Intelligent transportation systems as a factor of strategic transportation planning

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Abstract. The use of Intelligent Transportation Systems (ITS) in motor vehicles is anticipated to dramatically enhance both traffic safety and mobility. Successful large-scale implementation of these systems depends critically on the enthusiasm of potential users to accept them. However, market segmentation has gotten surprisingly little attention at the current level of ITS technology development, despite the fact that it is required to capture the predicted variance in demands and expectations of drivers in various categories of age, gender, country, etc. Therefore, this study's major objective was to analyze how open drivers of different demographics would be to adopting a wide variety of ITS systems with promising future safety applications. Finding out what people in cars really required in the case of an accident was an important first step. It seems that in order for ITS technology to be broadly embraced, it will be necessary to meet the demands and expectations of a wide range of driver demographics. Surprisingly low adoption rates were seen for alcohol interlocks and electronic license keys despite their effectiveness in reducing road trauma and expenses. There has been some discussion about what these findings mean for the future of ITS.

Keywords: intelligent transportation systems, ITS, traffic safety, drivers' needs and requirements, perceived acceptability

1 Introduction and theoretical background

1.1 Intelligent Transportation Systems

Safety risks, congestion, pollution, and the need for more energy and room are just some of the issues that modern transportation faces as a result of increased vehicle traffic. Unsafety is a key issue that has arisen as a result of road transportation's negative externalities in recent years. This is especially crucial since the prevalence of automobiles continues to rise, making it riskier to travel by car than ever before. Despite widespread efforts to reduce road deaths and injuries (including better road construction, more laws, etc.), we can observe that the incidence of road trauma is rising drastically in the majority of nations according to Baum et al. (2019). If something isn't done soon, road accidents are expected to overtake suicide as the fifth leading cause of death worldwide by 2030. Most car accidents occur when drivers are acting unsafely or negligently according to Febriani et al. (2020).

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In reality, drivers may be placed in precarious circumstances when they are required to perform many regulatory activities at once (i.e., heavy use of the accelerator, brake, gear shifter, and steering) due to their limited capacity for long-term adaptation. The most obvious manifestation of the problems drivers face on the road is an increase in accidents according to Dalinjong et al (2019). Any time a driver has an issue, the universal definition says that this points to a hole in the safety provided by the driving system itself. To meet these, we need what are called Intelligent Transportation Systems (ITS), which optimize the driving system so that it works better for the people who use it according to Liu et al (2020).

It is well understood that using ITS in motor vehicles has the potential to greatly improve traffic safety and efficiency throughout the world. When it comes to solving transportation issues, ITS refers to a wide range of electronic systems that use a wide range of information processing, communication, control, and sensing technologies according to Pitpitan et al (2020).

There are several ways in which ITS may help the environment and the community. These include enhancing traffic safety and efficiency, decreasing congestion, expanding road capacity, decreasing car emissions, and conserving energy according to Selmoune et al (2020). Although ITS systems show promise in protecting the environment and increasing economic efficiency, its biggest advantage is unquestionably in increasing the safety of road users according to Ebrahimnejad(2021).

When it comes to preventing or mitigating collisions, ITS safety applications are able to actively gather and interpret data from the surrounding traffic environment, send that data back to the vehicle's operator, and take appropriate action according to Shatanawi et al (2020). These systems range from those that help the driver with a specific sub-task of driving (such speed control) to those that automate the driver's regulatory tasks fully (e.g. the autopilot).

### 1.2 Acceptability of Intelligent Transportation Systems

Multiple research over the last couple decades have investigated whether or not drivers would welcome in-car ITS applications. Although several studies have attempted to quantify social acceptability, the approaches used have differed widely (Ashrafi et al., 2021; Zhong et al., 2022; Andreeva & Kozlova, 2017).

While it would be beyond the scope of this dissertation to detail the processes and results of these studies in full, we will discuss the most important takeaways (An et al., 2022; Gorvine et al., 2021; Petraki et al., 2022; Kozlova et al., 2022). The systems that have been studied the most often in terms of ITS acceptability are highlighted. Several studies have looked at the acceptance of a particular ITS product from every angle. The social acceptability of a technology called Intelligent Speed Adaptation (ISA), which aims to minimize speeding.

Yet drivers seemed to change their minds about restricting systems after using both features. This demonstrates how drivers' levels of acceptability are affected by their amount of experience.

It was also shown that Italian and Portuguese drivers, unlike other European drivers, were primarily in favour of speed restricting systems rather than informing ones, suggesting that drivers' cultural backgrounds may impact their preference and choosing behaviour. A lot of people are curious about the viability of a technology called Adaptive Cruise Control (ACC), which helps drivers keep a safe distance behind the car in front of them according to (Ito et al., 2022; Morton et al., 2021)
1.3 Technology Acceptance Model

Concerns about the Transportation System's technical viability have been transferred to those of the consumers. User acceptance of ITS products is crucial to achieving the expected advantages of ITS deployments. Users on the roads generate the need for ITS, and their level of acceptance of the technology will determine its success or failure. Therefore, intelligent transportation systems' acceptability is a crucial problem that must be tackled from the earliest stages of design and development. This chapter focuses on the degree to which different types of motorists accept certain ITS applications. However, defining acceptability and its constituent parts is a prerequisite to conducting an acceptance review (Baum et al., 2019; Febriani et al., 2020; Ushakov et al., 2022c). The idea of acceptability is typically taken for granted in the field of ITS research. Although it may seem that everyone is familiar with the concept of acceptability and agrees that it is crucial, we find that there is a lack of consensus across research when it comes to what is meant by acceptability and how it should be assessed (Liu et al., 2020; Pitpitan et al., 2020; Ushakov et al., 2022; 2022a, 2022b).

It may be said that as many publications on acceptability exist as there are questionnaires and processes for gauging driver satisfaction with ITS products. Given the many factors that go into determining acceptance and the many types of ITS technology, this is to be anticipated. Inter-study comparisons would be difficult, if not impossible, without a firm grasp of acceptability and its underlying conceptions that have been employed to gauge the customers' acceptance of ITS goods.

The Technology Acceptance Model is one of the earliest and most robust models, having been repeatedly proven accurate (TAM). Fig. 1 shows the proposed TAM conceptual framework. According to Davis's approach, a consumer's feelings about a technology are the most important factor in deciding whether or not they'll end up adopting it.

Two primary elements, including the app's utility and its simplicity of use, influence how people feel about using it. The perceived usefulness or utility of a technology is how much its potential adopters feel it will enhance their ability to carry out their jobs. Users' expectations about how simple it will be to utilize an application are what we call its "perceived ease of use" or "usability." It is predicted that one's impression of a product's usability will influence how they rate its perceived usefulness. The perceived usefulness and the usability of a system are, in turn, causally affected by elements of the system's design.

Thus, it is reasonable to assume that users' preconceived notions and actual actions about system utilization are influenced by the features of the system.

![Fig. 1. TAM Model.](image)

The initial step was to complete the necessary groundwork so that a select group of prospective in-vehicle ITS devices could be identified and evaluated for suitability. First, it was vital to determine what drivers really needed in the event of a collision. This was accomplished via in-depth interviews with traffic specialists who analyzed collision data to identify likely causes of accidents (Ebrahimnejad, 2021; Selmoune et al., 2020).

Further attention was paid to determining the most important barriers that drivers face
when it comes to using ITS systems. The method used to do this was to administer a questionnaire to 150 Iranian and Swedish motorists of varied ages, sexes, and driving histories.

2 Main focus of the study

2.1 Demographic characteristics of the population

Table 1. Gender of respondents surveyed.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>124</td>
<td>61.7</td>
<td>61.7</td>
<td>61.7</td>
</tr>
<tr>
<td>Male</td>
<td>77</td>
<td>37.8</td>
<td>37.8</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>200</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

In this study, there were a total of 201 respondents who were included in the sample. 124 of these respondents were female, which is equal to 61.7% of the complete sample, and 76 of these respondents were male, which is comparable to 37.8% of the sample.

Table 2. Age of respondents surveyed.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-20 year</td>
<td>21</td>
<td>10.4</td>
<td>10.4</td>
<td>10.4</td>
</tr>
<tr>
<td>20-30 year</td>
<td>74</td>
<td>36.8</td>
<td>36.8</td>
<td>47.3</td>
</tr>
<tr>
<td>30-40 year</td>
<td>63</td>
<td>31.3</td>
<td>31.3</td>
<td>78.6</td>
</tr>
<tr>
<td>40-50 year</td>
<td>30</td>
<td>14.9</td>
<td>14.9</td>
<td>93.5</td>
</tr>
<tr>
<td>50-60 year</td>
<td>5</td>
<td>2.5</td>
<td>2.5</td>
<td>96.0</td>
</tr>
<tr>
<td>Over 60</td>
<td>8</td>
<td>4.0</td>
<td>4.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>201</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

The sample addressed in this research consisted of 201 respondents, 21 respondents constituting of 10.4% falls in the age range of 15 years to 20 years old, 74 respondents constituting of 36.8% falls in the age range of 20 years old to 30 years old, and 63 respondents falling in the age range of 30 years to 40 years old constituting 31.3% of the sample addressed.

In addition, 30 respondents constituting 14.9% fall in the age range of 40 years to 50 years old, 5 respondents constituting 2.5% fall in the range of age between 50 and 60 years old, and 8 respondents are of age above 60 years old.

2.2 Regression Analysis

Table 3. Results of modelling.

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R Square</th>
<th>Adjusted R Square</th>
<th>Std. Error of the Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.653a</td>
<td>.426</td>
<td>.411</td>
<td>.990</td>
</tr>
</tbody>
</table>

a. Predictors: (Constant), Perceived Usefulness, Perceived Ease of Use, Perceived Control Behaviour, Self-Efficacy, Enjoyment, ITS Acceptability

Perceived ease of use, perceived usefulness, perceived control behaviour, self-efficacy, and pleasure are all addressed independent variables in the aforementioned model, and their combined R value of 0.653 indicates a 65.3% correlation with Intelligent Transport System Acceptability.
That is to say, the aforementioned independent factors tend to affect purchase intent by 65.3%, whereas the remaining 34.7% are not accounted for in the model. However, the model's R2 value of 42.6% indicates that only 42.6% of the variance in the dependent variable, here purchase intent, is explained by the variation in the independent variables.

### Table 4. Coefficients obtained.

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>.387</td>
<td>.196</td>
<td>1.977</td>
<td>.049</td>
</tr>
<tr>
<td>Perceived Usefulness</td>
<td>.248</td>
<td>.070</td>
<td>.243</td>
<td>3.555</td>
</tr>
<tr>
<td>Perceived Ease of Use</td>
<td>.132</td>
<td>.075</td>
<td>.134</td>
<td>2.763</td>
</tr>
<tr>
<td>Perceived Control Behavior</td>
<td>.079</td>
<td>.080</td>
<td>.276</td>
<td>2.993</td>
</tr>
<tr>
<td>Self-Efficacy</td>
<td>.081</td>
<td>.073</td>
<td>.283</td>
<td>2.117</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>.285</td>
<td>.074</td>
<td>.282</td>
<td>3.861</td>
</tr>
</tbody>
</table>

a. Dependent Variable: ITS Acceptability

The following equation will be formulated:

$$Y = B_0 + BX_1 + BX_2 + BX_3 + BX_4 + BX_5$$

Intelligent Transport Systems Acceptability = 0.387 + 0.248 perceived usefulness + 0.132 perceived ease of use + 0.079 perceived control behavior + 0.081 self-efficacy + 0.285 enjoyment

This implies that:
- For every 1% increase in perceived usefulness, ITS will increase by 24.8%.
- For every 1% increase in perceived ease of use, ITS will increase by 13.2%.
- For every 1% increase in perceived control behavior, ITS will increase 7.9%.
- For every 1% increase in self-efficacy, ITS will increase 8.1%.
- For every 1% increase in enjoyment, ITS will increase 28.5%.

### 3 Results Discussion

Keeping up with the ever-evolving road conditions is what makes driving what it is: a challenging and frustrating activity. The most blatant manifestation of the challenges drivers face may be seen in the form of accidents.

Improving road safety begins with understanding what drivers who need help really want and need. In-depth investigation of accident records may help diagnose this. At now, research is lacking in its ability to provide exhaustive details on the crash situations that may be mitigated by certain ITS technology. Such information would be useful for a number of reasons, including the assessment of ITS equipment's capacity to meet specific driver demands and the provision of a realistic safety analysis that would allow for effect quantification and the subsequent identification of action priorities.

The discovered risk factors point to a significant requirement for drivers to have assistance while navigating the complexities of the driving activity. It was speculated that intoxicated driving, excessive speed, mechanical failure, reckless lane changes, poor sight, and other similar issues were the primary causes of collisions.

The requirement for drivers to feel secure might be seen as a negative indicator of their incapacity to make up for flaws in the driving system that often leads to accidents. Incongruous, from a positive perspective, it shows what might have been done to avoid the occurrence if the relative need had been met. In reality, for ITS systems to be effective, they
need to be created in a way that makes allowances for the actual issues drivers face while driving.

From the results of this study, it seems that the Forward Collision Mitigation system has the greatest degree of acceptance. Because of the potentially huge benefits to safety, developing and distributing this technology should be a top priority for manufacturers. For instance, in the present day, the technological community is dealing with difficulties in the trustworthy identification of generic barriers like automobiles and pedestrians owing to the unstructured environment and the varied look of the individuals.

Surprisingly little attention has been paid to market segmentation at this stage in the evolution of ITS technology, despite the fact that drivers across all demographics—age, gender, nationality, etc.—have distinct requirements and perspectives that must be addressed. This study's findings, however, show that various groups of drivers have varying needs and expectations that must be satisfied before ITS technology may gain widespread acceptance. System designers and implementers have an obligation to recognize these distinctions and account for them in the creation and promotion of ITS products.

Every ITS device, including those specifically aimed towards improving the safety of road users, should get widespread support from those users, as was indicated at the outset of this paper. The higher the danger of creating goods that would never be bought or utilized by the customers, the farther ITS development must proceed without first gaining a knowledge of how potential users are likely to accept alternative technologies. To get the most out of ITS technologies and achieve these advantages, it's crucial to identify any roadblocks that drivers could face while putting them to use.

Proof of the ITS devices' efficacy in reducing road collisions and accident severity should be made available to users. The public at large has to be made aware of this. System designers and automakers should think about including a switch that disables the system when it's not in use. Take, for instance, the obligatory installation of speed limiters. There has to be a way for drivers to disable the system while passing or in an emergency. Users are often not supportive of a system that is prone to failure. It is crucial that the limitations of the technology be recognized and acknowledged in user guides since every technology has its own boundaries beyond which the system cannot work with 100% dependability and may pose a hazard to driver safety.

The proper authorities must also supply the necessary infrastructure for the systems to operate dependably. Examples of systems that need up-to-date digital maps include those that use real-time communication of speed data, such as Intelligent Speed Adaptation.

A gadget with a high false alarm rate is not likely to be adopted by its intended audience. The large number of false alarms in heavy traffic was a major reason why the first generation of forward collision warning systems was rejected by its customers. Therefore, it is incumbent upon system providers to first optimize their systems to reduce the number of false alerts, and then highlight the conditions where such alarms could occur in their documentation for end users.

By providing such details, the system becomes more trustworthy and user-friendly. If consumers see value in a system, they will adopt it without question. Nonetheless, this study's findings suggest that users often underestimate the potential value of ITS devices owing to a fundamental lack of awareness of the accident kinds that may be countered by such systems. In light of this, it is essential to educate customers on which kind of disasters these technologies are most suited to avert.

4 Methodological Concerns

Careful investigation of collision situations, including in-depth interviews with all parties involved and cinematic reconstructions of the occurrences, is necessary to identify drivers'
assistance requirements. The key drivers' demands, which could be determined directly from crucial scenarios that endanger the safety of the road users' community, were brought to the forefront with the help of the important feedback provided by specialists. The benefits of employing expert analysis of accident data to determine requirements are that the demands that are determined from the data are genuine safety needs of divers.

However, if every detail of a car accident is captured, the resulting data dump might be too much to handle. Since ITS functions have never been widely applied in real world transportation, it was unknown to what extent they are capable of averting certain kinds of accidents in the goal of establishing the capabilities of the ITS equipment to meet drivers' demands. Studies of real-world traffic conditions conducted over extended periods of time may provide useful safety signals for reducing accident rates. It may be a stretch to say that the established risk factors from the perspective of specialists may be extrapolated to the drivers as a whole, notwithstanding the high quality of the conducted interview.

This allows us to deduce that drivers in countries with a more advanced driving culture are less likely to encounter scenarios that may lead to severe accidents. As a result, the variables of danger identified by these specialists might be interpreted as the worldwide need for AIDS treatment.

However, one may argue that additional expert assessments allow evaluators to assess risk variables from a variety of angles and levels of detail, as well as to uncover country-specific driving issues. In reality, various specialists may provide varying answers to the question of "why an accident happened." For instance, technicians often look at objective elements like friction, velocity, and other physical variables when determining what causes accidents.

Some people have explained how the actions of drivers and pedestrians play a factor in creating accidents. However, some will provide answers as to why this conduct manifested itself. The investigation of the ability of safety systems to satisfy the demands of drivers in a real-world driving environment, including human parameters and external restrictions, is enhanced by considering all of these elements from diverse research domains.

Very little thought was given to the acceptability of ITS devices beyond one degree of utility. It's a good idea for a number of reasons.

First, as was previously said, the extent to which potential users believe a system to be beneficial is the single most important factor in determining whether or not that system is adopted.

Second, research shows that the importance of factors like perceived ease of use and subjective standards diminishes as one gains expertise with a system.

Thirdly, without direct experience with the equipment in question, it is difficult to accurately elicit and understand users' impressions of certain variables, such as the system's usability and efficacy. Finally, it was beyond the scope of this study to identify all of the conceivable constructs, their interrelation, and their meaningful contribution to the acceptance of ITS systems.

However, many responders may travel outside of metropolitan regions, although this may not constitute a huge proportion of the total. The degree to which drivers' preferences for the types of roads they often travel on may influence their openness to certain ITS technology is unknown. For this reason, it's crucial to conduct a research with a representative sample of drivers living in both urban and rural regions, and to use the drivers' yearly amount of kilometres driven on motorways, rural roads, and urban roads as an independent variable to gauge the drivers' degree of acceptance.

There was certainly diversity in driving style, occupation, socioeconomic class, and level of education among the drivers included in the sample. It's possible that these factors affected the results, but quantifying their impact is outside the scope of this discussion. • All of the systems in this research were presented separately from one another so that participants could
make informed decisions and help researchers better understand their perspectives and priorities. As it is significantly cheaper to add more features to a basic system than stand-alone functions, it is likely that ITS technologies will be provided as integrated packages including numerous optional features.

The methodology used to establish acceptance is a potential flaw in the study. Systems were presented in this study, and participants were tasked with providing objective feedback on each one. Despite the fact that this method of measuring is straightforward to grasp and somewhat straightforward for participants to complete, it has shown significant gaps in predicting overall choice and preference behaviour.

In practice, customers weigh their options and make tradeoffs as they try to choose which system or systems would best meet their needs and budget constraints. Due to the chosen technique of assessment, these costs and benefits were ignored in this study. To restate, price is the most important consideration for consumers when choosing whether or not to buy a product.

Acceptability was determined without taking into account the cost of acquisition for all systems relevant to the study. Researchers have asked "how much they would be prepared to pay" for a certain ITS system in order to better understand customers' expectations regarding the final cost of these goods.

5 Limitations

There is a large variety of ITS options on the market. Additionally, several applications are being developed and implemented to a higher degree. Since it may be difficult and complicated for average drivers to properly evaluate all the systems, this thesis focuses on the ITS applications that experts believe have the most potential to improve traffic safety and efficiency. Moreover, the optimum level of development for apps was given the most weight when gauging consumers' attitude towards recommended alternatives.

6 Conclusion

The main focus of this study has been on how well received ITS products for use inside vehicles is. To the author's knowledge, no research has been conducted to gauge motorists' openness to the many different kinds of ITS infrastructure now under development. It seems that road authorities and the creators of these technologies have established a set of priorities that forms the basis for their growth.

Thus, it is vital to do more study to discover what drivers truly accept in these systems to assure the success and feasibility of technologies of this kind.

References

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