SESSION 2A :

EFFECTS OF ITS ON DRIVERS' BEHAVIOUR AND INTERACTION WITH THE SYSTEMS

DETERMINATION THE BEST LOCATIONS FOR INSTALLING ITS[1] EQUIPMENT TO REDUCE ACCIDENTS

(CASE STUDY: POLEZAL ROADWAY, ANDIMESHK, IRAN)

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ABSTRACT: The use of intelligent transportation systems (ITS) has been very effective in traffic safety. In recent years, using ITS systems has received attention in Iran to increase traffic safety and reduce road accidents. However, finding of optimum and suitable locations for installing ITS equipment is very important and essential. Using the Geographic Information Systems (GIS) and location data analysis are a reasonable method that can be used to determine the ITS equipment locations. In this study, the history of accidents occurred along a specific road between 2006 and 2009 were collected and analyzed. After analyzing the causes of accidents, location and type of accidents, the best places to install the equipment is proposed. Andimeshk-Polezal road with 60 km length which is important Asian Highway in Iran is selected as a case study. Analysis of road accidents in Andimesk-Polezal road shows that human factors constitute nearly 97% of all the factors. With considering the impact of ITS in reducing human factors (by warning and notification of road users) that the use of ITS in the appropriate locations along with the highway police control will dramatically reduce the number of accidents in Andimeshk-Polezal roadway.

1. INTRODUCTION

Geographic Information Systems (GISs) have been presented as a powerful analyzing tool for civil engineers to help their decision-making processes. Integration of GIS and transportation has led to a trend of analysis, decision making and the implementations of projects which can be done faster and with more confidence. Application of GIS in better and more optimized designation of path, place-finding for parking, determination of black spots in road accidents which is an aspect that most engineers use today [3]. GIS which provides visual and text equipment allows users and experts to view the results of before and after the analysis, and to see possible results with

[1] Intelligent Transportation Systems

changes in the input data or analysis parameters.

ITS which is a powerful tool for information, management, and efficient use of road infrastructures used the GIS frequently; and therefore, many ITS services are based on the GIS. Services like Automatic Vehicle Location (AVL) or management of transporting hazardous materials are related to the GIS. Each country can make high alterations in movement process by the integration of ITS and GIS. Another important use of the GIS is determining ITS equipment and various facilities according to the effective parameters that can be used for determining traffic signs and equipment as well as ITS equipment. The location of ITS equipment is one of the issues that are important for transportation professionals. ITS experts usually use two significant methods for determining the ITS equipment. In the first method called (Down-Up Approach) a number of different systems and equipment that are believed to be appropriate to achieve the goal are selected and will be installed in appropriate places. After analyzing the long-term impacts of these systems and with optioned results, the suitable equipment and locations are selected. Another method that is more reliable is Up-Down Approach. This method is based on collecting and analyzing data such as accidents, traffic, pollution and other required data. According to these analyses, the appropriate equipment and best locations are recommended [4]. In the present study, the best equipment and locations of ITS are recommended in Andimeshk-Polezal highway according to the accidents and traffic data analyses in ArcMap GIS software. (Up-Down Approach)

Andimeshk-Polezal highway which is a part of Asian Highway (number 8) acts out as a connection bridge for the Imam Khomeini port to connect it to the north of Iran and central Asian countries through this highway. This 60-Km highway with about 8000 average daily traffic (ADT) is one of the high traffic highways in the Khuzestan province. The growth of traffic in this road is not compatible with the existent infrastructure. This causes a decrease in safety and an increase in the accidents in this highway as the number of accidents from 178 cases in 2006 changed into 245 cases in 2009 which shows a 38 percent annual growth. According to the accidents data analyses, annually 207 accidents or 3.5 accidents per kilometer occur in this highway that is 1.7 times higher than the average of Iran highway accidents. In table (1) the number of accidents is presented based on severity and in table (2) some of safety indicators are compared with Iran highways.

Table 1: the number of accidents in different years based on accidents severity (Police reports)

Year	Crash Accidents	Injury Accidents	Fatal Accidents	Total
2006	148	21	9	178
2007	164	45	10	219
2008	136	49	1	186
2009	205	36	4	245

The primary way to reduce congestion and increase safety seems to be building more roads. Although the construction of more roads increases capacity and reduces congestion, this solution is very expensive and unreasonable. In addition, in most areas, especially in the urban areas besides the high cost of construction, the space constraints limit the development of roads and highways. Thus, it seems to be a better solution to use the existing roads. The newer and safer infrastructure, the deployment of intelligent vehicles, and warning drivers with equipped alarm systems are more reasonable and effective methods to increase safety and reduce severity of road accidents [5].

Table 2: comparison of some indices of safety with the whole country [6], [1]

Safety Index	Andimeshk-Polezal Highway	Iran Road Network
The annual accidents based on 1 kilometer of the route	3.5	2.1
The annual death caused by accidents based on 1 kilometer of the route	0.1	0.7
Total daily accidents	0.6	-
The number of death per 100 accidents	1.7	3.2

2. METHODOLOGY

In this article, determining the practical installing locations of ITS has been used based on the police accidents data. For this reason, police accidents data from 2006 to 2009 were collected and registered in an especial database. Iran's police officers usually record accidents information such as weather condition, types of vehicles and other details about how the accident occurred in especial forms that is called COM113 [6]. After data collection, accidents information was analyzed in SPSS and Arcmap GIS software. Today, various intelligent transportation systems are presented and each country uses these systems depending on its needs and priorities. The ability of these systems to reduce traffic congestion and crashes is different and usually transportation managers use these systems based on the needs, problems and the determined programs. But because of Infrastructures weaknesses for using ITS in Iran and the high cost of using these systems (although the long term benefits of these systems are more than the application costs), it is very important to use these systems to achieve the best results in the shortest time. Hence, according to the critical conditions of traffic safety in the Khuzestan province roads, the ITS equipment in especial locations was considered in this paper to be applied in a short time and with reasonable costs to decrease significantly the number and intensity of accidents [5].

3. AN OPTIMAL LOCATION OF ITS

3.1. Finding Critical Locations Based on the Severity of Accidents

Figure (1) shows 5-kilometer sections of Andimeshk-Polezal highway which are categorized based on all the accidents that occurred from 2006 to 2009. According to this figure, the sections 1, 4, 6, and 9 had the most accidents. Figure (2) shows the results of GIS analyses based on the types of accidents in different sections. According to figure 1 and 2, although the section 1 had the most accidents, most of them are not injury or fatal accidents. Besides, in sections 4, 8, 9, 10 and 11 the severity of accidents was higher than other sections. Therefore, it can be concluded that sections 1 (0-5 kilometers after the police station), 4 (15-20 kilometers after the police station) and the 4 final sections (20 kilometers after the Polezal) are places which have the priorities for safety projects.

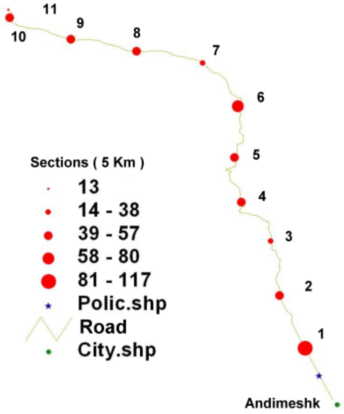


Fig. 1: Presenting sections based on the summation of accidents

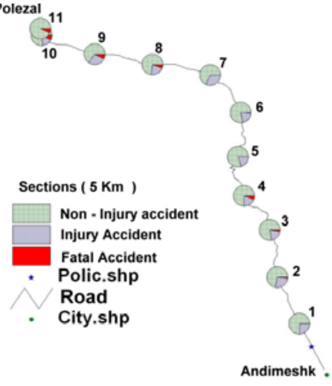


Fig.2: Presenting sections based on the type of accidents

3.2. Finding Critical Sections Based on the Time of Accidents (day/night)

Figure (3), (4), and (5) show brightness status (day or night) in Andimeshk-Polezal accidents. According to this figure, the severity of accidents is high in sections 1, 2, 4, 5, and 6 at night. Therefore, using the Variable Message Sign (VMS) as well as installing lighting systems in order to draw the drivers' attention at night and using speed monitoring is necessary in these sections. Also, section 9 and 10 are in second priority based on the severity of accidents.

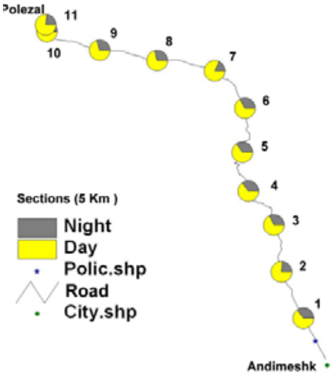


Fig.3: Time of all accidents occurred (day/night)

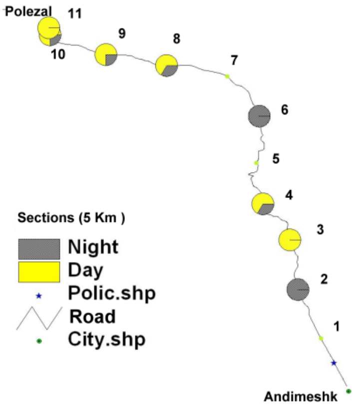


Fig. 4: Time of fatal accidents occurred (day/night)

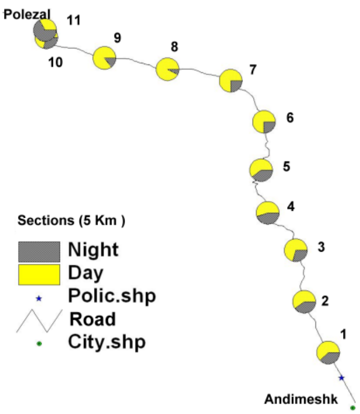


Fig.5: Time of injury accidents occurred (day/night)

3.3. Finding Critical Sections Based on the Collision Type

Figure (6) shows the collision type in different sections. According to this figure, the front-side and front-rear accidents are more important in almost all sections [1]. The main cause of front-side accidents is the various access roads (minor roads), not mentioning the movement priority and unsafe overtaking in this highway, is that drivers must be aware of the access roads and priority. In addition, no attention to front and longitude distance is the cause of front-rear accidents in Andimeshk-Polezal highway.

Figure (6) shows that the most front-side accidents occurred in sections 1, 4, 6 and 10 respectively. Also sections 8, 1, 2 and 6 had the most front-rear accidents. In injuries accidents front-rear and front-side had the most percentage. In addition, the other analyses showed that in sections 1, 7 and 9 most crash accidents (no injuries) were front-rear and in sections 1, 4 and 6 they were front-side accidents. Presentation of accidents analyses in GIS shows that the most front-side accidents in sections 1, 8, 9 and 10 and front-rear accidents in sections1, 5, 6, 7 and 9 were injuries accidents. In fatal accidents, front-front and front-side crashes are the most types of collisions. According to the analyses, the main causes of front-front accidents in this highway are excessive speed and changing the line due to improper overtaking [1]. The most front-front and front-side accidents occur in sections 4, 2, 9 and 10 and sections 3, 6 and 9 respectively. Considering these analyses, it can be concluded that the above sections are in priority for the installation of equipment and specifying ITS like VMS, speed control camera and monitoring systems.

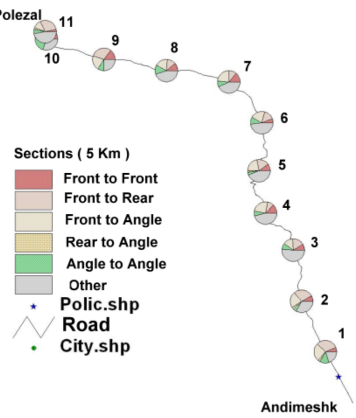
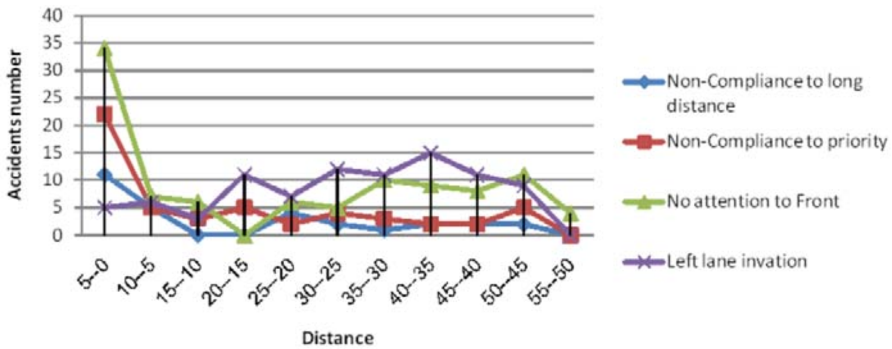


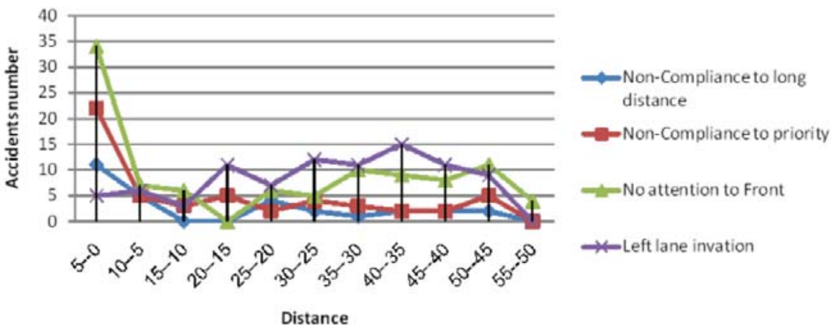
Fig. 6: Collision types in different sections

3.4. Finding Critical Sections Based on the Total Cause of Accidents

The graphs (3) and (4) indicate the most critical conditions in injury, fatality and the total of accidents in Andimeshk-Polezal highway. According to these graphs the first 5 kilometers of this road had the most accidents that are caused by wrong traffic behaviors such as not paying attention to the front and the violation of priority rules. In this section, using speed and surveillance cameras and VMS certainly can reduce these accidents. In addition, according to these graphs it can be clearly seen that most accidents which have been caused by exceeding to the left line occurred in 25 to 45 kilometers of Andimeshk-Polezal, but most injury and fatal accidents occurred in 40 to 45 kilometers of Andimeshk. Using speed and surveillance cameras and precedence warning systems in this section can decline fatal and injury accidents. Also by considering graphs in 35 to 45 kilometers of Andimeshk, no attention to the front was the most critical condition. Thus, using VMS in order to draw the driver's attention can reduce the accidents in these sections.



Graph 1: Main causes of injury and fatal crashes



Graph 2: Main causes of total crashes in Andimeshk-Polezal highway accidents

3.5. Determining the type of fault vehicles in different sections

The chart 1 illustrates the proportion of fault vehicles in Andimeshk-Polezal accidents. According to this chart, heavy trucks including mini trucks, trucks and trailers had the most percentage with 54%. Also, as the figure 7 shows almost in all sections except section 2 and 8 the proportion of trucks and trailers is higher than 50 percent in accidents. In sections 2 and 8, cars (including private vehicles and rent cars) and vans had the highest fault percentage. The chart (2) indicates the highest proportion of fault vehicles in injury and fatal accidents. The significant point in chart (2) is the high proportion of motorcycle and bicycle in injury and fatal accidents. Although in total accidents the proportion of motor and bicycle was 2 percent, in fatal and injury accidents this type of vehicles had a noticeable proportion by 9 percent. Also, according to chart 2 it can be seen that vans and rent cars had a high portion of fatal and injury accidents too. Thus, specific attention to the traffic behaviors of these vehicles (motors, bicycles, vans and rent cars) can reduce accidents for example in VMS messages and other controllers especially in sections that the proportion of these vehicles were high. According to figure (7), sections 2, 5, 7 and 9 are sections in which 2-wheeled vehicles had the most proportion of injury and fatal accidents and in sections 2, 5, 7 and 8 the vans had the most faulty vehicles. Also, in sections 6 and 8 buses had the highest role in accidents. These analyses can be very useful for ITS managers and the determination of goal vehicles in road safety planning.

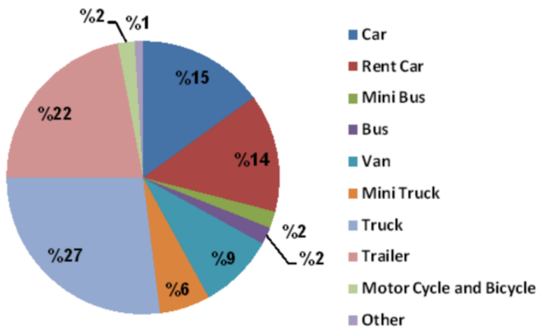


Chart 1: The proportion of fault vehicles in Andimeshk-Polezal highway accidents

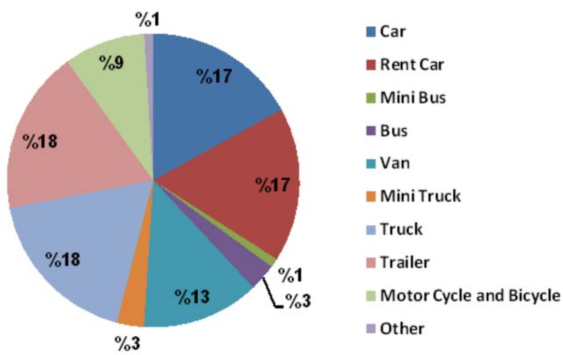


Chart 2: The proportion of fault vehicles in injury and fatal accidents

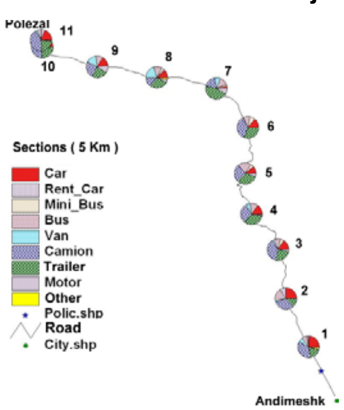
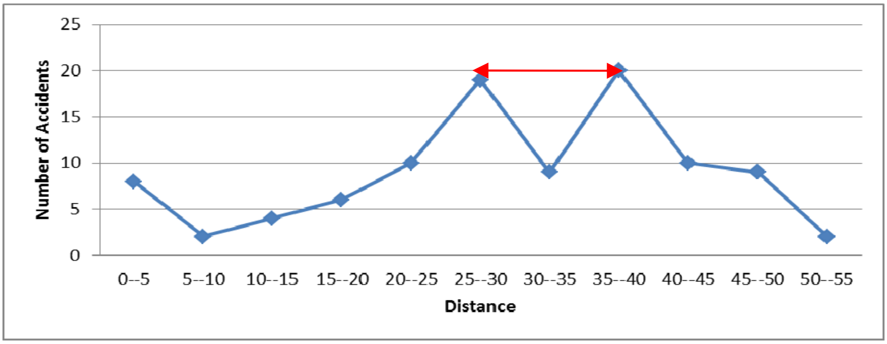


Fig. 7: The proportion of fault vehicles in different sections

3.6. Determining Critical Sections in Rainy Weathers

Khuzestan province is located in a geographic zone that has very low rainy days and most of the days roads are dry. But in rainy days (November to March) especially for the first rains pavements are very slippery and usually in these days the number of accidents has a noticeable growth. According to the studies, 17 percent of total accidents in Andimeshk-Poezal highway occurred in rainy conditions. In addition, the proportion of rainy conditions in injury and fatal accidents were noticeable by 18 and 49 percent respectively [1]. So the rainy day is very important in this road because the number and severity of accidents increased in this condition. Using weather reporting systems with the declaration of slippery pavement warning can provide road users more attention and fewer accidents. In graph (3) the number of accidents which occurred in rainy conditions is shown. According to this graph, the distance from 20 to 25 kilometers had the most accidents in these conditions. So using weather reporting systems can decline the number and severity of accidents in these sections and in the total roads.



Graph 3: Number of accidents which occurred in rainy conditions

4. CONCLUSIONS

According to these studies and characteristics of accidents in Andimeshk-Poleza, it is predicted that using proposed ITS equipment in the selected sections will reduce up to 40 percent of the accidents. Below the results of this study has been shown:

- By using ArcMapGIS, it is possible to recognize different sections based on the effective factors in accidents. Thus, according to this data and knowledge of ITS effects on safety, the best ITS equipment for each section can be selected.
- Analyses indicated that most injury and fatal accidents are because of no attention to the front and priority rules especially in the beginning 5 kilometers of Andimeshk-Polezal highway. So using surveillance cameras, monitoring systems, speed controller systems and VMS can reduce these accidents significantly.
- According to the analyses, front-side and front-rear accidents had the most proportion of damages. The main factor in the front-side accidents is disrespecting to the movement priority in intersections, and in front-rear accidents the reason is disrespecting to the longitudinal distance and exceeding the speed limit. So the use of alarm systems, surveillance cameras, Speed control systems and the observation of long distances alarm systems in the sections that

are specified in the GIS analysis can be effective in reducing accidents.

- There are plenty of dangerous curves which caused rollover and fall accidents which had significant contributions in Andimeshk-Polezal accidents. So making use of alarm systems, speed control systems and weight in motion systems (WIM) to control cargo and transit vehicles like truck and trailer will reduce these types of vehicles accidents. In the next step, the implementation of rollover alarm systems in critical sections can be very helpful to reduce these types of accidents.
- Analyses showed that rainy weather in Andimeshk-Polezal can be hazardous and increase the accidents in some months. Using weather reports systems can increase drivers’ attention and decrease accidents by warning them about rainy conditions and sliding pavements.
- Cargo vehicles like trucks, mini trucks and trailers have the highest ratio of accidents, but the ratio of two-wheeled vehicles in injury and fatal accidents is higher. Hence, attention to using proper systems can reduce these types of vehicles accidents.

Table (3) and (4) shows the summaries of this study and the proper ITS equipment.

Table 3: Summery of accidents conditions in every 5-kilometer section

		0 to 5	5 to 10	10 to 15	15 to 20	20 to 25	25 to 30	30 to 35	35 to 40	40 to 45	45 to 50	50 to 55
Total Accidents		✓			✓		✓			✓		
Accident Intensity					✓				✓	✓	✓	✓
Night Accidents		✓	✓		✓	✓	✓					
Crash Type	Front-Front	✓	✓		✓	✓	✓	✓		✓	✓	
	Front-Side	✓		✓	✓		✓		✓	✓	✓	
	Front-Rear	✓	✓				✓		✓			
Cause of Accidents	No attention to front	✓							✓	✓		

	Non-Compliance of priority	✓										
	Invasion to left lane						✓	✓	✓	✓		
Vision Obstacle	Curve				✓	✓	✓	✓	✓	✓	✓	
	Curve and Sleep					✓	✓					
Critical Vehicles	Car	✓	✓		✓						✓	
	Van		✓			✓		✓	✓			
	Trucks	✓				✓	✓			✓		
	Motor and Bike		✓			✓		✓		✓		
Defect of Vertical Sign		✓	✓				✓			✓		✓
Accident in Rainy weather						✓	✓	✓	✓	✓	✓	

Table 4: Recommended ITS equipment according to the accidents factors

Type of study	Critical condition	Proposed Systems					
		VMS	Precedence Control	Speed Controller	Speed Cameras	WIM	Other
Main cause of accidents	Inability to Vehicle Control Non-Compliance to Priority	✓	✓		✓	✓	✓
Type of crash	Front-Side Front-Rear Front-Front	✓	✓		✓		✓
Human factors	Disregarding the Rules Undue Haste	✓					✓
Road defects	Defect of Vertical Sign Narrow Road	✓	✓		✓		✓
Obstacle vision	Curve	✓	✓	✓	✓		
Weather	Cleary Rainy	✓		✓			
Pedestrian crashes	-	✓		✓			

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E MOBILITY: A NEW URBAN MOBILITY

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ABSTRACT:

In order to reduce CO2 emissions, the electric vehicle (EV) represents today an alternative to traditionally fueled vehicles. But this new eco-friendly mode of transport involves different kinds of constraints to use that are likely to affect mobility. To assess driver acceptability of EVs and to study the impact of electric technology on the mobility behaviours of drivers, the MINI E France project was undertaken by IFSTTAR and carried out under contract for BMW Germany. Twenty-five "private users" from Paris drove for 6 months an electric MINI E. This paper presents the mobility, charging and driving behaviours reported by EV users. In particular, the paper focuses on how users organize themselves to deal with the limited range of the EV, what changes are induced in their mobility and what are their requirements in terms of intelligent transport system functions relevant for e-mobility.

1. INTRODUCTION

International guidelines addressing the climate challenge, issued in 2011, are pushing countries to adopt concrete and effective measures for the rapid reduction of CO2 emissions. In this context, the electric vehicle (EV) represents a new eco-friendly mode of transport that is a practical alternative to traditionally fueled vehicles, and which can play an important role in reducing the environmental impact of transport. However, the arrival of the EV on the market will lead to new use constraints and perhaps to radical changes in the daily mobility of users. Indeed, the EV provides technical specificities that will impact on the individual's driving habits. In particular, the limited range of electric vehicles, the time involved in charging them and the limited number of charge points may force users to develop strategies to conserve battery life. These requirements may also influence the trips that the users choose to perform or not according to the remaining range available at that time in the vehicle. Finally, it is possible that limited range may result in users changing their driving style in order to adopt an efficient driving style for saving energy and for extending vehicle range.

To address these issues an experiment, previously conducted in Germany (1,2), the USA and England - for the vehicle manufacturer Bavarian Motor Works (BMW) - was replicated in Paris, France, with two waves of 25 drivers. These drivers utilized, for six months - from December 2010 to June 2011, and from July to December 2011 - a MINI E electric car. The aim was to study the acceptance of electric vehicles and the new behaviours of users brought about by use of the EV (3). In the present paper, we highlight the changes in mobility, charging and driving behaviours that occurred over time with daily use of EVs, for participants of the first wave. The EV user requirements in terms of intelligent transport system (ITS) functions relevant for e-mobility will be identified and discussed.

2. METHODOLOGY

Twenty-five participants were selected from the hundreds of people who applied online to participate in the study. Their selection was based on certain key criteria: being a resident of the Paris area; having a garage or a dedicated place to park the Mini E; being able to provide payment for leasing the vehicle; and having access to a suitable electrical power supply. The selection was also based on the number of kilometres potential partcipants were driving each day. Ultimately, 7 women and 18 men were selected with a combined average age of 44.5 years (sd=9.02). Twenty-five MINI E prototypes similar in external appearance to the MINI Cooper, but with only two-seats and equipped with a lithium-ion battery, were trialed. The range average of the MINI E is 160 km and the car has regenerative braking that slows the vehicle (while at the same time regenerating energy) from the moment s/he releases the accelerator pedal. To charge the vehicle, each participant had a wallbox of 12 amps installed in his or her home by the French electricity provider EDF. Drivers could also charge their vehicles from Parisian public charging stations. A full charge took about 9 hours to complete.

Data were collected from a set of questionnaires (items measured on a Likert scale of six points), focus groups, and travel and charge diaries, and data were compared across three time intervals: T0, T3 months and finally at T6 months (i.e., six months after the start of the study). The procedure was as follows. At T0, questionnaires were administered to collect data on issues like user expectations of the future use of the electric vehicle. Meanwhile, the travel diary was administered. It related to driver use of their own (private) car during a typical week (4). For 7 days, participants used it to register all their trips, detailing the trip distance, means of transport taken, the purpose of the trip, and so on. After 3 months of using the EV, participants were asked to complete other questionnaires, containing items that were either already presented at T0 or were new. These items concerned the experience and appreciation of participants about the use of the MINI E on a daily basis. Participants were also required to complete again a travel diary, related this time to use of the MINI E. Users were also required to complete a charge diary detailing all charges made during a week. Users reported place of charge, charge status at the beginning and the end of the charging process, and the reasons for the charge. Finally, at 6 months, participants completed again a questionnaire. The majority of items were identical to items from previous questionnaires. Participants were also asked to complete a final travel diary and a final charge diary similar to the previous ones.

3. RESULTS

To focus on the electric mobility and the new behaviours that appeared, we present in this paper the analysis of the final questionnaires, and the final travel and charge diaries. The results were derived from the qualitative treatment of open-ended questions and the quantitative treatment of Likert scales and diaries.

First of all, it should be noted that users who participated in the MINI E study presented a particular profile that was not typical of the French population. They lived in Paris and its suburbs. They possessed a great interest in innovative technology and the environmental benefit of EV, and a high level of income. They constituted a sample of potential EV customers who were drawn into the study by going to the MINI E website. Otherwise, they drove on average for 69.9 km per week (sd=56.67).

Concerning range, the main results showed that range was perceived by users of the MINI E as a major constraint in managing the use of the car. The charge diary indicated that this problem leads them to develop a deliberate strategy for planning their charges. For example, participants charged their vehicle on average 5.2 times per week, mainly at night and at home. Although drivers claimed in questionnaires they charged their vehicle when it did not have enough range to make the next trip, or when the battery was discharged, the diaries show that vehicles were charged when they had on average at least 42% of range remaining. Users seemed to be afraid of running out of battery power and, thus, of the risk of breaking down. Finally, charging the MINI E became a daily routine for 81% of participants after 6 months of driving and 96% of users appreciated being able to charge at home and therefore no longer needing to go to the gas station.

The results showed, however, that the limited range of the MINI E also influenced the trips that users chose to perform or not. Users felt they had not been able to do 21.3% of their daily trips with the MINI E, trips which had usually been done with their conventional car: the analysis of their travels shows that users used their own car instead of the EV for 16.3% of trips, and the average length of the trip with their own car was 39.8 km against 13.2 km with the MINI E. Overall, 81% of users thought the driving range of the MINI E was sufficient for everyday life.

Moreover, a majority (71.4%) of participants mentioned having to get used to the handling of the range by planning their trips according to the distance, and almost half of them did trips that allowed them to use less energy (47.6%). However, although more than one half (52.4%) assumed the MINI E had changed their mobility behavior significantly (by changing their travel patterns), 81% of users considered, at the end of the 6 months, that the range was sufficient for their daily needs; and 52.4% of them considered the MINI E to be more useful than a conventional car in meeting their mobility needs. But the inability of users to make long trips prevented the EV from being perceived as a potential main use car in the household; and, for 90.5% of users, the MINI E could only be considered as a second car (5).

Interestingly, use of the MINI E urged drivers to review their choice of using different modes of transport. Use of the vehicle caused drivers to review and reassess the place of walking, of cycling, of using the conventional car, and of using public transport in meeting their mobility requirements. Overall, the analysis of questionnaires revealed an increase in the number of short trips by MINI E users: for 76.2% of drivers, the electric car was more useful for their daily trips than the traditional car and 42.9% thought they had used their MINI E for trips for which they had not previously used their normal car. More specifically, 76.2% of users agreed with the following questionnaire item: "For short trips, I used more the MINI E than my traditional car ". Analyses of travel diaries confirmed that the number of trips, involving only the car, increased between T0 and T6 months (60% at T0 against 87% at 6 months) – and, in parallel, the average distance of trips reduced (19.9 km at T0 against 16.8 km at T6 months).

Finally, results showed that users changed their driving style in order to adopt an efficient driving style for saving energy. For 57.1% of drivers, their style of driving changed in a more flexible way than with a conventional car, and driving the MINI E reportedly made them safer drivers (76.2%). One can note that the regenerative braking feature of the MINI E (which slows quickly the car and recovers a certain amount of kinetic energy when the user releases the accelerator pedal) also induces change in their driving style: for 85.7% of users, regenerative braking reportedly changed their driving style which, for most, become more energy-efficient.

A final interesting point is that 76.2% of users reported that they would be very motivated in having an in-vehicle indication when driving energy-efficiently (acceleration, braking) or an advisory on how to drive more energy-efficiently (66.7%). These tools could improve planning of the use of the electric car and make mobility more flexible. In the same way, 81% of users reported that they would like access to information about the additional energy consumption of functions that reduce vehicle range, and 71.4% of users wanted access to information about the current amount of energy regenerated in kW. Drivers reported that e-mobility could be improved for almost all of them (95.2%) by ITS functions which allow information on location of the closest public charging station and their availability (for 85.7% of users); ITS could also realise a navigation system able to plan routes according to the remaining driving range of the EV (for 76.2% of users).

4. CONCLUSION

The research presented in this article focused on the charging, mobility, and driving behaviours induced by EV use. The results show that use of the MINI E did not amount to a simple replacement of the conventional car: the electric vehicle introduces a new activity of vehicle management, the charging process. Although we studied only 25 drivers, they used an EV for 6 months for most of their trips. This long period of exposure presumably gave them enough time to understand the characteristics of this new type of vehicle and to adapt to its constraints to best deal with their mobility needs. The charging solution chosen by most drivers was to charge almost every night, at home

(6). This strategy derived from the limited distribution of charge infrastructure and the duration of the current charge, and will probably change when charging infrastructure becomes more widespread and when charging times are faster.

Another consequence of the limited range is that it led drivers to review their choice of transport mode and to increase the number of short trips they did in their daily mobility with the MINI E compared to use of their traditional car. This change arises probably because the drivers wanted to maximize their time with the MINI E and because driving an electric vehicle is relatively environmentally friendly.

Finally, the results suggest that the range of electric mobility is still a significant obstacle to the acquisition of electric vehicles as the main car of use. However, it is tempered by the fact that users report that the EV covers most of their daily mobility needs, and by the fact that they seem to be ready to change their driving behavior and habits of mobility: by adopting a more energy-efficient driving style and by adjusting their routes in order to optimize vehicle range (7,8). Moreover, it is interesting to note that users expect support systems (ie ITS) in order to facilitate these different aims to optimize their e-mobility - like indications concerning location and availability of public charge stations, advisory information about driving energy efficiently, and so on.

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