Impacts of Intelligent Transportation Systems on Users’ Mobility: A Case Study Analysis

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“And it appears to me, the doing what little one can to increase the general stock of knowledge is as respectable an object of life, as one can in any likelihood pursue.” – Charles Darwin (1809-1882)
Abstract
People have many reasons to be mobile, from day-to-day activities involving work, studies, and family, to maintaining participation in society, health, and quality of life. Information and Communication Technology (ICT) is increasingly being deployed in the transportation context to improve individuals’ mobility; for example via information provision. Advanced use of ICT in transportation is commonly referred to as Intelligent Transportation Systems (ITS).

Despite many opportunities for ITS services to enhance personal mobility, the collection and use of movement and activity data also poses challenges, as it facilitates easier access to more information for people to use, but about them as well. Knowledge about users’ perceptions of advantages and disadvantages (for example assurance and privacy) associated with the use of ITS services is limited. Even less is known regarding to what degree their perceptions influence their acceptance of the services or their behavior.

The aim of this thesis project is to gather empirical interview and survey data from multiple user groups in order to learn more about the factors impacting users’ attitudes towards ITS services. In exploring not only demographic factors, but also the potential positive and negative impacts from the users’ perspective, this project attempts to paint a more holistic view of the issues surrounding the possibilities for ITS to enhance mobility.

From the two case studies presented in this thesis, results indicate that respondents are pro-technology and are not highly concerned about privacy in general, but other ethical issues serve to shed light on the situations of different user groups. In the first case study with visually impaired individuals, the ability to lead an autonomous and independent life is a strong driver for the acceptance of a pedestrian navigation system, which the users themselves would choose to use. While the participants are generally optimistic about the possibilities of using ITS to enhance their mobility, their comments illustrate that ICT development does not necessarily result in ethically sound, universally accessible technology, and that a coordinated effort on multiple fronts is vital in addressing users’ needs and meeting broader social goals such as social inclusion and the accessibility of transportation, technology, and information.

In the second case study with professional heavy goods vehicle drivers and their employers, the drivers are in a dependent (employee) position and have less personal control over the use of ITS services in the vehicles. The employers are perceived as the greater beneficiaries of the services, which could be linked to the systematic lack of feedback to the drivers. Generally, the respondents trust the employers to protect the drivers’ privacy. However, there also exist gaps in organizational communication regarding data gathering and handling practices as well as in expected versus stated behavior modification as a result of workplace monitoring. As employees are not normally able to provide informed consent due to their dependent position, recommendations for organizations include performing comprehensive impact assessments, engaging in an ongoing dialogue with employees, and providing an opt-out option in order to move towards a more informed consent.
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Chapter 1

Introduction

The aim of this thesis project is to gather empirical interview and survey data from multiple user groups in order to learn more about the factors impacting users’ attitudes towards ITS services. In exploring not only demographic factors, but also the potential positive and negative impacts from the users’ perspective, this project attempts to paint a more holistic view of the issues surrounding the possibilities for ITS to enhance mobility.

1.1 Background

People have many reasons to be mobile, from day-to-day activities involving work, studies, and family life, to maintaining participation in society, health, and quality of life. Indeed, mobility is not only a characteristic of modern social life, but also a precondition for it (Thomsen et al, 2005). The concept of mobility varies greatly between disciplines, from the movement between two points to social mobility between classes to the spread of ideas. One classification divides mobility into four general types of movement: personal, object, virtual (information), and imaginary (media) (Urry, 2000). This thesis focuses on personal mobility, which can be destination-dependent or destination-independent (Metz, 2000), actual or potential (Gudmundsson, 2005, Kaufmann, 2002).

When considering personal mobility, one finds a broad range of mobility barriers such as demographic factors (age or disability), accessibility, availability, affordability, safety concerns, lack of information, etc. Such mobility barriers may in turn act as impediments to public and private services, leisure activities, employment, and education, potentially generating long-term social impacts. In order to address some of these mobility barriers, especially those related to information sharing, Information and Communication Technology (ICT) is increasingly being deployed in the transportation context. Advanced use of ICT in transportation is commonly referred to as Intelligent Transportation Systems (ITS).

ITS services have great potential to improve individuals’ mobility. For example, advancements in positioning and mobile systems allow for increasingly precise and continual measurements of the locations and movements of individuals and objects over time. These tracking and monitoring capabilities facilitate the collection of movement
and activity data, which enables further development of services and devices, for instance, to provide information for pre- and on-trip planning. Examples include maps and journey planners, real-time information about transportation options or conditions, location-based services (LBS), alarms, multimodal navigation systems, etc. Information is especially important in unfamiliar locations and situations; but, for vulnerable social groups, access to information may be the deciding factor in whether to travel or not (Waara, 2001).

The increased access to information and communication offered by ITS services (and ICT generally) can serve to reduce perceived risk and uncertainty, especially in unexpected or unfamiliar situations, by imparting a sense of connectedness and control. The Swedish word *trygghet* encompasses concepts of perceived safety and security as well as connotations of confidence and comfort. Thus, the English word “assurance” is used in this thesis rather than some version of safety or security. These concepts, when used in transportation, often focus on accidents, sabotage, terrorism, or crime, none of which convey the entire meaning of *trygghet*.

Despite many opportunities for ITS services to enhance mobility, assurance, safety, security, etc, the collection and use of movement and activity data also poses challenges, as the use of ICT in transportation facilitates easier access to more information for people to use, but about them as well. Information and privacy are intertwined at a fundamental level. Privacy in itself is an elusive concept and for the purpose of this thesis, focus is placed on the importance of privacy rather than on nailing down a definition (although it can broadly be considered to be the ability to control one’s contact with others, where contact is a general term not limited in time and not only referring to the physical). For example, it has been argued that privacy is important because it safeguards the more fundamental value of personal autonomy (Rössler, 2005). Additionally, it also enables anonymity, solitude, isolation, reserve, and intimacy, as well as serves the functions of emotional release, and self-evaluation (Pedersen, 1997) and the development of personality and personal relationships (Margulis, 2003).

One key aspect of privacy, which is relevant in this thesis, is its contextual nature. Nissenbaum (2004) argues that concerns for privacy are concerns about “appropriate flows of information” that are dependent on the social norms within a particular context. Another is the common notion “if you have nothing to hide, you have nothing to fear”, which is deliberately included in the author’s instrumentation due to its prevalence and generality. Solove (2011) claims this argument, although customary, is problematic as it is limited in scope since the concept includes more than concerns about secrecy, illegality, data collection, or even limited disclosure. Among other things, privacy also entails aspects of not having one’s information shared with a third party, aggregated with other information, distorted, etc. In other words, a more fundamental problem which the “nothing to hide” argument does not directly capture is exclusion, or individuals’ lack of influence and power over how their information is used.

Following these examples and lines of reasoning, it can be concluded that concerns about privacy are concerns that are not only, and not even mainly, about the disclosure
and processing of information. Instead, information is considered private depending on context and control. Loss of privacy, therefore, can be considered part of a larger ethical debate concerning personal integrity (which is also the Swedish equivalent of the word “privacy”) and exclusion.

Knowledge about users’ perceptions of advantages and disadvantages (e.g. assurance and privacy) associated with ICT use in the context of transportation is limited. Even less is known regarding to what degree their perceptions influence the acceptance of the services, or to what degree the services influence the users’ actual or stated behavior. This thesis empirically explores users’ attitudes towards ITS services and their impacts, including ethical issues and trade-offs of using technology to enhance mobility.

1.2 Aim and Research Objectives

This thesis project considers ITS from the perceptions of the users, based on data gathered via two empirical experiments. The following research questions are addressed in this thesis:

- **RQ1** How do ITS services affect perceptions of assurance and privacy? Does there exist a trade-off between assurance and privacy?
- **RQ2** What is the potential impact of ITS services on the mobility and independence of vulnerable social groups?
- **RQ3** How do attitudes towards ITS services and related issues in the workplace differ between employees and employers?

In order to address the above questions, two extensive case studies (A and B) are performed, the results of which are presented in three scientific papers (I, II, and III). Paper I, based on Case Study A with visually impaired persons, focuses on the perceived potential effects of a tailored pedestrian navigation system on the users’ mobility. Papers II and III present results of Case Study B with professional Heavy Goods Vehicle (HGV) drivers and their employers. Paper II addresses aspects of workplace privacy, contrasting the attitudes of employees (drivers) versus employers, while Paper III analyzes a specific ITS service within this setting, namely Intelligent Truck Parking. Table 1.1 provides an overview of the contribution of each paper in addressing the research objectives.

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Research Questions</th>
<th>Papers</th>
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<td>RQ1 Impact on assurance and privacy and possible trade-off</td>
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<td>B</td>
<td></td>
<td>II</td>
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<td>x</td>
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<tr>
<td>x</td>
<td>RQ2 Impact on vulnerable users’ mobility and independence</td>
<td>x</td>
</tr>
<tr>
<td>x</td>
<td>RQ3 Impact of employment status</td>
<td>x</td>
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Table 1.1: Overview of papers and research questions
CHAPTER 1. INTRODUCTION

1.3 Methodology

The papers presented in this licentiate thesis are based on two case studies. For both, the data was collected via individual, structured interviews, a quantitative data collection method in which each respondent receives the same pre-determined questions in the same order and the questions often have a limited set of pre-determined responses. This consistency between individual structured interviews enables data aggregation and comparisons across respondents and time periods. Additionally, although contextual effects of question order cannot be completely eliminated, the nature of the structured interview holds the context effects constant across participants.

Structured interviews are employed due to two factors. First, a self-administered questionnaire was judged to be a potential deterrent to recruitment as visually impaired persons might find it too demanding or time consuming and as professional drivers might be reluctant to dedicate breaks from driving to such a task. Second, the number of respondents was expected to be limited. Although structured interviews traditionally only allow for minimal responses, the interviewers did allow for respondents to elaborate if they so desired, with additional comments recorded by hand by the interviewer.

As the data is primarily ordinal due to the nature of the ranking questions, the statistical analysis is based on non-parametric methods, e.g. the Mann-Whitney U Test is used to compare differences between two independent groups and the Wilcoxon Signed Rank Test is used to compare differences between two dependent groups. The statistical analyses are performed using the software package PASW Statistics 18.0 or 19.0 for Macintosh.

1.3.1 Instrumentation

The full content of the questionnaires and structured interviews are found in the appendices. Respondents are allowed to skip any question except those necessary to guide the skip logic, e.g. if the respondent is eligible for Dial-a-Ride or not. To summarize briefly, the interview content includes the following, in consecutive order:

- An introduction about the project;
- A first section of questions addressing the socio-demographic characteristics of the participants. Two characteristics, sex and year of birth, are common to both case studies, while others are specific to the case study. In addition, Case Study A includes a series of questions about the respondents’ travel patterns, e.g. use of public transportation, eligibility and use of Dial-a-Ride (Färdtjänst), use of ICT-based travel services, etc.
- A section of questions addressing the respondents’ general attitudes. Respondents are asked to rate a series of statements according to how much they agreed or disagreed using a Likert scale: Totally Disagree (1) to Totally Agree (5). The statements are chosen to reflect attitudes about selected factors the author hypothesizes can influence the acceptance of ICT-based travel services
(based on a literature review undertaken at the beginning of the thesis project),
e.g. technology, privacy, trust, independence, assurance. These general attitude
questions are intentionally placed before the scenario questions so as to reduce
the influence of descriptions of specific technologies on the responses.

- For Case Study B, respondents are asked about their work situation, including
  existing services used in the vehicles, perceived benefits, internal communication
  regarding privacy and positioning, etc. This section also includes a series of
  rating statements (using a Likert scale, as described above) related to aspects of
  the work situation, e.g. privacy, trust, assurance, knowledge and information
  about data gathering and handling processes, etc.

- A section including scenarios about specific ICT-based travel-related technologies
  or services in order to capture responses related to privacy and assurance in more
  specific contexts (so as to assess a potential trade-off). Additional questions,
  depending on the scenario, included, for example, perception of benefit, impact
  on the user, willingness to pay, etc.

- Concluding questions for control purposes, e.g. previous experience with a
certain technology.

- An open question giving each respondent the opportunity to reflect on the
content of the structured interview, share additional thoughts, etc.

### 1.3.2 Respondents

Table 1.2 provides an overview of the convenience samples in each case study, including
a breakdown by sex and age. More specific socio-demographics and the recruitment
methods are presented in the papers.

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<th>Case Study B</th>
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<td><strong>Data Collection Method</strong></td>
<td>Structured Interviews</td>
<td>Structured Interviews</td>
</tr>
<tr>
<td><strong>Respondent Group</strong></td>
<td>Visually impaired adults at least 18 years old</td>
<td>Professional heavy goods vehicle drivers and road haulage company representatives</td>
</tr>
<tr>
<td><strong>Number of Respondents</strong></td>
<td>n = 23</td>
<td>Drivers: n = 30; Company Representatives: n = 20</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>7 = Female</td>
<td>4 = Female</td>
</tr>
<tr>
<td></td>
<td>16 = Male</td>
<td>46 = Male</td>
</tr>
<tr>
<td><strong>Estimated Age = Response Year</strong></td>
<td>$\bar{x} = 47.2$, range [23, 92]</td>
<td>$\bar{x} = 44.1$, range [20, 66]</td>
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<td>- Birth Year</td>
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Table 1.2: Overview of respondents per case study
1.3.3 Limitations

A limitation in this thesis is related to the stated preference nature of many interview questions, which can call into question the responses’ reliability and limit the strength of claims made about actual, resulting behavior. In Case Study A, the main factor of concern is the respondents’ previous experience with the e-Adept navigation system (e-Adept, 2012) under development in Stockholm and how this might affect their attitudes, particularly their attitudes towards such a navigation system. However, very few significant differences are found between the “experience” and “no experience” groups, which strengthens claims made in this study regarding the potential impact of a navigation system. In Case Study B, the main factor of interest is employment status (driver or company representative), which does prove to affect some attitudes (although not privacy attitudes); this is discussed primarily in Paper II.

1.4 Main Results

Results from these two case studies indicate that respondents are pro-technology and are not highly concerned about privacy in general. This, however, does not translate into equally high levels of trust for government agencies and privacy companies to protect personal data, which reflects the contextual nature of privacy. Respondents in both case studies feel that the ITS services in question have or would have a positive effect on their sense of assurance and a neutral affect on their sense of privacy, which does not support the existence of a perceived trade-off between assurance and privacy.

In Case Study A with visually impaired persons, results indicate that with the provision of detailed information about the built environment and public transportation via a tailored pedestrian navigation system, positive potential effects on mobility include an increased ability to travel alone, to travel in unplanned and unfamiliar situations, and to prioritize public transportation use over the use of special transportation services. The respondents perceive a high personal benefit of the described navigation system and express an interest in future purchase. In the broader sense, the system may also serve an integrity enhancing function by improving the possibility of leading an independent and autonomous life, which is a strong driver for the acceptance of such a system.

Although participants’ responses do not indicate high levels of concern for data misuse or being tracked through their data in this context, this does not translate into an absence of concern over technology’s potential negative impacts on personal integrity. As the participants’ comments illustrate, ICT development does not necessarily result in ethically sound, universally accessible technology. While the participants are generally optimistic about the possibilities of using ICT to enhance their mobility, they also emphasize that ICT is not the “magic bullet”. As such, this study serves to remind us that a coordinated effort on multiple fronts is vital in addressing users’ needs and meeting broader social goals such as social inclusion and the accessibility of transportation, technology, and information.
In Case Study B, contrasting perceptions of professional heavy goods vehicle drivers and road haulage company representatives, results (Paper II) indicate that most respondents trust the employer to protect driver privacy and HGV data. However, the results also reveal significant gaps in knowledge about what HGV data is collected, in communication between employers and employees regarding data gathering and handling practices, and in expected versus actual behavior modification as a result of workplace monitoring. The employers are perceived as the greatest beneficiaries of the in-vehicle positioning systems and services, which could be linked to the systematic lack of feedback to the drivers. As employees are not normally able to provide informed consent due to their dependent position, recommendations for organizations include performing comprehensive impact assessments, engaging in an ongoing dialogue with employees, and providing an opt-out option in order to move towards a more informed consent.

Paper III specifically analyzes the potential benefits of an Intelligent Truck Parking (ITP) service for different stakeholder groups. Comparing results of the structured interviews with the theoretical benefit assessment indicates that the end users (drivers and road haulage companies) may not perceive ITP as highly beneficial although they theoretically benefit the most. Both drivers and company representatives think that ITP would have a positive effect on the drivers’ sense of assurance, although two drivers express concerns over becoming potential targets if parked in a “secure” area. Perceived effects on drivers’ privacy are neutral although some respondents point out that having detailed logs can enhance integrity by proving that one is honest and follows the rules. Average ratings of benefit are neutral for drivers and only slightly positive for companies, which also translates into a low willingness to pay on the part of the companies, particularly for national haulers. The general response to a service providing parking information and booking is perhaps most analogous to such a service about hotel rooms, i.e. users are willing to pay for the room/parking spot itself, but not for information and booking.

1.5 Further Research

For Case Study A, further research of interest includes a before-after study to examine the nature of the pedestrian navigation system’s use and its actual effects on users’ mobility and perceived quality of life. Convenience aspects of the door-to-door, car-based Dial-a-Ride service may also prove to be too big a pull to shift users to public transportation due to the use of a navigation system, particularly when the choice does not hinge on a lack of information. Further studies of the perspectives of users in secondary market segments are also necessary for generalization purposes. For example, elderly persons may not share the same positive outlook regarding technology or dependence on alternative forms of transportation. Thus, they may not perceive the same benefits of such a navigation system, which can influence their interest in purchase and usage.

For Case Study B, further work can include comparing different groups of professional drivers (e.g. taxi drivers), investigating international differences between HGV drivers (e.g. across different countries in the European Union, which is attempting to harmonize certain ITS services), and exploring the effects of driver feedback mechanisms and
reward structures on privacy and benefit perceptions. Furthermore, it is important to evaluate if the goals of the implementation of ITS systems are actually achieved, e.g. by performing before-after studies of specific systems and services, and to investigate the longitudinal effects of e.g. organizational privacy policies on employee trust and privacy concerns. For the ITP service specifically, further work can quantify the benefit areas for a defined case, assess benefits for HGVs versus private cars, analyze subservices, and extend the empirical analysis to more stakeholder groups.

It is also of interest to explore the broader ethical aspects of other ICT systems and user groups within the transportation context. The situations of cognitively impaired users and children, for example, certainly present an ethical quandary from the perspectives of paternalism and voluntary consent.

In the context of the thesis project, the next steps include analysis of survey data gathered for a case study of elderly individuals; initial results reveal significant differences in attitudes by gender. Also, analysis of data gathered in a national survey on ICT and privacy with several scenarios in the transportation context, and analysis of a local case study addressing the use of mobile alarms for elderly persons.

1.6 Papers

1.6.1 Papers Included in This Thesis

Paper I
Sochor, J. (2012) “Mobility-Enhancing ICT from an Ethical Perspective: The Case of a Navigation System for Visually Impaired Persons”
Submitted for publication (Transportation Research Part A: Policy and Practice).

Paper II
Submitted for publication (Transportation Research Board). Extended from a conference paper by Jana Sochor presented at the 19th World Congress on ITS.

Paper III
Submitted by invitation for publication (International Journal of ITS Research). Extended from a conference paper by the same authors presented at the 18th World Congress on ITS.

The author of this thesis is the main contributor to these three papers.
1.6.2 Other Related Reports and Conference Publications


Sochor, J. (2011) “User Acceptance and IT: Privacy Issues and Concerns When Enhancing Mobility”, project funded by The Swedish Transportation Administration (Trafikverket).

Sjöström, T., Larsson, P., Sochor, J., Udin, C., Jarlebring I (2010) “ITS and Telematic Services—Different Implementation Aspects” together with Sweco Infrastructure AB, project funded by the The Swedish Transportation Administration (Trafikverket).


The thesis project work has also been presented at the World Congress on ITS, the ITS Sweden National Conference, Transportforum (a Swedish conference), the Swedish STS Association’s spring seminar, the 1st ITS UK/Sweden doctoral candidate workshop, KTH seminars (TrafikNet, Safety on the Move), meetings with the Stockholm Traffic Office and Stockholm Public Transport (SL), and various internal seminars and workshops at KTH and in the Swedish National ITS Postgraduate School. The author appreciates the valuable feedback received from the international and national research community, colleagues, and practitioners.

1.7 References


