

# **USER NEEDS IN GREEN ITS: THE RESULTS OF A QUESTIONNAIRE SURVEY ON DUTCH AND JAPANESE DRIVERS**

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## **ABSTRACT**

A web survey has been conducted to study the attitude towards Green ITS among drivers in the Netherlands and Japan. The survey consists of four parts: personal information, driving behavior and ITS experience, attitude towards environment, and Green ITS preferences. The results show that the greatest motivation for drivers to follow fuel efficient behavior is to provide them with information on how much money they would save. To a lesser degree drivers are also interested in information on their fuel consumption during the trips. The least preferred information is about impact on environment, such as CO<sub>2</sub> emission. Correlations are found between information preference and the driving style. The majority of the respondents think that the provided information is relevant and they are willing to use the system. This positive attitude towards Green ITS can lead to acceptance and frequent use of Green ITS. Based on the survey results, a new design for Green ITS is proposed. It provides information on driving behavior, expenses on fuel consumption and environmental factors. During the trip, advice and fuel consumption will be displayed with simple indications on an on-board screen. After the trip other information will be presented with trends, numbers and texts. In the design of such a system also safety, distraction and other psychological influences of the driver are taken into account.

## **INTRODUCTION**

Greenhouse gas emission and energy consumption are making changes to our living environment that are damaging in the long term (1), such as global warming. Road traffic is a major contributor to such changes. Now, more than ever, people are being encouraged to act upon it to create a better environment for the future. Diminishing car use would decrease CO<sub>2</sub> production (2), but this is difficult to achieve in this modern and dynamic world (3). A solution might be to direct our drivers to a fuel efficient driving behavior. High speeds, heavy acceleration and the lack of anticipation in traffic have been identified as the main causes of excessive emission production (4). By improving the driving skills to a more environment friendly style, we can reduce fuel consumption, fuel expenses as well as emission production. Therefore it benefits both the environment and the driver.

Green ITS (Green Intelligent Transport System) monitors drivers' performance in order to achieve a more fuel efficient behavior. By displaying driving history and CO<sub>2</sub> emission, the system informs drivers of their impact on the environment. The concept of Green ITS is rather new and no driver experiences have been reported yet. To promote and improve these systems, the design and functioning should satisfy the desires of the user (5). By measuring the attitude of drivers towards Green ITS, designers will be aware of the needs and preferences of drivers.

This research focuses on user needs in Green ITS. The objective is to improve current designs of Green ITS by considering factors that motivate drivers to change their behavior. From the results of a web survey, this paper will elaborate on the preferred information and attitude towards Green ITS among Dutch and Japanese drivers. Based on these results a new design of Green ITS is proposed. This proposal defines the design of the system in order to motivate Dutch and Japanese drivers to change to environmental friendly driving behavior.

## **BACKGROUND**

Several measures have currently been implemented to reduce greenhouse gas emissions and to achieve sustainable mobility. Traditional measures include construction of extra lanes and tax rating on fuel (6). The car industry has also been active in introducing hybrid cars and information technology systems (7). In the field of reducing GHG emission, researchers have been focusing on new car technology, policy measures, infrastructural changes, modal shift, transport management and driving behavioral changes. In this research we focus on the driving behavioral changes. Changing current driving behavior by adopting new skills is difficult for most drivers.

To help the driver in changing his behavior, several in-car systems in Green ITS are currently in development. These systems have the objective of achieving fuel efficient behavior and they provide the driver with information on his driving behavior. These systems show the driver several indications of his performance by a display during driving. Examples of indications are fuel consumption and speed behavior. More developed systems collect data from previous trips and compare these with optimum fuel efficient behavior. Based on this analysis, personal advice on the driver's behavior can be given. Other systems correct the current driving behavior to a more fuel efficient behavior. The system will intervene when inefficient behavior is practiced. In this way the driver gets directions on how to change his behavior while being encouraged with direct feedback of his progression.

## **QUESTIONNAIRE SURVEY**

In order to propose a design for in-car Green ITS systems, we have to measure drivers' opinion on Green ITS. Therefore a web survey has been deployed. The purpose of this survey is to find out the following aspects:

- Type of preferred information to motivate change into fuel efficient behavior;
- Influence of personal driver's characteristics on the type of preferred information;
- Attitude towards Green ITS.

Most of the currently available in-car technologies are designed from a technical point of view. By analyzing the attitude and preferred information of drivers, the current designs of Green ITS can be improved.

## QUESTIONNAIRE DESIGN

Approaching the drivers directly is the most effective way to unveil drivers' attitude on Green ITS. For this research it is chosen to deploy a questionnaire survey. The survey "Green light for a better environment" consists of questions concerning the following parts:

- General information: personal information of the respondent, including age, vehicle possession, and features of the vehicle;
- Driving behavior & ITS experience: the driving habits of the respondent, such as trip purpose, average mileage, frequency, and the experience of using ITS;
- Attitude towards environment: the self-image of respondents with environmental friendly behavior;
- Green ITS: the preference of the driver on different types of information in Green ITS.

The survey gives the respondent an impression of Green ITS, but does not include the attributes of Green ITS (such as the possibility of different interfaces, sounds and lights), in order to avoid confusion and assumption that respondents have already confirmed to desire these systems. The results of this survey will show the willingness to use the system and the attitude towards Green ITS.

**General information** This first section consists of questions on the personality of the respondent. With this information drivers can be categorized. Only respondents with a driving license participated in the survey. The questions are related to age, occupation, possession of different types of driving licenses, vehicle possession, most often used vehicle and the features of it. Factors such as driving experience and personality can be easily retrieved from this dataset.

**Driving behavior & ITS experience** Questions in this part are related to average mileage, driving frequency, trip purposes, route choice and the familiarity with several ITS technologies. Investigating the respondents' driving behaviors reveals which driver group has the most impact on the environment. This driver group thus needs the most support from Green ITS in order to change their behavior. Also the driver's experience with ITS will be studied. Familiarity with the use of technology in the vehicle has influence on the driver's adaptability towards Green ITS. This is an important factor in the design of Green ITS.

**Attitude towards environment** Drivers are asked to rank several types of information in terms of their likelihood to trigger a behavioral change. Questions related to the attitude towards environment in general and the self-image of the respondent are also asked. By measuring the attitude of respondents towards environment it will become clear which type of driver has a positive attitude and is more willing to change their behavior. This means that the drivers who are not impressed by the environmental issues need other stimulus to change behavior.

**Attitude towards Green ITS** To design a system that satisfies the desires of the driver, the attitude towards Green ITS needs to be measured. Many drivers are not familiar with these systems, because in-car Green ITS is still a novelty. To measure what their attitude is towards such systems, examples are provided to give the respondent an impression of in-car Green ITS. Respondents will be asked which kind of information is relevant to help them in changing their behavior. Also the timing of the information supply is important. The types of information are divided into four parts:

- the supply of general information such as fuel consumption, costs and CO<sub>2</sub> emission;
- the need for advice on driving behavior;

- the interest in an analysis of previous driving behavior;
- display of progress in driving behavior.

## **RESPONDENTS**

Web survey is chosen as survey method. Web surveys have the advantages of easy accessibility through internet, low costs, direct collection of digital data, and convenience in data processing. For this research we target only Dutch and Japanese drivers. Therefore the survey is set up in both Dutch and Japanese language. Limeservice ([www.limeservice.com](http://www.limeservice.com)) is selected as the survey interface owing to its ability to edit both Latin and Japanese characters. The final web survey is hosted on the following webpages:

- Dutch version: <http://wingyan.limeask.com/index.php?sid=56984&lang=nl>
- Japanese version: <http://wingyan.limeask.com/index.php?sid=97472&lang=ja>

The survey was conducted in the period between December 2008 and February 2009. The respondents were informed on the survey by an email which included information on the research and a link to the survey webpage. Respondents in the Netherlands were reached through a personal network. They were also asked to forward the questionnaire among their networks. To reach the Japanese respondents, the survey was spread over companies and universities. This snowball method turns out to be very effective, because of the efficiency in email services and the flexibility of a web survey.

## **RESULTS**

### **DESCRIPTIVE STATISTICS OF THE RESPONDENTS**

In total 100 respondents from the Netherlands filled in the survey. In Japan, there were 98 respondents. Table 1 shows the general characteristics of the respondents. For both countries the majority of the respondents are between 18 and 39 in age, and students in profession. No professional drivers have responded in Japan; the variation in profession is higher in the Netherlands than in Japan. Significant differences between the two countries are observed in car possession, annual average mileage and primary trip purpose. Some Dutch drivers have the luxury of possessing more than one car, while most of the Japanese drivers surveyed have a single car or no car at all. In terms of annual mileage, results of Japanese drivers are much lower compared to Dutch drivers. Using car to commute is far less popular in Japan than in the Netherlands. Japanese drivers often use the car for more private purposes, such as social and recreational activities. These results are visible in Table 1.

### **INFORMATION PRIORITY**

Instead of categorizing types of drivers and examine what kind of information is important to each type, this analysis has been done in reverse. In the survey the respondents are asked to choose the most relevant information to receive in order to change their behavior; they had to rank these types of information to the priority of preference and motivation. These results will be the point of reference in our analysis: this priority information defines the respondent's character and attitude towards environment. By correlating this character to his driving style and experience with ITS, suitable Green ITS based on the preferred information can be designed.

Table 2 shows the frequencies of the four types of information being ranked with the highest priority. For both countries, money related information is the most important to drivers. The second most preferable information is about fuel consumption; this information is more

preferable for Japanese drivers than for Dutch drivers. A remarkable difference is the importance of CO<sub>2</sub> emission between the two countries.

Characteristics		Dutch	Japanese
<i>Age</i>	18-24	48%	40.6%
	25-39	36%	38.5%
	40-64	13%	19.8%
	65 and older	3%	1.0%
<i>Profession</i>	Student	39%	53.1%
	Office worker	28%	30.2%
	Professional driver	5%	0.0%
	Other	28%	16.7%
<i>Car possession</i>	None	32%	44.8%
	1	38%	45.8%
	2-3	28%	9.4%
	More than 3	2%	0.0%
<i>Annual average mileage</i>	0 - 1.000 km	11%	41.7%
	1.000 – 5.000 km	19%	29.2%
	5.000 - 10.000 km	13%	14.6%
	10.000 - 20.000 km	29%	12.5%
	20.000 - 30.000 km	13%	1.0%
	More than 30.000 km	15%	1.0%
<i>Primary trip purpose</i>	Commuting	41%	15.6%
	Work related	13%	3.1%
	Social & Recreational	45%	56.3%
	Shopping	1%	25.0%

**Table 1. Characteristics of respondents**

Priority information	Dutch	Japanese
Fuel consumption	17%	34.4%
Money saving	64%	56.3%
CO <sub>2</sub> emission	11%	2.1%
Contribution to environment	8%	7.3%

**Table 2. Distributions of priority information**

**Personal character** Several key factors have been chosen to find correlation between the preferred information and the character of the driver. To define the personal character of the driver, three key factors have been analyzed: age, profession and car possession. Age and profession tells something about the driver's daily life. Generally, office workers drive or commute more by car than students, which makes them a more important target for Green ITS. The possession of the car reveals that the driver needs a car or wants to drive. These factors were compared with the preference of information.

The result of the survey gives a distribution of priority information based on personal characters for two driver groups. An interesting observation is that Dutch drivers between the age 18 and 24, being students, or without car possession, are much more interested in money related information than other driver groups. The fact that office workers are forced to use the car and usually can declare their expenses to their employer explains the importance of fuel consumption instead of expenses.

***Driving style*** Driving style shows the driving behavior in ordinary life. The annual average mileage and frequency gives information about car use. Drivers with a higher average mileage produce more emission. Trip purpose reveals the familiarity of the routes. Commuting is often via the same route, which means that the driver is familiar with it and drives more smoothly. This causes less emission than when the driver has different routes all the time and has to learn the route's conditions.

The survey results show significant differences in all factors of driving style between the two countries. Dutch drivers have a high average mileage, frequent use of the car and are more likely to commute by car. On the contrary, Japanese users have a low average mileage, use the car occasionally and the main purpose of using the car is for private situations. Although the majority of drivers from both countries prefer money related information, the differences in driving style may still be noticeable in the designs. For example, Dutch drivers should be more concerned about their fuel efficiency, because of their frequent driving behavior.

***Experience with ITS*** To design comprehensible Green ITS it is important to know what kind of ITS systems the driver is familiar with and therefore easy to adapt to. In this survey, respondents are asked about their familiarity with cruise control, navigation systems, adaptive cruise control, lane departure warning and intelligent information systems. The striking difference between the two countries is that the Japanese respondents appear to be significantly less familiar with the current ITS systems than the Dutch respondents. For both countries cruise control and navigation systems are widely used. Therefore a comprehensible new system should have the same level of adaptability as these systems. Possibly, some interface aspects of the current systems can be borrowed to keep the familiarity in the system. Besides, the preference of information is not strongly related to the experience with ITS, as indicated by the similar ratios in the familiarity with different ITS systems.

***Attitude towards environment*** In the survey respondents are asked to reflect their self-image of their attitude towards environment. Environmental friendly behavior concerns actions that people take to improve the environment, such as recycling or low energy use. Most of the respondents hesitate to call themselves very environmental and reflect themselves as having an average environmental friendly personality. Dutch respondents who have environmental information as their priority do think they are more environmental friendly, while on the contrary Japanese respondents who are interested in their contribution to environment refer themselves as not environmentally friendly.

The respondents are also asked to give their impression on their fuel consumption behavior during driving. It is expected that respondents who care about the environment should know that fossil fuels are running out and excessive use affect the environment. Therefore these respondents should drive more fuel efficient. This is not the case for the Japanese respondents who choose environmental contribution as their priority information; they consider their driving behavior not very fuel efficient. Another outstanding result is that fuel efficient drivers still care about their fuel consumption, which might mean that they really want to reduce their fuel consumption to the minimum.

The intention of raising fuel price is to reduce fuel consumption. It is expected that respondents with money or fuel consumption as their priority information are influenced by fuel price. However, this is not the case in our survey results. For each of the four driver types in Japan, the amount of respondents who answered that fuel price has influence, is almost the same as the amount of respondents who state no influence. This means that for Japanese

drivers, the effect of raising fuel price is independent of the driver’s priority information. For the Dutch respondents who prefer money related information, the majority thinks that fuel price has no influence at all on their behavior. A possible explanation could be that these drivers are dependent on their car and cannot reduce their frequency because of commuting.

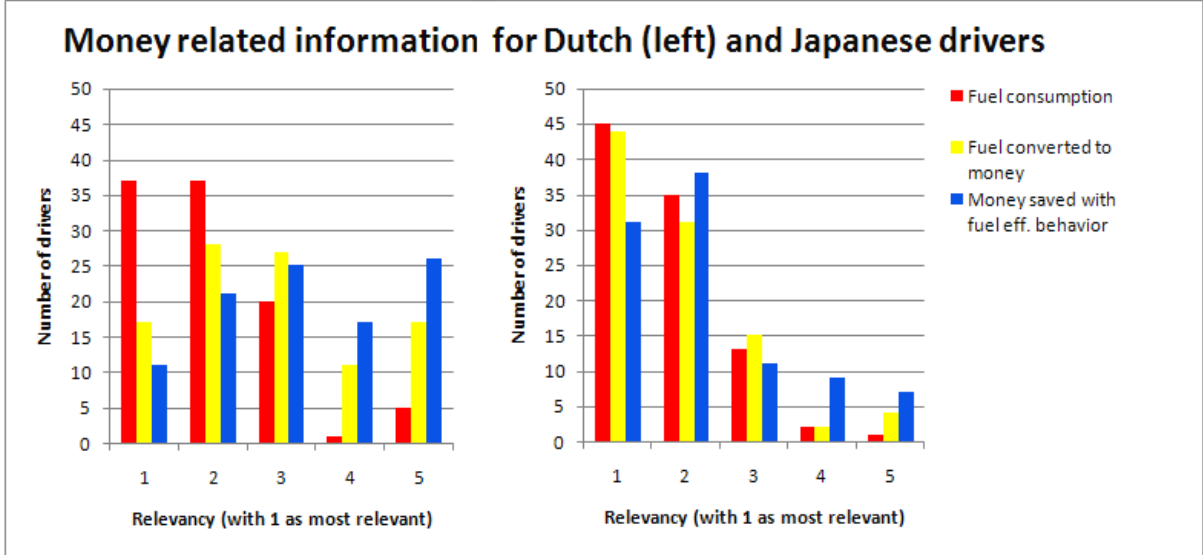
In conclusion, the attitude towards environment is not related to the preferred information in Green ITS. Respondents with care for environment do not find themselves more fuel efficient than drivers with money information as their priority; these money focused drivers are not always influenced by the fuel price.

**RELEVANT INFORMATION FOR CHANGING DRIVING BEHAVIOR**

In the survey respondents are asked to give their opinion on several aspects of Green ITS information supply, such as advice and history of driving behavior. A high relevancy of this information equals a willingness to use Green ITS and a big influence on the change of driving behavior. Therefore, the information which resulted in the highest relevancy will be the most preferable for the drivers to receive. Next to type of information, the respondents are also asked to give their preferred timing of information.

*Monetary impact* The majority of drivers chose money related information as their most important motive to change behavior (Table 2; Figure 1). These drivers also include the most frequent drivers (i.e. those who produce the most emission). To improve environment, Green ITS should be designed to satisfy the desires of this type of driver.

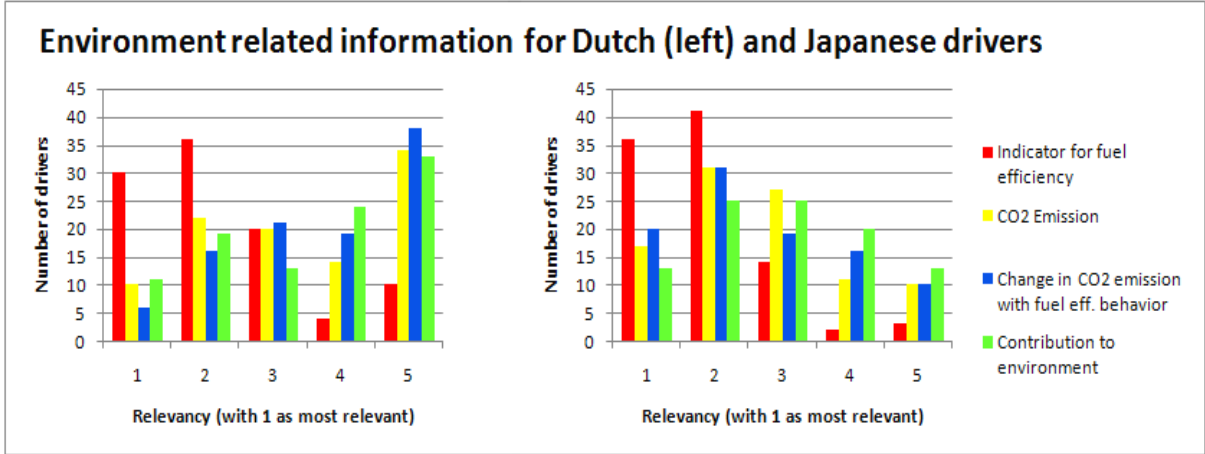
From the results we can see that information directly or indirectly related to money is likely to be received. This type of information concerns fuel consumption, money converted from fuel consumption, and the amount of money saved with fuel efficient behavior. This money related information is significantly more relevant for Japanese drivers, although more Dutch respondents chose money related information as their priority than Japanese respondents.



**Figure 1. Level of relevance for money related information for both Dutch (left) and Japanese (right) drivers (with 1 as most relevant information)**

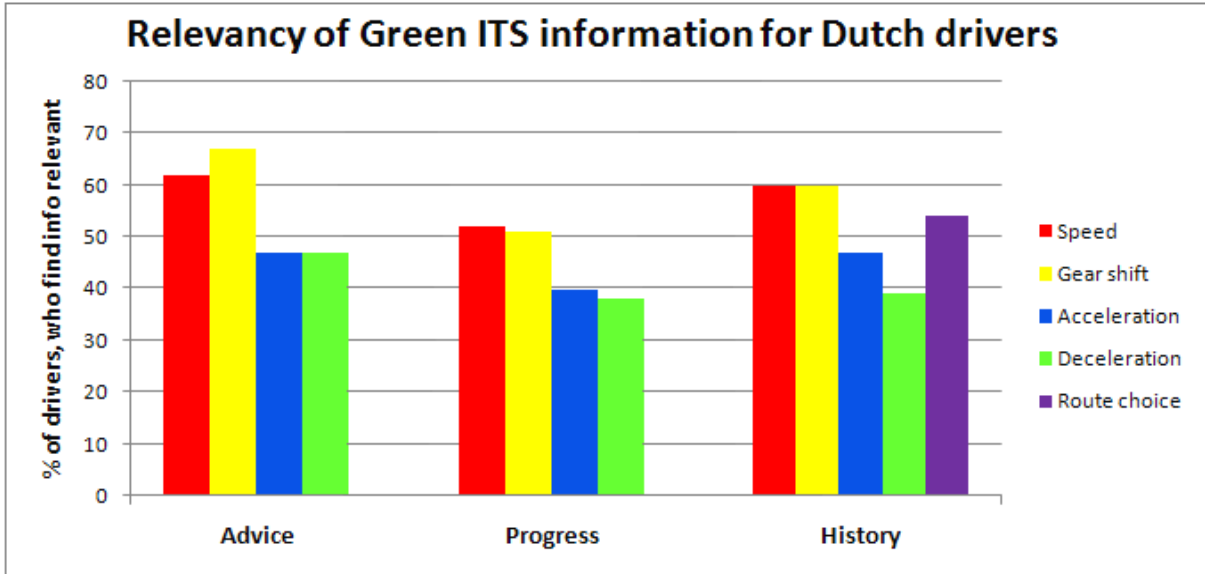
*Environmental impact* As for environment related information the indicator for fuel efficient behavior is very popular (Figure 2). For Dutch drivers environment related information is overall irrelevant, but the results are not negligible to exclude this information from Green

ITS. It is clear that Japanese respondents find environment related information more relevant and are more willing to receive this type of information than the Dutch respondents. A possible cause could be the eagerness to use new technology and to receive all kinds of information.



**Figure 2. Level of Relevancy for environment related information of both Dutch (left) and Japanese (right) drivers**

*Personal driving behavior* For information related to personal driving behavior, the respondents are asked to indicate which type of information they would find relevant for helping change their behavior: advice on, history of or progress in their driving behavior. Dutch drivers find advice on their behavior very relevant to receive (Figure 3-4). Compared to this information, driving history and progress are less relevant. Japanese respondents are steadily keen on receiving new information from Green ITS. Each type of information is equally relevant. A remarkable result is that Japanese respondents find advice the least relevant while Dutch drivers find it the most important type of information. Overall, the relevancy of and interest in information is high, which means a positive attitude towards the use of Green ITS.



**Figure 3. Level of relevance of types of Green ITS information for Dutch drivers. The percentage of drivers, who think such information is relevant, are displayed.**



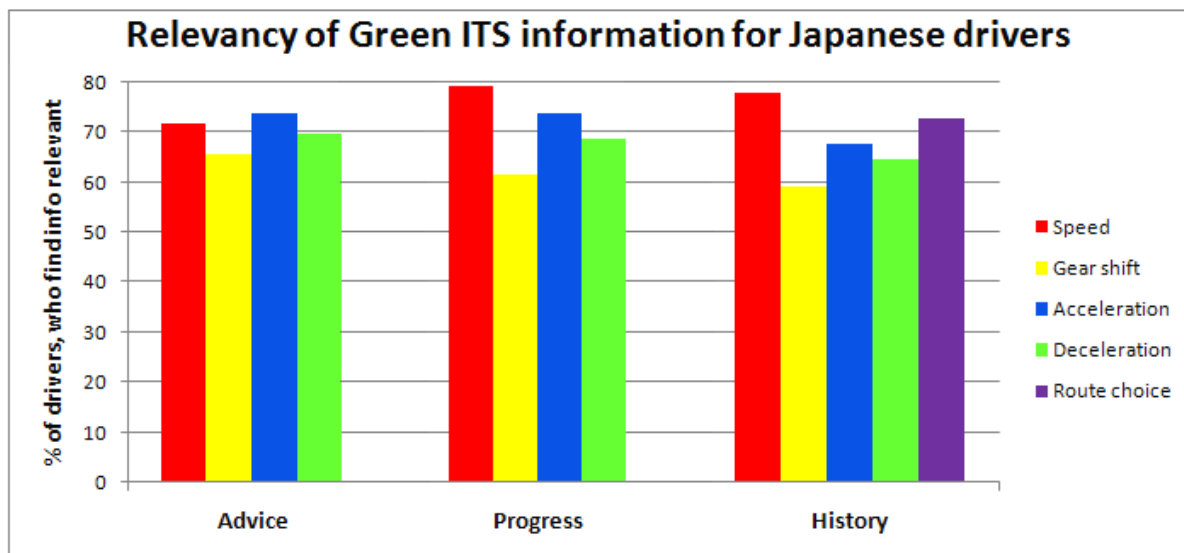


Figure 4. Level of relevance of types of Green ITS information for Japanese drivers. The percentage of drivers, who think such information is relevant, are displayed.

### TIMING OF INFORMATION

In the design of Green ITS the timing of information supply is very important. Wrong timing of information can reduce the impact on driving behavior, e.g. when advice on behavior will only be given after trips. After trips, drivers usually do not care about their behavior anymore and for the next trip they are more likely to have forgotten the advice.

In the survey control-related advices and money-related information are presented to the respondents, asking for their preferences on the timing of these advices. The results conclude that Japanese drivers prefer to receive advice on their behavior during the trips and environment related information after the trip (Figure 5). Dutch drivers have more variety in their choice of timing. Advice, history of speed and gear shift and fuel consumption is preferred to receive during the trip. Progress, information on money value and environmental facts are according to Dutch drivers more of use after the trips.

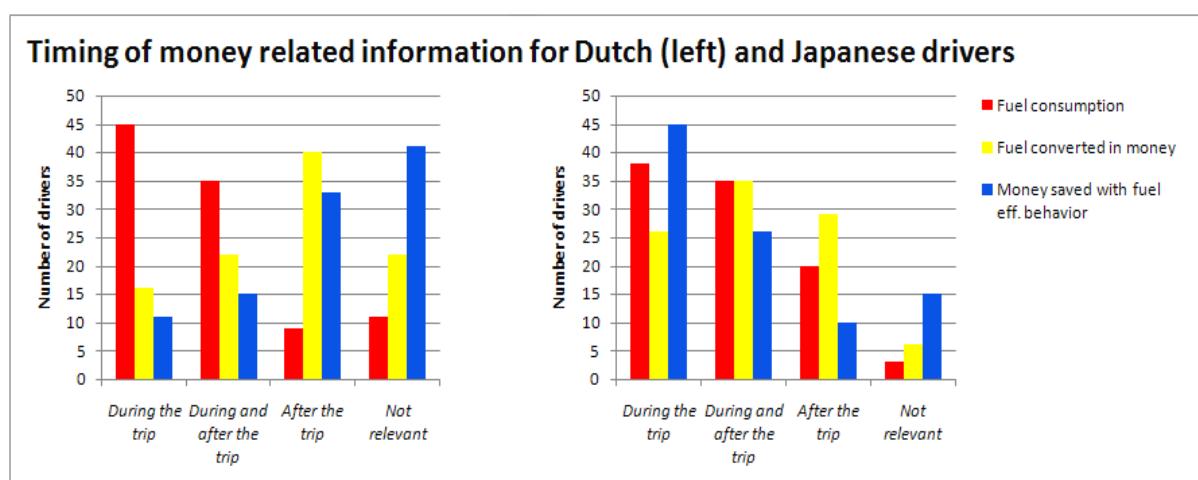


Figure 5. Timing of the preferred money related information of both Dutch (left) and Japanese (right) drivers

## **PROPOSAL FOR GREEN ITS DESIGN**

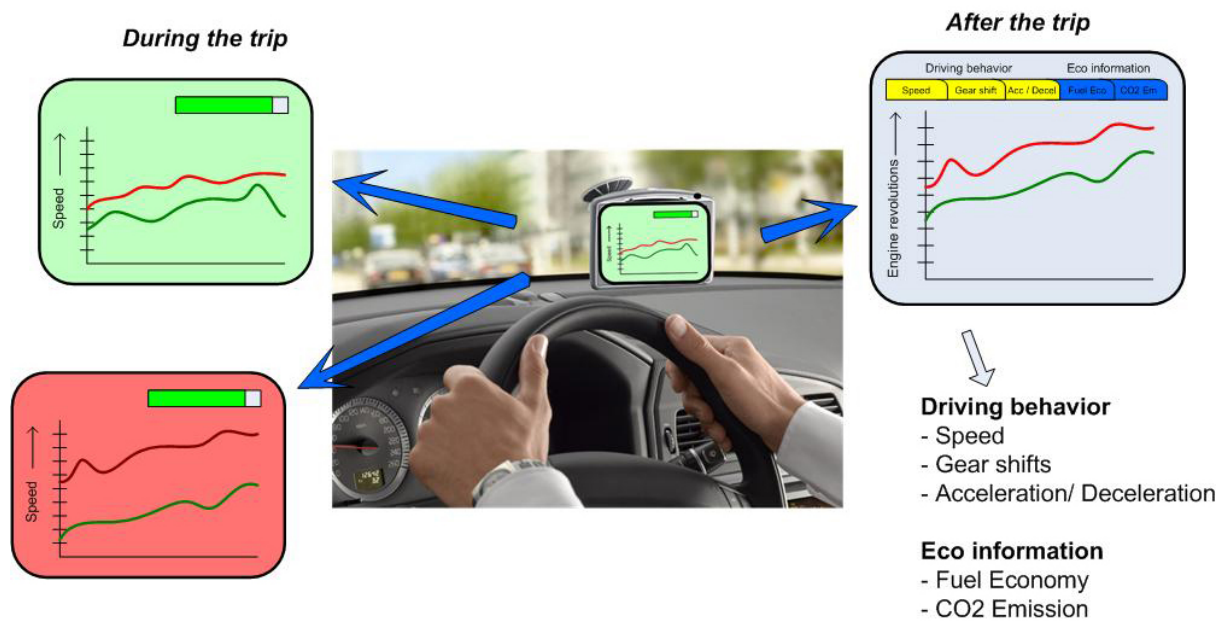
From the results of the web survey, improvements can be made to current Green ITS systems to accommodate drivers' preference better. A possible design of new Green ITS is proposed here.

History, progress and advice on driver's behavior are based on the factors of speed, gear shift, acceleration and deceleration. During the trip, data of these factors will be collected and shown as the driving history. These results will be compared with the optimal fuel efficient behavior, such as optimal speed and optimal gear shift moments. Based on this comparison, advice will be given to achieve a more fuel efficient behavior. Once following the advice, drivers are able to see their progress in fuel efficiency.

Next to information of personal driving behavior, other information will be displayed to encourage fuel efficient behavior. Money related information contains the fuel consumption of trips in liters per kilometer, fuel consumption calculated in the value of money and how much money is saved by progress. Environment related information includes the amount of CO<sub>2</sub> emission during trips and the reduction of CO<sub>2</sub> emission by progress. Drivers will be encouraged to be more fuel efficient by making them conscious of their consumption and production. By giving information about their progress, the system challenges the drivers to reduce consumption and emission production.

The use of Green ITS should not affect the driver's safety. To avoid stress, distraction and confusion during driving, drivers can choose to only display the essential information directly related to their driving behavior. Other information about driving behavior will be displayed before or after the trip. Information that will have direct effects on the driving behavior is advice for fuel efficient behavior. Unlike information about progress and driving history, advice can directly be adapted by the driver. The driver has the choice to display advice for speed, gear shifts, acceleration and deceleration. Extra encouragement to drive fuel efficient is to display the progress compared with previous trip behavior while driving. During the trips, only the factors speed and gear shift of progress will be available for display. As for money related information, only fuel consumption will be displayed during the trip. Because of changing fuel prices, information on the value of money is not accurate at all times and therefore will only be displayed before or after the trip. All environment-related information will be available after the trip.

During the trip the information displayed should be easily understandable without any difficulty or distraction. An on board screen, easily attached to the dashboard, will display information about gear shift, acceleration and deceleration. By inefficient behavior, such as excessive pedal pressure or gear shift at high revolutions, the screen will slowly turn red; the deeper the color, the more inefficient the behavior is. With fuel efficient behavior the display will turn soft green. The bar in the corner will display how much fuel is left. The factors speed, gear shift, acceleration and deceleration will be displayed in trends on screen. Trends will show the optimum behavior with the actual behavior. Graphs, displayed after the trip, will define the differences between actual fuel consumption, actual money spending on fuel and fuel consumption and expenses with fuel efficient behavior. Calculations explain how much excessive fuel has been used and how much money could have been saved with fuel efficient behavior. This concept will also be used with the environment related information. Differences between actual CO<sub>2</sub> emission and emission with optimum behavior will show how much CO<sub>2</sub> emission could have been spared. Figure 6 gives an impression on the proposed Green ITS system.



**Figure 6. Conceptual sketch of the proposed Green ITS system**

## CONCLUSION

By deploying a web survey we studied the attitude towards Green ITS among drivers in the Netherlands and Japan. The greatest motivation for drivers to follow fuel efficient behavior is to provide them with information on how much money they would save. Next to that, drivers are also interested in the fuel consumption during their trips. The least preferred information is about impact on environment, such as CO<sub>2</sub> emission. The cause of this disinterest could be that drivers do not see a direct relation between their car use and its impact on the environment. To make these drivers aware of their impact and motivate them to improve environment instead of saving money, a direct, understandable and imaginable relation should be established between the environmental impact and their behavior. An example could be the comparison between the amount of emission and reduction of trees.

According to the survey, personal character, experience with ITS and attitude towards environment do not have a big influence on the preference of information. However, correlations were found between the preference of information and the driving style. Drivers with frequent car use, high mileage and commuting as their primary trip purpose also have a considerably high interest in other types of information, such as contribution to the environment by using the car. Concluding, the types of information in current in-car systems in Green ITS are positively received by respondents. The majority of the respondents think that the provided information is relevant and they are willing to use the system. This positive attitude towards Green ITS can lead to acceptance and frequent use of Green ITS.

Green ITS is a relatively new concept and deployment experiences have not been reported yet. When the Green ITS system is implemented and promoted, experiences with Green ITS should be gathered. By analyzing these experiences, likes and dislikes of users will be known and room for improvement will become available. These improvements will be based on the type of information supply, the timing of information supply and the display of information. Different types of information or modes of display might have other or stronger effects on the driving behavior.

A proposed system for Green ITS will provide information on driving behavior, expenses on fuel consumption and environmental factors. During the trip, advice and fuel consumption will be displayed with simple indications on an on-board screen. After the trip other information will be presented with trends, numbers and texts. In the design of such a system, safety, distraction and other psychological influences of the driver are of great importance.

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