie Needham, where I discovered that the website had been introductory. Needham’s advice was to look into the possibilities of becoming a PhD-student. After a quick and in-depth consultation with my girlfriend Doménique (she was more convinced of my intellectual capacity than I was), I managed to convince myself that I could one day obtain a PhD. Well, my looking into possibilities led me to the, in Nijmegen, ‘green’ professor Rob van der Heijden who informed me about a vacant PhD project on Intelligent Transport Systems and spatial development. After reading the project proposal I discovered that the research aimed to link ‘Technology’, ‘Transport’ and ‘Spatial Development’. It was particularly my interest in technology development and the spatial effects of transport planning that motivated me to apply for the job. The rest is history.

As promised I would also like to thank people for a wide variety of reasons. Some people should be placed in every category. If your name is not in the list below I have forgotten about you today. But I am sure I’ll think of you tomorrow.

First of all I want to thank all the people I have worked with at the planning Institute in Nijmegen and from the BAMADAS programme in Delft. I wish you all the best in your private lives and professional careers and hope to meet each of you again one day. A special thanks also to the TBM department in Delft for their hospitality.

As every academic knows, the best “work” environment is at conferences or international workshops. In this perspective I want to thank Edwin, Wouttie and Gabriele for their company during the AESOP workshops and conferences. Especially the student’s workshop in Amsterdam and the conference in Leuven in 2003 inspired me so much. A special thanks to John Forrester for his inspiring discussions during the Amsterdam workshop and his detailed comments on my first-ever academic paper. Of course I also had great laughs in Vienna (2005), especially with Edwin, Ronald, Margo, Gabriele and some people whose names I have forgotten. It is a pity, but I was not able to go to the AESOP conference every year. In 2004 I went to the WCTR conference in Istanbul with my friend Pascal. Besides the conference and the inspiring discussion with researchers from India after my paper presentation, we also had a great holiday in and around Istanbul thanks to Özlem. In 2006 I presented my FADAS work in London together with Jan-Willem. I really regret that we could not extrapolate our beer evening from London to Beijing but you probably managed to enjoy it without me. My final international conference as a PhD-student was in 2007 in San Francisco at the AAG. I found out that transport planning is still more planning than geography. Anyway as Doménique and both her and my fathers joined me for an additional holiday we had a wonderful American, California experience.
Besides these international conferences, smaller seminars and workshops in the Netherlands were inspiring and fun too. Highlights were the CVS conference in Zeist with Edwin, where we won a paper prize and the RSA/NETHUR school in Groningen where I met Oswald Devisch and ended up in the worst pub ever.

As necessary as a good working environment as is described above, was of course good supervision and the debate with my peers on my work. Helpful comments on earlier drafts of papers by Edwin Buitelaar, Erik Louw, Egbert Wever and Martin van der Velde are gratefully acknowledged. Further I want to thank my colleagues from the BAMADAS programme (Geertje, Nina, Maura, Kiliaan, Cornelie and Meng and their supervisors) for their critical remarks and comments during the many BAMADAS sessions. Closely involved in the first year of my PhD-project was Daan Drenth, who I want to thank for his support and sharing his extensive knowledge of the literature with me. Since my third year of research I have profited from my colleague Ilona Bos, who became a sort of daily supervisor. Thank you for your methodological support, professional attitude and the 24 hour availability!

A special thanks also of course to my supervisors Rob van der Heijden and Vincent Marchau. I have learned so much from you in the past years. Most of all I will remember our once in a while one-day sessions in which we discussed my work, and the direction to proceed. I will never forget Vincent’s razor-blade sharpness for cutting in my work in combination with his sense of humour that always made us laugh. I will also never forget Rob’s analytical mindset, structured in drawings and diagrams through his hands on the white back of my paper pages. I must have dozens of those by now. Thank you for your dedication to my project, and your apparent enjoyment of working with me. Thank you for supervising me!!

What everybody knows is that the output in the professional environment is for a large part dependent on your private life. Especially when one is working on a big project like a PhD for which one person has permanent responsibility. In that respect I want to thank all my friends for all the indoor and outdoor entertainment. If I have only a single memory of Lowlands (always somebody to get my tent ready in advance), the several board game evenings/nights (viva la Junta!), Wednesday soccer practices, and the cycle tours around Nijmegen, my face gets a grin from ear to ear. Also I want to thank Domenique’s parents, sister and grandparents for their great hospitality when I am in the deep south. Further, I want to thank my father, Pietro, and my mother, Liesbeth, for shaping the right environment and maintaining a strict education policy during the first 19 years of my life. Thank you for supporting me during my spatial planning studies in Nijmegen and cooking great Italian meals for Doménique and I over the last 9 years. Besides that I also want to thank my sister Letizia and my brother Virgilio. Thank you for being my sister and thank you for being my brother.

Last but certainly not least I want to thank my girlfriend, Doménique. I really owe her a lot. Nobody told me I would need a good psychologist when working on a PhD. I found myself very lucky, Doménique always knows how to listen and what to say (or what not to say). Actually I do not need to thank you, Domenique, for that because you are just the type of mellow person to understand me during those moments. Perhaps more thanks is needed for those moments you had to battle through when I was feeling down or stressed because of work, but did not feel like talking about it. That was sometimes not so good, but for the most part we had so much fun. I even like dances with rules now! And one day you might even beat me cycling up a hill! Thank you for loving me!

Raffael Argioliu, Nijmegen September 2007 – Where I end and you begin (Radiohead)
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Chapter 1

Research context, goal and questions

1.1 Introduction

This chapter describes the background and the research questions of this dissertation. The dissertation is about research on the spatial effects of Intelligent Transport Systems (ITS). The urgency for this research lies in the fact that there is a growing confidence that technological changes in transport will reframe traffic and mobility problems, transport policy and the impacts on spatial development. Section 1.2 describes the background of this development and addresses the context in which the development of ITS is taking place. Section 1.3 focuses on ITS and shows which aspects of ITS need more research. Section 1.4 links ITS to location choices and describes a resulting research agenda. Section 1.5 describes the goal of this research and specifies the research questions.

1.2 ITS: an emerging instrument for transport policy

Modern societies are continuously faced with problems of mobility. These problems relate to the environment, such as the use of space and pollution, traffic safety, and threatened accessibility due to congestion. In the Netherlands, for example, the annual economic damage caused by congestion expressed as a waste of time is calculated at 0.2 billion euros for freight transport and 0.5 billion euros for passenger transport¹ (Advisory Council for Transport Public Works and Water, 2003). These figures are often used as an argument for greater investment in infrastructure. Ongoing economic growth and the increased individualism of people has meant that many urbanized areas in western countries have doubled in size since World-War II. This has led to a more dispersed pattern of activities which has encouraged even more mobility. Western governments are trying to influence the mobility of people. On the one hand governments aim to minimize pollution by implementing active land use policies and thereby minimizing the distances between activities (Schwanen et al., 2004), and by encouraging people to use public transport or to share cars. On the other hand governments have built many new roads and public transport systems to provide the necessary

¹ ‘These costs as a result of traffic jams caused by users can be seen as a financial value for the loss of time’ (Advisory Council for Transport Public Works and Water, 2003: 59 Translation from Dutch)
infrastructure for the increased demand for mobility. Today, traffic has become safer, but the total pollution and congestion levels are still increasing.

New possibilities to tackle mobility problems might be offered by the Information and Communication Technology (ICT) development since the eighties, which has also influenced the level of traffic and transport service. This new ICT results in car manufacturing with new intelligent devices, a wide range of new information devices to support travellers, and new traffic and transport management systems. The range of these applications is called Intelligent Transport Systems (ITS). ITS systems focus on driver and travel support, dynamic traffic management and logistical organisation (Bell, 2006).

That some have great expectations from ITS technology is illustrated by the short story in Text box 1. It shows how an illustrative example of a theoretically integrated ITS concept appeals to human values. The story is based on a publication by the Dutch Ministry of Transport and Waterways (1987) about the year 2050. It is based on a vision of the future in which we can drive longer distances with clean engines whilst reading newspapers. This vision is driven by a great belief in the technological improvement of car driving based on ICT. This technological development, which we can already witness in our modern society, is interesting for many aspects of society. It is, for example, known that the whole evolution of settlement patterns and the internal structure of cities have always been closely associated with the prevailing transport technology (Feitelson & Salomon, 2000). Almost every period of development in modern history can be attributed to the location advantages offered by the incumbent technology. Terms like the ‘railway age’, the ‘automobile city’ or the ‘telecommunications age’ are all well known for their immense impact on everyday life. With each technological leap people have become more mobile and the geographical distances have become easier to overcome. So, are we now about to enter an ‘ITS age”? It would certainly be welcomed by many people: since the publication of the short story on automated highways in Text box 1, motorways have become more congested every year.

Text box 1. An imaginary future

Let us imagine the year 2055. Pan European Integration is a fact. My friends live in the Paris city region, Köln and Amsterdam. It is Dutch diner time: 18:00, Wednesday and grandchildren day. I have an appointment in Paris where I will meet some of my oldest friends for our monthly fifty year old board-game-evening. When kissing my wife goodbye my Personal Intelligent Transport Assistant bleeps. There is a ten kilometer traffic jam on the E15 around Liège. The advice: consider the international automatic motorway E2 via Antwerp. While leaving the agglomeration of Arnhem and Nijmegen in the east of the Netherlands, I need to switch my car from conventional driving to the international automatic standards. While catching up with a platoon of cars in front of me, I decide this is the moment to stretch my legs and arms. Some time later, while my car is refueling at the battery station, I look for a bottle of water and this week’s newspaper in the shopping area. And I must not forget to switch off the onboard computer. I hate all these uninvited people daring me for a game of chess. I start driving and reading. One hour and some drowsiness later, my onboard computer keeps stalking me with the French route information. I will leave the automatic highway in thirty minutes. I am expected at Peter’s around 20:00.

ITS includes many electronic applications that support the surface transport and traffic of passengers and goods. Various types of organisations are involved in the development of ITS, including many different industrial companies. The primary objective of these organisations is to develop ITS in order to make the transport of people and goods more comfortable, efficient and/or safer.

The main enabler of ITS is the rapid development of ICT since the nineties. Before that, concepts to improve the transport and traffic technology were mainly built on electronic devices. The use of electronic devices in traffic and transport, however, goes back more than one hundred years. An example is the introduction of traffic lights in the 1920s. Many years
later, in 1961, policymakers designed buses that were electronically guided. Other initiatives were taken by the motor industry, including General Motors who launched a prototype of the Firebird II and III in the fifties. The firebird II had a system, called the “Autoglide,” which allowed the car to drive itself provided it was running on a specially constructed roadway fitted with a powered cable that guided the car along the way. This car was essentially the first road vehicle which did not require any steering guidance from its user. Later, these ideas would remain essential in the theoretical concept of Automated Highway Systems (AHS), in which cars can drive automatically on highways. The firebird III included the first Cruise Control device that now, improved significantly, is used in many cars. Figure 1 illustrates the high expectations from technology during that time.

![Figure 1. Man in hovering car](image)

In the early sixties the United States government initiated an ITS program to encourage the development of intelligence in transport. It was only in the nineties, under the influence of the ICT revolution, that policymakers, car industries, electronic device manufacturers as well as research institutes became commercially interested in the field. As a result of increasing research and development, the Intelligent Transportation Society of America (ITS America) was established in 1991 including the private sector, universities, governments and stake holding associations. In the same year ERTICO (now ERTICO–ITS Europe) the European organisation was established as an initiative of the European Commission. It included mainly car manufacturers and associated organisations and its goal was to coordinate research and development within the sector. In 1994, ITS Japan, then named VERTIS (The Vehicle, Road and Traffic Intelligence Society), was established as a response to the developments in the United States and Europe and, similar to its European and American sister societies, focused
on the development and deployment of ITS. Later ITS organisations were established in many other countries. With the growth of organisations the international knowledge exchange also increased. The first ITS world conference was held in 1994 in Paris, the first ITS Europe conference in 2001. These conferences offer cross-disciplinary possibilities for car industries, device manufacturers, research and development institutes and scientists to exchange knowledge on multiple themes within ITS. Further, during the mid nineties the ITS Journal was founded to provide an international scientific forum for publishing research results on ITS specifically in a peer-reviewed journal. Currently, all over the world co-initiatives are occurring to speed up the development and deployment of ITS. On the European level, many ITS projects are performed focusing on the impacts of and conditions for implementation. The results are state-of-the-art documents, workshops and roadmaps.

Today, the ITS-society has become international and well established. It is important to car, and device, manufacturers because it offers the possibility to present new features onto the car market. ITS is also important for fleet managers and logistics organisations because they can manage their operations more efficiently. This is also true for public transport organisations that work with bus services. To governments it might fulfil, but also threaten, their policy goals. And finally, to consumers it increases the travel and transport choices. However, to understand the possible impact of ITS possibilities better, a more detailed view on different application areas together with their threats and opportunities is necessary.

1.3 The threats and opportunities of ITS
ITS can be typified by three categories, which all apply to car driving as well as public transport: systems that support the driving tasks (ADAS; Advanced Driver Assistance Systems), systems that provide information about travel choices (ATIS; Advanced Traveller Information Systems), and systems that improve the management of traffic and transport, (ATMS; Advanced Transport Management Systems).

The first group of applications, ADAS, advise or intervene in the driving tasks indirectly by braking, steering and/or accelerating. The interrelation between the basic devices to enable ADAS processes is explained by Hall (1995) and illustrated in Figure 2. The five devices are: sensors, intelligence, memory, transmitters and actuators. Sensors are devices that collect information by observing the direct environment of the vehicle, driving conditions and/or receiving messages from other vehicles, infrastructure or road operators. Thereupon this information is processed to the intelligence, a device that formulates commands and/or messages based on the received data and stored knowledge in the memory. The commands from the intelligence are transformed into actions by the actuator and transformed into relevant messages (e.g. to the driver) by the transmitter.

ADAS vary from informing drivers about their driving performance to warning devices that try to influence the driver’s behaviour and finally systems that temporarily control some driving tasks. The basic functionality of ADAS is longitudinal and lateral support. Applications that have been developed are for example Lane Keeping, Intelligent Speed Adaptation (ISA) and Adaptive Cruise Control (ACC). The expectation is that in the future at least some ADAS applications will be used integrated in cars to alleviate the driving task.
Figure 2. Devices of ADAS (Hall, 1995)

The second group, ATIS, is used to make travelling more comfortable and reliable by providing information about congestion, alternative routes, filling stations, hotels, parking availability, public transport facilities, departure and arrival times, etcetera. ATIS are used both in car driving and in public transport.

The third group, ATMS, mainly focuses on traffic flow performance and transport efficiency. Examples are ramp metering and Automatic Vehicle Location (AVL). Ramp metering regulates the entry of cars onto motorways by allowing one car per time interval, for example every three seconds. The system prevents instant demand which could lead to a network overload. AVL is a tracking and tracing system, which enables the continuous monitoring of a vehicle position within a road network (e.g. using GPS), enabling improvements in, for example, service scheduling and vehicle usage efficiency in public transport. The use of tracking and tracing systems makes fleet management more efficient and is therefore widely used by public transport companies and logistics organisations.

To understand the interrelationship between different ITS applications and their impact on traffic, the transport system and mobility, Van der Heijden & Marchau (2002) present a market perspective, which is described in Table 1. They conceptualise the transport system by 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 physical subsystems. The three markets are the transport need market, the transport market and the traffic market. Important is that all market and subsystems are interconnected, which means that any change in one is likely to affect another market or subsystem. Table 1 shows which market and/or physical features of the transport system ADAS, ATIS and ATMS are supposed to have impact on. The level and character of the impact is dependent on the technological development. From a theoretical point of view various ADAS, ATIS and ATMS applications or combinations of applications offer potential in terms of road network throughput of vehicles, safety and alleviation of negative effects on the environment. However, promises seem very dependent on the specific system described and the operating characteristics. Furthermore, especially the long term development of ITS in the vehicle market, for example ADAS, is uncertain.
Table 1. Market approach to ITS  *(derived from Van der Heijden & Marchau, 2002)*

<table>
<thead>
<tr>
<th>Subsystem</th>
<th>ITS functionality</th>
<th>Possible ITS application</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation of society</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport need market</td>
<td>Systems for facilitating virtual mobility</td>
<td>Electronic commerce; tele-working; tele-education</td>
</tr>
<tr>
<td>Freight and passengers</td>
<td><strong>ATIS</strong> Information supply on transport services; booking of services</td>
<td>Park and ride information; public transport services information; traffic information on radio or teletext; internet booking services (multi-modal) trip reservation; route planning systems; telecommunication for fleet management and operational control (tracking, tracing); trip matching systems (e.g. carpooling) Self-diagnostic engine control systems; crash recorders; reverse parking aid; navigation systems; adaptive cruise/speed control; lateral/longitudinal control; co-operative driving</td>
</tr>
<tr>
<td><strong>Transport service market</strong></td>
<td><strong>ATIS/ATMS</strong> Pre-trip planning support systems for logistic optimisation</td>
<td>Dynamic route information traffic information on radio; differentiated electronic payment; dynamic (directional) lane assignment; ramp metering; speed control; variable message sign; incident detection; aid co-ordination systems Dynamic lane configuration adaptation; surface measurement and deterioration detection</td>
</tr>
<tr>
<td><strong>Vehicles</strong></td>
<td><strong>ADAS</strong> Smart motor technology driver support systems</td>
<td></td>
</tr>
<tr>
<td><strong>Traffic flow market</strong></td>
<td><strong>ATMS</strong> Dynamic traffic management systems</td>
<td></td>
</tr>
<tr>
<td><strong>Physical transport infrastructure</strong></td>
<td><strong>ATMS</strong> Lane optimisation technology; infrastructure status control systems</td>
<td></td>
</tr>
</tbody>
</table>

Although the box of possible ITS applications is left blank for the level ‘organisation of society’, an important lesson from the framework explained in Table 1 is that ITS might affect the organisation of society. Although this can be regarded as the most far reaching influence, it is not unimaginable, by definition of this framework. Let us for example imagine that an ITS concept evolves that cross cuts all of the markets set out in Table 1. Such a concept would be based on an interconnected system of infrastructure, a dynamic management system, specific vehicle technology, and travel information planning support systems. The concept described would change the way in which different urban areas are connected, thereby potentially influencing the societal organisation of land use. This brings us to the question of what the strength and the nature of this influence would be.

The market approach mainly shows how interconnected the transport system is, both internally and externally. It also shows that ITS has serious opportunities to influence the transport system and its environment. A complication however to these possibilities and their
impacts are the uncertainties that surround the technological development of ITS. This is explained in the four dimensions of Figure 3, which shows how technology relates to higher scaled dimensions in the sense of nested conditions, with each relationship having its own characteristic uncertainties.

Figure 3. ITS technology and its environment

ad 1. Initially there is uncertainty about the technological developments of ITS. This relates to the development stage, uncertainty about the effects and the corresponding implementation barriers. There is a rapid development of many applications, and it is unlikely that all systems will survive the pioneering stage of product development. Part of product development is dependent on research in the supplying industries, for example in the case of sensor development. Another part is dependent on the type of selection that will take place because of priority in use. It is not likely that car drivers can simultaneously handle many ITS applications. Furthermore, there is much uncertainty about the conditions for market implementation. For example, tensions regarding the liability issues of ADAS still remain largely unsolved, emphasised in the first research steps into legislation and liability issues regarding ADAS (see e.g. Van Wees, 1999; Van der Heijden & Van Wees 2001; Van Wees, 2004). These liability issues focus on control and the necessary override ability of car drivers. Finally, another uncertainty is the development of public policy (see e.g. Van der Pas et al., 2006). On the one hand western governments, like the USA, EU and Japan, encourage research programs and pilots that support the reduction of uncertainties at the afore-mentioned levels (ADASE 2, 2003). On the other hand it is clear that the implementation of more controlling ITS, for example an in-car speed regulation system, would probably need an unambiguous political commitment to become implemented.

ad 2. Secondly, besides the uncertainty of the development of ITS, there is also great uncertainty about the effects of different ITS on drivers and uncertainty about how well drivers will be able to adapt to the new technologies offered by ITS. For example, there is uncertainty about the behaviour of drivers that use ADAS and other traffic participants that are encountered with cars equipped with ADAS (see Houtenbos et al., 2005; Dragutinovic et al., 2005). Furthermore, the simultaneous use of several ADAS in one car might confuse drivers.

ad 3. A third uncertainty lies in the relationship between ITS technology and the traffic system. The effects of some ITS are far but 100% clear. The OECD (2003) reports for example that ADAS in general could reduce the amount of road crash injuries in the European Union by 40%. One could be critical of these numbers considering more differentiated ITS studies (see e.g. Golias et al., 2002a; Lu et al., 2005). Additionally,
some ITS might contribute to one policy but may obstruct another. For example an Intelligent Speed Adaptation (ISA) device might improve the safety of car drivers (Regan et al., 2006; Jagtman et al., 2005), but can at the same time negatively influence the capacity of road infrastructure (Hoogendoorn & Minderhoud, 2001). From a traffic system perspective the success of ITS is very much dependent on the type of infrastructure. Some ITS require a substantive change of infrastructure to support the success of the implementation (Lu et al., 2005).

A fourth uncertainty lies in the relationship between ITS technology and its spatial environment. An important improvement of for example the traffic throughput by ITS in a certain lane, might improve the accessibility of the immediate area. This might also be true if ITS can achieve a higher transport service by offering a more reliable transport mode. It is however rather unclear what combinations of ITS might improve the transport service significantly. Both examples might attract new activities to the immediate area resulting in, for example, higher land use prices. Such a process of attracting activities is possible at various, for example, local and regional levels.

A great deal of scientific research has been carried out at most levels of uncertainty, with the exception of the fourth uncertainty: ITS influencing transport performance and therewith changing land use activity. Research on this topic is scarce. This might become problematic since especially transport infrastructure investments are long-term and are in many cases irreversible. Furthermore, ITS are becoming an increasingly important factor in transport planning and society demands that the topic is fully researched. In the next section we explore this topic in more detail.

1.4 ITS and land use
An important question is: how might future ITS concepts change land use? The answer can be found in the complex relationship between land use and transport in general. Although the general relationship is already hard to make explicit (Priemus et al., 2001), many transport-land use schemes focus on accessibility. These schemes follow a particular line of reasoning: since the accessibility of activities is important to the mobility of people, any improvement in accessibility will make certain regions, areas and locations more attractive for working, living etcetera. This relationship between accessibility and altered spatial choices is partially reflected by studies that indicate that accessibility plays an important role for firms (Louw, 1996; Bruinsma & Rietveld, 2007) and people (Kim et al., 2005) when choosing locations.

From the perspective of ITS it is important that an ICT technology component is introduced into this reasoning. Figure 4 illustrates a transport-land use scheme including a technological innovation for transport. It shows the mutual demand for accessibility and the demand for space. A demand for space requires spatial adaptation or spatial development, which is again under the influence of time-space compression due to transport planning. Spatial development results in increased interaction between activities and an increased demand for accessibility. The demand for accessibility is met by the planning and building of new infrastructure, transport service innovation and applications of technologies that improve transport and traffic performance. This again leads towards an improvement of accessibility and demands for spatial adaptation. According to Figure 4, spatial development is influenced by the development of ITS when it responds to the demand for accessibility by innovative transport services. To significantly change land use patterns, ITS should really ‘boost’ accessibility.
The crucial question resulting from Figure 4 is how ITS as a transport innovation might improve accessibility. If we define accessibility as the effort for people to travel from one place to another, the following aspects of mobility should be decreased and improved:

1. Time spent
2. Costs made
3. Other factors, like reliability, stress, comfort and safety should be improved.

If ITS is successful in decreasing travel time and costs and improving other factors like reliability and comfort, locations can become more accessible for people. An significant overall reduction in effort is possible and plausible with an innovation of transport: a combination of driver support, travel information and management systems, since each of these aims to significantly improve the performance of travelling.

Grübler (1991) distinguishes basic innovations, and product innovations. Basic innovations are the result of the introduction of fundamentally new solutions (e.g. ICT in general). Product (or process) innovations are the result of incremental improvements in existing techniques and systems. To change the accessibility of locations ITS development needs a leap from the current implementation of many different technologies in many market segments (product innovation) to a situation in which combinations of complementary technologies form new transport concepts (basic innovation or system innovation (see e.g. Geels, 2005). The speed of this kind of innovation process is rather slow (Van Zuylen & Weber, 2002; Geels, 2002). Such a leap in ICT applications can be compared to the past introduction of new transport modes (e.g. trams), which was closely associated with enabling technologies (Grübler, 1991; Grübler & Nakićenović, 1991; Geels, 2005).

According to Banister (1994), knowledge and information will become instrumental in road transport innovations that are based on intelligent highways and intelligent cars. One strategy is to make car infrastructure more efficient by implementing transport management

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**Figure 4. Extended model of the process of spatial re-organization and new technology**

(Derived from Janelle, 1969)
schemes that increase the capacity of a given road network, and it is expected that technology through intelligent highways can continue that process (Banister, 1994; 2002). According to Banister (1994), road users will be affected both by traveller information systems, control systems in vehicles and more control over the transport network, including demand and traffic control systems. This thought matches those arrows of Figure 4 indicating that ITS are likely to improve the accessibility of places, which will result in a new demand for space. Eventually, it would result in altered land use choices of households and/or firms.

The potential relationship between ITS and land use changes has already been addressed in publications as an important theme for research (see e.g. Miller et al., 1997, Johnston & Rodier, 1999, Janelle & Gillespie, 2004). However, the number of publications based on empirical findings is small. The few exceptions include Tayyaran & Kahn (2003) and Tayyaran et al. (2003). A major conclusion of the latter, Stated Preference, study on residential location choice was that telecommuting and ITS measures were highly significant factors in residential location choice decision (Tayyaran et al., 2003). Telecommuting was tested as a variable, but ITS was not. The conclusions concerning any positive influences of ITS were based on the fact that the estimated coefficient of travel time was negative. This indicated that, everything else being equal, people would choose residential locations along transport systems that provide them with more reliable travel time to work. According to Tayyaran et al. (2003) this suggests that if ITS were applied to any part of the region which would reduce the variability of people’s daily commute, the probability of choosing housing in that area would increase. It is exactly the promise that ITS will reduce travel effort that indicates a possible causal relation between ITS and location preferences. Based on this study Tayyaran & Khan (2003) conclude that a large scale implementation of ITS is likely to lead to a decentralized urban structure. Further, they argue that the incorporation of information technology measures in a business location model would confirm the dispersal impacts of office location choice, as they did for the residential model. Other studies that focus on the role of ITS related transport concepts in shaping the urban structures analyse, for example, Advanced Vehicle Control Systems (AVCS) based on magnetic levitation (maglev) (see e.g. Lee, 2003) or Automated Highway Systems (AHS) (see e.g. Miller et al. 1997).

In conclusion the empirical exploration on the relationship between ITS and land use changes is very limited although the importance of its relationship is acknowledged in publications by several experts.

1.5 Research for ITS and office location choices

From the perspective of the theoretical exploration in section 4, research on ITS and location choices is challenging. However research on ITS and all forms of location choices seems too complicated for one dissertation. One might for example focus on retail, housing sites and businesses locations in general. From an explorative point of view it seems acceptable to focus on just one sector since in-depth analyses require a solid and straightforward theoretical and methodological framework. From that perspective a focus on office locations is most promising, for three reasons: the location preferences of offices is considered to be more influenced by accessibility than the two other sectors mentioned, the office market has the highest economic impact on city development, and it is a very mobile market (Louw, 1996). Therefore office locations are most likely to be first affected, compared to for example transport logistics organisations. Since offices relate to the mobility of people, in the form of employees or clients in city regions, the ITS concepts used in this study will only focus on passenger transport in urbanized areas.

Few researchers have conducted academic empirical research on the topic of ITS and office locations. For office keeping organisations the relevant ITS concepts have not been fully realised yet and changes in geographical patterns take many years. It is therefore not
possible to carry out an analysis based on observed ITS-related concepts and office location choices. This research will therefore focus on future – within 10 to 15 years – ITS-related transport concepts and preferences for office keeping organisations, thereby taking into account that a full scale implementation and potential changes in geographical patterns will occur further in the future. The goal of this study is the conceptual and empirical modelling of the influence of future ITS concepts on office location preferences in urbanized areas. An important assumption in this context is that preferences for locations give a strong indication of actual choices for locations. The main question of this research is, therefore: ‘How might ITS affect location preferences of office keeping organisations in urbanized areas?’

This main question includes many issues that have to be made operational before research is possible. The following set of questions needs to be answered to answer the main question and to reach the stated research goal:

1. (a) What specific theoretical framework can be derived from the field of location theory to formulate hypotheses on ITS and location choice behaviour? (b) What methodological approach is then suitable to test the hypotheses?
2. (a) How can current knowledge on ITS development and the uncertainties be structured to specify plausible ITS concepts for the future? (b) What is the result of this analysis?
3. (a) How can the relationship between future ITS concepts and office location preferences be measured and modelled in depth? (b) What is the result of this analysis?
4. (a) How can the results of a model of preferences be validated? (b) What is the result of this analysis?

Chapter 2 will focus on the conceptual framework. It describes the main research elements (office location preferences, accessibility and ITS) and a theoretical causal relationship. It also proposes more detailed methods and techniques to research the main hypotheses.

Chapter 3 describes the approach and the performance of a study aimed at conceptualizing several ITS related transport concepts that might appeal to organisations because of the assumed benefits for accessibility.

Chapter 4 describes the set up of a preference modelling study in which the derived ITS concepts are presented to office keeping organisations.

Chapter 5 presents the preference study plus the calibration of the models. In this chapter the main hypotheses are tested.

Chapter 6 describes an external validity study in which the predictive power of the models of the preference study is tested.

Chapter 7 draws conclusions about the main research question and explores to what extent the goal of the study is achieved.