ATLANTIC

A Thematic Long-term Approach to Networking for the Telematics and ITS Community

A Partnership of ITS Communities in Europe and
North America

SYNOPSIS

And Highlights of

DISCUSSION PAPER

HUMAN MACHINE INTERFACE & USER FRIENDLY ITS

Human Factors and ITS

Prepared by

Work Group 3.2

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In collaboration with Participating Partners and Sponsors

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0. PREFACE

ATLANTIC (A Thematic Long-term Approach to Networking for the Telematics and ITS Community) is an international cooperative undertaking that aims to foster information exchange and policy debate related to the application and development of intelligent transport systems (ITS). ATLANTIC originated as a project sponsored by the European Union under the 5th Research Framework with self-sustaining partners in Canada and the United States. ATLANTIC is organized into 8 work groups focused on different topics related to telematics and ITS. This document is the product of one of the Canadian work groups to benchmark and assess the state of ITS practice and research and development in Canada.

This Synopsis report is a summary of the discussion paper prepared by Work Group 3.2 on the topic of "Human Machine Interface and User Friendly ITS: Human Factors and ITS". It is intended to provide readers with a brief overview of the research results of Work Group 3.2. The Synopsis follows the same structure as the discussion paper so that one can easily find the more complete discussion and treatment of subtopics in the corresponding section of the discussion paper. This is particularly true of lists of references and descriptions of projects.

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1. ACKNOWLEDGEMENTS

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The ATLANTIC Canada network node is sponsored by Transport Canada, Ministry of Transportation Ontario and Ministère des Transports du Québec and jointly managed by the ITS Centre and Testbed, University of Toronto and the Centre de recherché sur les transports, Université de Montréal. The core team providing overall leadership for ATLANTIC Canada includes Professor Baher Abdulhai (Toronto), Professor Teodor Gabriel Crainic (Montréal) and Dr. William Johnson (Ottawa).

The Canadian Work Group 3.2 Human Machine Interface and User Friendly ITS (Human Factors and ITS) is jointly managed by Dr. Jeff Caird, University of Calgary (leader) and Ms. Ling Suen, ICSA Inc. (rapporteur). They provided the intellectual leadership and writing skills to assemble and document this discussion paper with inputs and contributions from a network of Work Group members. The contributions of these Work Group members and contributors are gratefully acknowledged.

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TABLE OF CONTENTS

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2. EXECUTIVE SUMMARY

Background and Purpose of Paper

The potential economic impact of ITS in-vehicle devices may exceed $40 billion (USD) by 2010 (OECD, 2003). Among the economic benefits the OECD and ITS America (ITS America, 2002; OECD, 2003) have identified is the potential of in-vehicle technologies to reduce crashes, injuries and fatalities. However, the rapid proliferation of ITS devices also has the potential to reduce safety, in particular through distraction of the driver. Our predecessors in the European Atlantic WG 3.2 also identified driver distraction from ITS devices as a critical issue that required further investigation.

Identification of Discussion Threads

A number of topics were initially considered and modestly expanded (see Section 3). Specifically, these were:

- Human factor analysis of ITS application to highway-railway grade crossings
- Application of universal design principles in ITS
- Evaluation of in-vehicle telematics for distraction
- Usability and utility of navigation systems
- Feasibility of haptic and auditory systems for collision warnings
- Complacency and intelligent cruise control (ICC)
- Interaction and prioritization of multiple telematics interfaces
- Standards and guidelines for infrastructure and in-vehicle information display

Survey Overview and Results

Rather than composing a paper on one of these topics, we sought the input of human factors experts in North America and Europe on a set of evaluation problems that do not appear to be resolvable within the next 3 to 5 years.

The questionnaire that we developed focused on how to evaluate in-vehicle ITS or telematics based on safety and system performance. The methods and measures used to determine safety and system performance have not necessarily achieved consensus in North America, Europe or Japan and represent a fundamental barrier to the development of viable systems. The purpose of sampling the state of the practice was to determine if consensus had been reached.

Discussion and Conclusions

The questions of which variables to measure and how to set limits is really one of the key questions in automotive human factors.

The aggregated responses by our sample of experts appear to be a reasonable approximation of best practices and the state of knowledge. The responses were structured so as to convey the problem solving of the respondents. Each scenario and compiled responses in Section 4 are interesting to reflect upon. The references provided in support of particular responses, and those of the discussion threads, could be an important resource to those required to perform an evaluation of similar products for similar reasons.

Future Directions

In addition to the discussion threads and questionnaire results introduced thus far, a number of additional research and development topics require concerted efforts. These include:

1) The human factors implications of cooperative in-vehicle/in-vehicle and in-vehicle/infrastructure systems.

2) Evaluation of in-vehicle products over the course of a number of design cycles with different evaluation steps has not been fully developed.

3) The focus of the expert questionnaire was on the empirical evaluation of systems. However, the validity and reliability of cost-effective means such as modeling and usability needs to be established.

4) Extrapolation of driver performance with a device to increases or decreases in crashes, injuries and fatalities needs to be empirically established. Projections of ITS safety benefits are based on a number of implicit assumptions. These estimates tend to be highly speculative (cf., OECD, 2003).

5) A workshop or roundtable consisting of invited experts should be held to discuss state of the art human factors research results on ITS and to arrive at priorities in the research agenda proposed in the preceding bullets. In addition, it could be the forum to explore the infrastructure issues of ITS, which has not been addressed in this paper.

3.0 WORK GROUP OVERVIEW WITHIN THE SCOPE OF ATLANTIC

3,1 WORK GROUP TITLE

Work Group 3.2: Human Machine Interface & User Friendly ITS *(Human Factors and ITS)*

The name of this work group reflects the European perspective. A preferred terminology for Canada is "human factors." The sub-title in parentheses is more likely to be recognized and understood in North America.

From a human factor's perspective, the following questions should be posed regarding any proposed ITS device:

1. Can a driver see it and understand it?
2. Can a driver make it do what they want?
3. Is interaction with it safe and useful?
4. What are the consequences if it is not safe?
5. What can be done to fix it if it is safe or not?

WG 3.2 is one of the 8 work groups within the Canadian ATLANTIC network.

The 8 work group themes are as follows:

- Integrated Transport (3 Working Groups):
  - Telematics-based Traffic and Travel Information Services
  - Network Monitoring and Traffic Management and Control
  - Intermodal Collective Transport Information
- Technologies and Services (3 Working Groups):
  - Intermodal Freight Info, Pre-clearance & Logistics (logistic chains)
  - Intelligent Vehicles and Intelligent Vehicle Highway Systems
  - Electronic Road User Charging & Integration with Payment Systems
- Assessment and Evaluation of ITS (2 Working Groups):
  - ITS User Acceptance & Impact Assessment
  - Human Machine Interface/User Friendly ITS

3.2 SCOPE

The focus of the WG 3.2 is on the "driver". The scope can be described as follows:

- Human Machine Interface (HMI) measuring techniques and criteria
- Behavioural & safety impacts of driver support
- Application of universal design to ITS
- Product development and evaluation

- Implicit and strategic driver adaptation of technology
- HMI standards and guidelines
- Driver workload and distraction
- Shaping of driver behaviour by assistance systems

As can be seen, the scope is rather extensive. The challenge is to prioritize our effort in this area within the resources and time constraints. Among these, driver distraction of ITS devices is a major issue. Another issue is the user's response to ITS information, within the context of driver-vehicle and driver-infrastructure interface.

3.3 WORK GROUP COMPOSITION

WG 3.2 consists of a leader, a rapporteur and a team of invited experts recruited from both the public and private sectors. The leader of WG 3.2 is an academician from the University of Calgary, supported by a rapporteur drawn from the private sector consultancy.

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Experts were identified and invited to participate from the following four groups: universities or institutes, public agencies or governments, private firms or corporations, and private consultants or practitioners, and consumers or travelers including those with disabilities. A brief description of definition, role and expected benefits by stakeholder category are listed below:

i. Research agents (i.e. universities or research institutes)

Universities are conduits of research and development, frequently on behalf of governments and corporations. Resources within universities are often focused on the mission of producing the new ideas, inventions, innovations and human capital of tomorrow. The research and development of Intelligent Transportation Systems was and continues to be initiated by governments in concert with universities. A total of 15 experts were solicited.

ii. Public agencies (i.e. government departments or carriers)

Governments have the role of fostering research and development and developing new economies. Government also has an interest in regulation on behalf of citizens to maintain a safe transportation system. A total of 4 experts were solicited.

iii. Private firms (i.e. service and product providers)

Private consultants/ practitioners act as catalyst to bridge the gap between basic research in universities and industry through applied research.

Results derived from human factors research in ITS could be applied to the interface between humans and transport systems through the efforts of this group. This could facilitate the introduction of novel ITS devices to enhance the safety, convenience and comfort of users. Private sector efforts could speed up the process of technology transfer and information. A total of 8 experts were invited to participate.

iv. Consumers and travelers, including seniors and persons with disabilities

The traveling public, whether by private automobile or public transport, constitute the market for the ITS devices. In order for any ITS product to be commercially viable, their requirements need to be taken into consideration from design to implementation. Only one expert was recruited from this group due to the difficulty of the questionnaire.

The role of the consumer was defined as:

- be willing to participate/share knowledge
- be a qualified and informed user, who is willing to appreciate other points of view and be willing to compromise except on safety issues,
- be committed to objective of the operation/mandate

The benefits of their participation in ATLANTIC is to ensure the usability of the ITS devices by all user groups.

3.4 WORK GROUP OBJECTIVES

The Work Group is the focal point for the preparation of discussion papers and the collaboration among experts. Through discussion and interaction will identify, validate and prioritize a list of specific topics for the theme area that are:

(a) Relevant to Canada,

(b) Present an opportunity for international benchmarking,

(c) Offer an opportunity to increase the knowledge base for decision making by ITS professionals in government and industry, and

(d) Lead to follow-up proposals for cooperative R&D submissions to funding agencies.

Based on the inputs of Canadian experts on the highest priority issues, the present discussion paper has been developed by WG 3.2. More ambitious activities that cannot be undertaken because of budget or time constraints would be noted as issues for future study. Discussion results from the Work Group will be incorporated into the summary report of ITS research and development in Canada.

4. WG 3.2 SUBTOPICS AND THEMES SUMMARY

4.1 Conduct Literature Search

WG 3.2 Leader and Rapporteur have organized and managed the research work to develop the background material, collect data and conduct analyses with the assistance of students and others for this discussion paper. Papers relevant to the WG 3.2 discussion threads have been extracted from the literature as in ***Section 7.*** This will be placed on the Canadian ATLANTIC site as part of this discussion paper. These references could be used as stimulants for further discussion, may suggest fruitful new areas or may be a useful resource.

In Europe, the ATLANTIC WG 3.2 has completed one paper on standards based on four expert responses. Obtaining responses from experts on the second topic of driver distraction was more difficult. Results of their discussion paper have been integrated in the appropriate discussion threads below.

4.2 Identify Main Discussion Threads

From literature research and discussion with experts, WG 3.2 Leader and Rapporteur have developed a list of discussion paper topics and to select the highest priority topic for the project discussion, as follows:

4.2.1 Human factor analysis of ITS application to highway-railway grade crossings

The development, testing and evaluation of highway-railway grade crossing ITS is ongoing in Canada, Europe, U.S. and Asia. The effectiveness of various ITS systems to reduce violations, injuries, crashes and fatalities has not been determined. From the literature, not much has happened in this domain except 1 or 2 reports from the Volpe Center since the University of Calgary produced a study report on this domain (Caird, et al., 2002), for Direction 2006, a limited number of developments have occurred (see, e.g., Carroll, et al., 2001).

4.2.2 Application of universal design principles in ITS

Universal design is a set of principles that have the potential to benefit all users of transportation (see, e.g., Vanderheiden, 1997). Currently, the design of ITS has not paid special attention to the needs of elderly and drivers with disabilities. Application of well-designed assistive technologies within transportation has the potential to benefit people with functional limitations and everyday users. Determining how newer technologies such as adaptive cruise control can benefit the widest range of people is central to the universal design of ITS.

It does appear that the UD (universal design) movement is catching on in Europe and Japan, but is still a novel concept in the ITS domain in North America.

4.2.3 *Evaluation of in-vehicle telematics for distraction*

The European WG 3.2 launched the second discussion topic on "Measures of driver distraction – how much is too much?" April 2002. However, the discussion forum was closed in June 2002 due to a lack of response.

Numerous driver distraction measurement methods have been developed. Visual demand and occlusion are two such measures (see University of Michigan 2001, available on-line). In addition, Peripheral Detection Task (PDT) has recently received much attention (see Stevens, 2003). Others include the measurement of mental workload, reaction times and vehicle parameters. Presently the ISO standards group (TC22 SC13 WG8) is developing an occlusion measure for distraction. It aims to develop standardizing methods for dynamic measurement of in-vehicle distraction so that different research groups can collect comparable data for benchmarking purposes. The criteria for selecting subjects take part in the measurements or research studies require standardization. The definition of the reference group (i.e. the "normal" driver) in terms of age driving experience, familiarity with technology etc. needs better description, so are the target groups under study.

In Canada, it was found that driver distraction is a significant contributing factor in collisions. Transport Canada has launched consultation with the auto industry to find ways to reduce the potentially dangerous distractions of telematics devices (Transport Canada, 2003).

Recent surveys cite distraction by cellular phones as elevating the risk of collision by up to 4 times (Goodman et al., 1997; 1999). Currently there are no federal laws directly regulating the use of telematics, but Transport Canada is contemplating enactment of regulations calling for the disabling of certain services and devices while a car is moving. Provincially, only Newfoundland has banned the use of cell phones while driving. Ontario and Alberta have also considered bans. Prince Edward Island has amended its Highway Traffic Act to ban cell phone use but has yet to enact the regulations to enforce it. About 35 countries have banned cell-phone use while driving. In New York State and Japan, crashes dropped by half within a year of such new laws. (The Gazette, Montreal, Tuesday June 17, 2003 Page A15).

The potential for driver distraction is not unique to cellular telephones. The frequency with which new technologies will be introduced into the vehicle is accelerating. Samples of these new applications include: navigation, night vision, collision warning, and intelligent cruise control systems. A similar set of issues surround the proliferation of ITS in-vehicle technologies as those associated with cellular phones. In addition, new issues such as which ITS application of many requires attention first are also emerging.

4.2.4 Usability and utility of navigation systems

Navigation or route guidance systems provide drivers with directions to desired destinations. After the driver inputs a destination, the system guides the driver with voiced and/or displayed turn-by-turn instructions. Navigation systems have the potential to optimize routes, ease trip planning, avoid congestion, and solve or avoid getting lost. Route optimization can be requested and alternative routes can be suggested if congestion or traffic accidents impede a path. Manufacturers as options in higher priced vehicle models offer many different navigation systems (Kline et al, 2002). Not all systems are designed so that all users are accommodated.

4.2.5 Feasibility of haptic and auditory systems for collision warnings

A promising alternative to visual and auditory warning modalities for collision warnings is the use of haptic or kinesthetic warning displays. Haptic warning devices can be constructed in the form of seat shakers, accelerator or brake pulsing (or push back) methods, and torque enhanced steering wheels. Each of these techniques offers both advantages and disadvantages in warning a driver of a potential critical situation. The University of Calgary's team has completed a literature review for the Transportation Development Centre in Montreal on these topics as an interim report (Caird, et al., in preparation).

4.2.6 Complacency and intelligent cruise control (ICC)

The purpose of intelligent cruise control (ICC) is to increase driver comfort by adapting conventional cruise control, through sensor feedback loops and/or algorithmic tailoring to forward vehicle's changes in velocity. The driver is allowed to relax somewhat because they do not have to continuously adjust headway. At a predetermined limit, the system will disengage, change gears, and/or apply limited braking for the driver. ICC systems do not necessarily provide a warning after the headway closure has reached the limit nor is evasive action taken by the system (Francher, et al., 1998). Drivers who assume that an ICC system will solve particular circumstances may be complacent or have a misunderstanding of the functionality of a system.

4.2.7 Interaction and prioritization of multiple telematics interfaces

The interaction with multiple in-vehicle interfaces produced by different manufacturers presents a difficult design challenge. How should information from multiple interfaces be presented to the driver such that the most important information is given first? This is a difficult problem to tackle (Horrey & Wickens, 2002). There is little current work to show because of the complexity of experimental designs.

4.2.8 Standards and guidelines for infrastructure and in-vehicle information display

Human factors guidelines and standards are essential to the design and manufacture of both infrastructure and in-vehicle technologies. While this discussion paper concentrates on discussing in-vehicle technologies, equal attention should be paid to ITS infrastructures, such as issues pertaining to the hardware design, message content, installation and placement of variable message signs. Numerous European and North American organizations are very active in creating human factors guidelines and standards that will guide the creation of in-vehicle telematics (see, e.g., AAM, 2002; EC, 2001; SAE, 2001). Human factors guidelines typically specify ways that designs should consider the user. Guidelines serve a number of functions including a means to summarize human engineering data, to make general recommendations about design, and to specify design principles. Standards, in contrast to guidelines, are much harder design constraints, that is, manufacturers tend to follow them closely. SAE and ISO are extremely active on a number of standards.

Not all manufacturers of ITS devices adhere to design guidelines (Green, 1999; in press; Kline, et al., 2002; Transport Canada, 2003). One common error is to fail to consider the capabilities of all drivers who might be using an in-vehicle technology—especially those who are disabled or who have age-related declines in capability (Caird, 2003; Kline et al., 2002; Nicolle & Peters, 1999; Vanderheiden, 1997). The form that guidelines appear is essential to their effective use (Cambell, et al., 1998; Noy, 1997; Parkes, 1997).

For example, SAE has developed a "15 second rule" which states that if a task can not be undertaken within 15 seconds statically (i.e. without driving) then it should not be attempted while driving (Green, 1999). However, because this approach is lacking consensus, the SAE has not accepted it as a standard but as a "Recommended Practice".

The European ATLANTIC WG 3.2 launched the first discussion topic on “The Future of the EU Statement of Principles on 27 November 2001. Of the 17 experts enlisted, a total of four people contributed to the discussion. Their conclusions are:

- Practically speaking, there are likely to be different approaches in Europe, the US and Japan towards Codes and Guidelines. Good liaison between the experts involved in future developments could promote synergy.

- Every organisation involved in producing driver information systems needs to be aware of their legal responsibilities. Following good practice (and consulting appropriate experts) is highly recommended.

- There is substantial scope for making the current “Statement of Principles” and its expansion more specific. Research and development and consensus building will be important and development is probably required before further general legislation could be considered. [ATLANTIC, 2004. Available online]

5. EXPERT QUESTIONNAIRE

The purpose of conducting the present survey was to capture the current status of how to establish whether an in-vehicle ITS device is safe or not, which is critical to the development of viable ITS systems (ITS America, 2002; Transport Canada, 2003). A number of qualitative methods were considered to obtain expert input (see, e.g., Kantowitz et al., 1997).

The questionnaire that we developed focused on how to evaluate in-vehicle ITS or telematics based on safety and system performance. The methods and measures used to determine safety and system performance have not achieved consensus in North America, Europe or Japan and represent a fundamental barrier to the development of viable systems. The purpose of sampling the state of the practice was to determine if consensus had been reached.

5.1 Methods and Results

Each question or item is presented as an evaluation scenario. That is, how would the expert go about determining whether a system was safe or usable given a particular research focus. The most difficult part of the questionnaire was to assign numbers, criteria or a safe/unsafe cut-off. This data is not necessarily available or universally accepted.

The questionnaire (see Appendix 7.2) was distributed by email to 28 experts in Europe, US and Canada on September 22, 2003 and several days later. Responses were requested by October 7th, 2003. A number of respondents indicated that they were unable to complete the questionnaire in the time available and others said that they thought that the questionnaire was important (11, 39.3%); although apparently not enough to respond after several reminders. A total of 8 or 28.8 percent of experts completed the questionnaire.

Of those who completed the questionnaire, not all items were addressed by each expert. Expertise varied across respondents as did time available to complete the survey. Most experts recognized the importance of the questions being asked in the questionnaire, but the completeness of responses trailed off with latter items.

Not all answers that were given by participants were in accord with the experimental scenarios presented. Often their responses were prefaced by the statement that they did not know much about the topic. Answers were not included in the lists of responses created for each item.

A compilation of responses by item is presented followed by a discussion of the pattern of qualitative information across questions. So as to not identify individuals, responses were aggregated and identifying phrases were removed. Minor editing is applied throughout to improve clarity.

5.2 Aggregated Item Responses

1) To determine the visual demands associated with driving and interacting with an in-vehicle ITS device.

What variables would you measure to determine performance with a system and safety using it?

Driving Task:
- Lane keeping (e.g., RMS error in tracking, lane departures, SD lane position)
- Perception response times (PRTs) to critical or safety-related road events (e.g., pedestrians, vehicles, brake lights)
- Braking force
- Headway/tailway
- Velocity/speed control (deviation around a target velocity)
- NASA-TLX ratings of subjective workload
- Situation awareness measures
- Expert observations of driving quality

ITS Task:
- Total task time
- Task accuracy

Eye Movements:
- Glance frequency
- Average glance duration (i.e., fixation duration)
- Distribution of glance durations
- Eyes off road time per interaction goal
- Total glance time
- Meaningful changes in looking patterns (e.g., shed mirror checking)

Important Independent Variables:

- For driver: age, gender, fatigue, colour blindness, visual acuity, reaction time, day and night time, driving experience (e.g., rural, urban, suburban), mental models of devices

- For technology display: location in vehicle, text, symbols, size font type, task demand, amount of information, change rate, message repetition, colour, contrast, experience with device

What mean and/or range of the dependant variable(s) do you consider to be safe and usable/ unsafe or not usable? [Note these two questions were combined into one list.]

General Responses:

"For ITS, some suggest that the total interaction time (while in a stationary vehicle) should not exceed 15 seconds (Green, 1999). McGehee (2001) recommends a 2-10-30 second guideline (single glance time, total glance time, total interaction time; respectively). I agree that these guidelines are important for regulating the interaction with ITS devices, however these alone are not sufficient. There needs to be some connection to performance on the driving task, such that lane departures or slowed response times to road events are not overlooked (regardless of ITS task time). This, however, is a non-trivial problem and such research merits more attention.

Any ITS that results in excessive lane deviations or slowing in response to hazards should be ruled unsafe. Of course, quantification of these variables will depend on the particular road situation or context. Again, more research or perhaps some meta-analytic approaches to synthesize existing findings."

Specific Responses:

Safe

Fixation Duration: < 1.5 s
Fixation Frequency: dependant on task, target relevancy
Accuracy of Performance: Dependant on task (device)
Lane Variance: Dependant on lane size (vehicle size), no incursions into opposing lane.
Speed Variance: <10 km/h (increase or decrease)
Eyes off road time: < 1.5 s
Headway/tailway time: 2 s or greater depending on speed.

Unsafe

Fixation Duration: >1.5 s
Fixation Frequency: > 10 s in total
Accuracy of Performance: not able to perform task accurately
Lane Variance: Incursions into opposing lane
Speed Variance: >10km /h (increase or decrease)
Eyes off road time: > 1.5s
Headway/tailway time: less than 2s depending on speed

"There is no clear decision on this at this point. You might be able to make the argument that off road glances exceeding 2s are undesirable based on previous research."

"Unknown to me at this time, may be available in the literature, but highly context dependent."

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers. If so, what?

ISO (2002*). International Standard 15007-1: Road vehicles—Measurement of driver visual behaviour with respect to transport information and control systems—Part 1: Definitions and parameters*. Author.

ISO (2002). *International Standard 15007-1: Road vehicles—Measurement of driver visual behaviour with respect to transport information and control systems—Part 2: Equipment and procedures*. Author.

Green, P. (1999a). The 15-second rule for driver information systems. *Proceedings of the Intelligent Transportation Society of America Conference*.

Green, P. (1999b). *Visual and task demands of driver information systems* (Rep. No. UMTRI 98-16). Ann Arbour, MI: UMTRI.

Green, P. (2002). Where do drivers look while driving (and for how long)? In R.E. Dewar and P.L. Olson (Eds.), *Human Factors in Traffic Safety* (pp. 43–76). Tucson: AZ: Lawyers and Judges Publishing.

McGehee, D.V. (2001). New design guidelines aim to reduce driver distraction. *Human Factors and Ergonomics Society Bulletin, 44*(10), 1-3.

SAE (2000). *SAE J 2396: Definitions and experimental measures related to the specification of driver visual behavior using video based techniques*. Author. [www.sae.org]

Stevens, A. (2003). *Occlusion as a technique for measuring in-vehicle information system (IVIS) visual distraction: A research literature review* (Unpublished Rep.). Crawthorne, U.K.: Transportation Research Laboratory.

2) To examine the <u>cognitive distraction</u> potential of a system.

What variables would you measure to determine performance with a system and safety using it?

<u>Driving Task</u>:

- Lane Keeping (e.g., RMS error in tracking, lane departures, SD lane position)
- Perception response times (PRTs) to critical or safety-related road Events (e.g., pedestrians, vehicles, brake lights)
- Braking Force
- Headway/Tailway
- Velocity/Speed Control (deviation around a target velocity)
- NASA-TLX Ratings of Subjective Workload
- Situation Awareness Measures
- Expert observations of driving quality

<u>ITS Task</u>:

- Total task time
- Task accuracy

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

<u>General Comments</u>:

"I don't know what safe means and usability is extremely context dependent."

"As for the <u>visual demands</u> question, quantification of these variables is elusive and will vary across road conditions. As before, I suggest that performance on *actual* driving tasks should be emphasized in any such quantification (not performance on the ITS task)."

<u>Specific Comments</u>:

<u>Safe</u>

Perception response time: Within 0.3 s of baseline with device use
Accuracy of performance: Dependant on task (device)
Lane positioning: Dependant on lane size (vehicle size) – no incursions into opposing lane
Speed variances: <10km/h (increase or decrease)
Headway/Tailway time: 2s or greater depending on speed

NASA TLX: Low subjective workload rating

Unsafe

Perception response time: increase of 0.3 s over baseline hazard detection performance.
Lane positioning: Incursions into opposing lane
Speed variances: >10km/h (increase or decrease)
Headway/tailway time: Less than 2s depending on speed
NASA-TLX: High subjective workload rating

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

HASTE (Human Machine Interface And the Safety of Traffic in Europe) (2003). *Development of Experimental Protocol*. HASTE. [A review of dependent variables associated with in-vehicle ITS evaluation.]
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3) To determine the effects of fatigue on driving performance and strategic use of in-vehicle ITS device.

What variables would you measure to determine performance with a system and safety using it?

General Comments:

"[Evaluation of fatigue] should incorporate similar measures of performance noted in previous questions, although with an emphasis on the variability in performance across time (on both driving and ITS tasks)."

"The strategic use of ITS devices represents an interesting question—one that, to my knowledge, has not received much attention in the literature."

Dependent Measures:

- Perception response time
- Accuracy of performance
- Fixation frequency
- Eyes off road time
- Environmental complexity
- Error rate
- Speed variance
- Lane positioning
- Perclos
- Subjective ratings of fatigue

Independent Variables:

- Hours of operation
- Day/night driving
- Work schedule
- Weather conditions
- Drug use
- Eating habits
- Age, gender
- Driving experience/exposure

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

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4) To examine the <u>comprehension, reliance and potential confusion</u> between existing road signs and in-vehicle signing information.

What variables would you measure to determine performance with a system and safety using it?

<u>Dependent Variables</u>:

- Time to recognize or read ITS information
- Accuracy on ITS task information
- Driver compliance to ITS information and/or sign information
- Comprehensibility of the sign or ITS information
- Legibility of the sign or ITS information
- Spatial frequency characteristics of sign or ITS information
- Response latency to the information from the device
- Error rates
- Speed variation while reading and using information
- Day/night performance
-
- Fixation frequency
- Average fixation duration
- Areas of interest
-
- Subjective ratings; confidence, trust, confusion

<u>Independent Variables</u>:

- Day/night, colours, location, contrast

<u>General Comments</u>:

"From my naïve perspective, understanding the level of trust in the ITS system is important. Also, how is trust built and how many insults can a driver take before not trusting a system. This would be particularly important during the adoption/learning phase and would likely be affected by recovery strategies provided by the ITS device."

What mean and/or range of the dependant variable(s) do you consider to be safe and usable/ unsafe or not usable?

It follows that reduced time to recognize ITS information will be safer for drivers, especially to the extent that the timing follows previously mentioned guidelines (e.g., 2-10-30 rule, McGehee, 2001).

Safe:

Ability to understand the sign: Quick and accurate comprehension of the sign/ symbol.
Legibility of the sign: ability to see the sign quickly and accurately.
Spatial frequencies of sign: Lower spatial frequencies are less likely to blur and are thus easier to see.
Perceptual response time to the information from the device
Error rates: low errors
Speed Variation: <10km/h (increase or decrease)
Fixation duration: <1.5s
Fixation Frequency:

Unsafe:

Ability to understand the sign: difficulty comprehending the sign/ symbol.
Legibility of the sign: inability to see the sign.
Spatial frequency of sign: Higher spatial frequencies are more likely to blur and more difficult to see.
Perceptual response time to the information from the device:
Error rates: high errors
Speed Variation: >10km/h (increase or decrease)
Fixation duration: >1.5s
Fixation Frequency: > 10 s

"Usually these are relative; there is no golden number."

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

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Green, P. (1993). Design and evaluation of symbols for automobile controls and displays. In B Peacock and W. Karwowski (Eds.), *Automotive Ergonomics* (pp. 237–268). Washington, D.C.: Taylor & Francis.

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5) To identify the impact of <u>new and novel uses</u> of a device by younger drivers.

What variables would you measure to determine performance with a system and safety using it?

<u>General Comments</u>:

This sort of examination may best lend itself to focus groups, at least in establishing what sorts of uses drivers' employ. Once these alternative uses are established, they can be explored more rigorously in an experimental setting.

<u>Dependent Variables</u>:

- Time on ITS task (to assess efficiency of new uses, relative to old ones)
- Comprehension of task functions
- Eyes off road time
- Speed variances
- Lane positioning
- Perceptual Reaction Time
- NASA-TLX
- Headway/tailway time
- Useful field of view
- Error rates

- Observations & reports of usage patterns
- Focus groups
- Surveys
- Naturalistic driving studies
- Accident rates

Independent Variables:

- Age
- Level of education
- Driving experience
- Visual and auditory capabilities

What mean and/or range of the dependant variable(s) do you consider to be safe and usable/ unsafe or not usable?

"As with most questions, it is important to ensure that new and novel uses of ITS devices do not interfere with the primary driving tasks. (As for quantification of these parameters: it depends.)"

6) To determine the cognitive and physical impacts of a system on older driver safety and mobility.

What variables would you measure to determine performance with a system and safety using it?

Dependent Variables:

Duplication of variables cited in questions 1 and 2 is mentioned.

Safety

- UFOV [useful field of view] of drivers
- User preferences (various scales and metrics)
- NASA-TLX – focus on subscales for mental and physical effort
- Accuracy of performance
- Ability to interact with a system
- PRT to critical events with system
- Eyes off road time
- Lane positioning
- Speed variance
- Error rates
- Working memory load

Mobility

- # of trips
- Use patterns
- Satisfaction
- Quality of life

- Preferences
- Amount driven (# of miles/km)

Independent Variables:

- Age, type of disability (sensory, cognitive, agility), gender, use of prescription drugs, driving experience, reaction time, need to use manual controls

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

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Oxley, P.R. (1996). Elderly drivers and safety when using IT systems. *IATSS Research, 20*(1), 102-110.

7) To increase driver underload or decrease driver overload while using a system.

What variables would you measure to determine performance with a system and safety using it?

Dependent Variables:

- NASA-TLX ratings of subjective workload
- Driver performance ratings by trained observers

- Standard performance variables
- PRT
- Performance Accuracy
- Speed Variance

- For underload: could measure increased choice to perform secondary task performance

- For overload: see distraction (see answers on cognitive & visual distraction 1-2)

Independent Variables:

- Environmental Complexity: Low to high amounts of ambient traffic, scenery and or roadway geometry.

- Task difficulty: Moderate difficulty level- able to complete but still requiring some attention

Suggested Solutions:

- To increase underload: use of visual and audio controls and displays, use of manual controls

- To decrease overload: use of visual and audio controls and systems (e.g. phone, radio, CD player, navigation system), use of manual controls

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

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Stanton & Moray (200x) – on malleable attentional resources for low workload situations

8) To determine the <u>loss of reliability</u> of a system on driver performance.

What variables would you measure to determine performance with a system and safety using it?

<u>Dependent Variables</u>:

- Operator trust in automated system (pre- and post-failure)
- Performance on all noted variables when automation fails
- Frequency/willingness to use a system
- Time or number of trials till trust / confidence is regained following failure
- Time or binary detection required to recognize failure
- Sensitivity to different losses of reliability, e.g., complete failure and misinformation
- Desire for alternate redundant systems to overcome failures

<u>Independent Variables</u>:

- Error rates/incorrect information rates

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

<u>System trust</u>:

- Error rates: high error rates
- Incorrect information rates: high amounts of incorrect information
- Unreliable systems are unacceptable

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

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9) To determine potential <u>physical or cognitive conflicts</u> between new ITS controls and existing conventional in-vehicle controls (e.g., HVAC, radio, etc.).

What variables would you measure to determine performance with a system and safety using it?

<u>General Methods/Approaches</u>:

- Usability testing

<u>Dependent Variables</u>:

- Error rates interacting with the device
- Performance accuracy with and without device
- Confusion errors
- Task completion times
- Errors of omission
- Mental workload ratings (e.g., frustration)

<u>Independent Variables</u>:

- Location of controls and visual devices
- Types of visual output
- Level of integration with 'other' controls
- Soft vs. hard buttons
- Portability of device (built-in versus in-dash)

<u>General Comments</u>:

"The multiple resource model (Wickens) would predict increased task interference for task combinations that both use manual outputs (e.g., making two responses with a single hand)."

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

Rossen, M.B., & Carroll, J.M. (2002). *Usability engineering*. San Diego: Academic Press.

Wickens, C.D. & Holland, J.G. (2000). *Engineering psychology and human performance* (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

Wierwille, W. W. (1993). Visual and manual demands of in-car controls and displays. In B. Peacock and W. Karwowski (Eds.), *Automotive ergonomics* (pp. 299–320). Washington, DC: Taylor and Francis.

10) To determine the tradeoffs among <u>visual, auditory and/or haptic modalities</u> of ITS presentation.

What variables would you measure to determine performance with a system and safety using it?

<u>Dependent Variables</u>:

- Measures described in sections on visual & cognitive distraction
- For warning systems, focus on PRT to hazard events with different system modalities (or combinations)
- PRT to hazards with and without system
- Accuracy of primary and secondary tasks
- Various performance measures under the different modes
- Eyes off road time

- Hands off steering wheel time
- Number of steering corrections
- Speed variance
- Lane position variance
- Tailway/headway times

- NASA TLX
- Attitudes
- Preferences

<u>Independent Variables</u>:

- Device sound levels: heard over background noise

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

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[3] D. Crundall, G. Underwood, and P. Chapman, "Attending to the Peripheral World While Driving," *Applied Cognitive Psychology*, vol. 16, pp. 459–475, 2002.

[4] G. Burnett, "Usable Vehicle Navigation Systems: Are We There Yet?," presented at Vehicle Electronic Systems 2000 - European Conference and Exhibition, 2000.
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11) To determine the degree to which an ITS application is accessible and useful to range of users with functional limitations.

General Comments:

"In the realm of the federal understanding when speaking of persons with disabilities, "physical" includes sensory; however, in some provinces and territories, each disability classification may need to be spelled out completely so that assumptions are not made."

General Methods/Approaches

- Usability testing

Dependent Variables:

- Degree of functional limitations (e.g. physical, mental, sensory and cognitive)

- Time required for training to use system
- Time to access system
- No. of errors in using the system
- Frequency of use
- No. of complaints/compliments received
- Time required to respond to problems/enquires
- No. of accidents in the use of system
- Primary and secondary task performance
- Other measures as in items 1&2
- PRT

Independent Variables:

- No. of fail-safe and compensatory features (e.g. audio, visual, tactile, haptic etc.)

General Guidelines:

- It must be simple, easy and quick to review by the operator and/or others
- It should have redundancy factors built into the operation to enhance safety
- It must be simple to maintain with check lists, if and as necessary
- It should be inspected frequently and certified to meet standard industry codes, as applicable
- Proper signage

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

Nielson, J. (1993). *Usability engineering*. New York: Academic Press.

Nielson, J. (1994). Heuristic evaluation. In J. Nielson and R. L. Mack (Eds.), *Usability inspection methods*. New York: Academic Press.

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12) To determine, from a set of functions or the overall product, whether or not a product will be accepted by users.

What variables would you measure to determine performance with a system and safety using it?

General Methods/Approaches:

- Focus groups
- Usability testing

Observations & Dependent Variables:

- Acceptance
- Willingness to purchase
- What they would pay
- Marketing versus reality

- Time required for training to use system

- Time to access system
- No. of errors in using the system
- Frequency of use
- No. of complaints/compliments received
- No. of accidents in the use of system
- Cost of system.

- Reliability
- Back-up capability
- Costs, maintenance, updating, longevity
- Obsolesce rate
- Satisfaction
- Enjoyment
- Fit to task
- Ease of use

5.3 GENERAL COMMENTS:

"The questions of which variables to measure and how to set limits is really one of the key questions in automotive human factors. For me, as a practical person what variables really depends on the budget and timescale. So, I could distinguish 3 levels of assessment:

A) using an expert human factors checklist to highlight any "obvious" design problems;

B) using some simple tools such as occlusion gogogles or eye-mark camera or video camera to derive eyes off the road time and glance frequencies and glance times;

C) full spectrum simulator or field study measuring longitudinal and lateral control."

"We are decidedly short in the absolute measures of safety department! The 15-second rule is one simplification. We have also used alcohol to benchmark the "impairment" caused by mobile phones or in-vehicle information systems. However, validity could be spurious."

"For many of the questions, there is no consensus on best practices or procedures; hence the huge amount of work currently underway by groups such as AAM, CAMP, ADAM, HASTE, SAE and many governments and universities. In the areas of ITS & Driver Safety/Distraction Groups such as IHRA. For example, seven priority projects were identified at a workshop in Washington, DC (1999):

- Harmonized Safety Evaluation Methodology Framework
- Driver Understanding And Expectation of ITS Systems
- Human Factors Principles Checklist for In-Vehicle Systems
- Normative Data on Naturalistic Driving Behaviour
- Simulator Reference Test Scenarios
- Improved Secondary Task Measures of Driver Workload
- Harmonization and Validation of Surrogate Safety Measures "

"Depending on the type of product or equipment and the potential damage possible, there may be the need for medical qualifications/testing to be in place before commencing an operation. This would include drug/alcohol testing, fatigue, stress levels, personality portfolio and frequent performance evaluations. Of course, if the product is not considered dangerous, the need for testing and evaluations can be lightened accordingly."

6. DISCUSSION AND CONCLUSIONS

At first glance, the aggregated responses by our sample of experts appear to be a reasonable approximation of best practices and the state of knowledge. The responses were structured so as to convey the problem solving of the respondents. Responses speak for themselves. The references provided in support of particular responses also form an important resource.

The results from the questionnaires, however, may be misleading in the sense that few have the resources to collect all the variables that are listed in each question. Given the sample of convenience, the frequency of responses did not predicate descriptive statistics. Therefore, duplicate responses were combined into categories. Variable lists, across experimental scenarios, tend to be inclusive. If a researcher with limited resources is looking for a prioritized list of variables from which to choose, the lists that were compiled do not support this important need. Considerably more input, such as during the creation of a standard, is needed before a ranked list can be tabulated.

If the capacity to specify desirable variables is an indicator of the number of variables used in researchers own studies, the means to compare multiple dependent variables is also needed. Respondents were not asked to interpret results from multiple dependent variables. (Multivariate experimental design and statistical knowledge is required.) Thus, the meaning of convergent or divergent results relative to safeness is an important extension of the present preliminary investigation.

Specification of which dependent variables to use appeared to be a function of the experts familiarity with certain methods and measures. Familiarity with a particular evaluation approach and the availability of testing resources (e.g., driving simulation, instrumented vehicles) logically constrains which variables were included. One potential advantage of the questionnaire results is to expand the repertoire of methods and measures researchers may consider in the future.

6.1 Limitations

Although a more representative sample of experts was desirable, the unavailability and limited number of experts constrained the generality of this study. Obviously, the overall response to the questionnaire was not ideal and reflects the length of the survey and the degree to which our experts were burdened by ongoing work.

In general, experts from industry were less likely to respond. Perhaps, these individuals are accustomed to the unilateral flow of knowledge from universities to ITS-related corporations. Time is money is another possible explanation.

6.2 Conclusions

The questionnaire targeted the current state of knowledge necessary to determine if in-vehicle ITS devices were safe or unsafe. With few exceptions, the body of knowledge necessary to unequivocally recommend specific quantitative cut-off values does not, as yet, exist. Numerous government, corporate and university research programs are focused on the development of a corpus of empirical research on which to make decisions of in-vehicle design, development and marketing.

The breadth of expertise to determine the relative safety of in-vehicle telematics does not necessarily reside in Canada. Reliance upon knowledge derived from the research activities in the E.U., U.S., and Japan will be necessary. Given the difficulty of the evaluation problems presented herein, no single country, region or corporation can necessarily afford to be ignorant of research activities going on elsewhere (cf., OECD, 2003). Canada is no exception.

6.3 Future Directions

In addition to the discussion threads and questionnaire results introduced thus far, a number of additional research and development topics require concerted efforts. These include:

1) The human factors implications of cooperative in-vehicle/in-vehicle and in-vehicle/infrastructure systems.

2) Evaluation of in-vehicle products over the course of a number of design cycles with different evaluation steps has not been fully developed.

3) The focus of the expert questionnaire was on the empirical evaluation of systems. However, the validity and reliability of cost-effective means such as modeling and usability needs to be established.

4) Extrapolation of driver performance with a device to increases or decreases in crashes, injuries and fatalities needs to be empirically established. Projections of ITS safety benefits are based on a number of implicit assumptions. These estimates tend to be highly speculative (cf., OECD, 2003).

5) A workshop or roundtable consisting of invited experts should be held to discuss state of the art human factors research results on ITS and to arrive at priorities in the research agenda proposed in the preceding bullets. In addition, it could be the forum to explore the infrastructure issues of ITS, which has not been addressed in this paper.

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DOT/FRA/ORD-01/01) Cambridge, MA: Volpe National Transportation Systems Center.

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APPENDIX A   SURVEY QUESTIONNAIRE OF WG 3.2

A Thematic **L**ong-term **A**pproach to **N**etworking
for the **T**elematics and **I**TS
Community (**ATLANTIC):** The Canadian Network

To Invited ITS Experts
Date: September 22, 2003
Dear Colleague,

Invitation to Join the Canadian ATLANTIC Network as an "Expert" Member

ATLANTIC is an international network of professionals, researchers and decision-makers from Europe, the USA and Canada working together to solve key problems in Intelligent Transportation Systems (ITS) in a coordinated and structured way, and to communicate results to stakeholders. Initial support for the ATLANTIC thematic network came primarily from the European Commission (EC) with additional funding from the Federal Highways Administration (FHWA) in the USA, and Transport Canada.
(www.atlan-tic.net)

In April 2003, sponsored by Transport Canada, the provincial Ministries of Transportation for Quebec and Ontario, the Canadian ATLANTIC Network Project was officially launched as a partnership of ITS stakeholders in Canada under the joint lead role of the University of Toronto and the Université de Montréal. ATLANTIC is open to participants from all universities in Canada with an interest in the issues and problems associated with the application of Intelligent Transportation Systems (ITS) and the research and development opportunities that flow from them. It is also open to participants from the public and private sectors with similar interests.
(www.civ.utoronto.ca/sect/traeng/its/atlantic.htm)

We have identified you as an expert in the area of ITS and are inviting you to become an expert member of the Canadian ATLANTIC network and, specifically, as a member of Work Group 3.2, Human Machine Interface and User Friendly ITS (i.e., Human Factors and ITS). Experts are the key members of the Canadian ATLANTIC network as they bring the knowledge and expertise needed to successfully research and develop the ITS discussion topics. The Canadian ATLANTIC network project is comprised of eight working groups, as follows:

WG 1.1 Telematics-based Traffic and Travel Information Services
WG 1.2 Network Monitoring, Traffic Management and Control
WG 1.3 Intermodal Collective Transport Information
WG 2.1 Intermodal Freight Information, Pre-clearance and Logistics
WG 2.2 Intelligent Vehicles and Intelligent Vehicle - Highway Systems
WG 2.3 Electronic Road User Charging and Integration

WG 3.1 ITS User Acceptance and Impact Assessment
WG 3.2 Human Machine Interface / User friendly ITS

We are specifically inviting you to participate in Work Group 3.2 and you will find an outline paper for this Work Group in an attached Word file for your information and consideration. Work Group 3.2 will be devoting its efforts to the Human Machine Interface (HMI) for ITS systems with emphasis on the HMI measuring techniques and criteria, behavioural & safety impacts of driver support, and universal design for ITS. The end product will be a discussion paper reporting on this topic.

However, as a member of the Canadian ATLANTIC network, you are entitled to participate in any of the 8 Work Groups. To explore this option further, you will find the outlines of the proposed papers for all 8 Work Groups in the ZIP file that accompanies this letter and also posted at the following websites for easy reference.
(www.civ.utoronto.ca/sect/traeng/its/atlantic.htm) (English versions)
(www.umontreal.ca/) (French versions)

Each Canadian ATLANTIC Work Group consists of a leader, a rapporteur and a team of experts as members. Briefly, the role of experts is as follows:

- To contribute knowledge of ITS-related activities in Canada and elsewhere that will enable the Canadian ATLANTIC network to become the leading source of information on ITS research and development in Canada; contributions can be forwarded via e-mail or telephone exchanges;
- To participate actively in one or more Work Groups (representing ITS thematic areas) to contribute advice and expertise to the preparation of the discussion papers and to review and comment on draft versions and other outputs; participation may be via electronic exchanges, teleconferences or, occasionally, Work Group meetings; and
- To participate in international ATLANTIC electronic forum discussions, e-mail exchanges and other networking opportunities and make contributions to the debates and discussions (register at www.atlan-tic.net).

Experts are invited to join or may apply to join the Canadian ATLANTIC network. Membership is voluntary but the rewards are tangible - recognition as a member of the leading ITS research and development thematic network in Canada, and, opportunity to contribute to setting priorities and to fostering the overall success of future ITS research and development in Canada and internationally.

Those experts who wish to be more active in their participation can consider pursuing one or more of the following optional roles and tasks:

- Planning of proposals for follow up ITS research and development submissions to funding agencies, for example, planning for an ITS network of centres of excellence;

- Participation in the Canadian ATLANTIC workshop in October 2003 to contribute to finalizing the project outputs and to share new information and insight among network participants;
- Participation in selected international discussion forums, workshops and “orange book” focus groups with U.S. and European partners to make presentations and to contribute knowledge.

Participation in the ATLANTIC network offers an opportunity to make your views known and to share your experiences with the ITS community in Canada, North America, Europe and the world. The results of our discussions will be summarised and presented to key policy-makers in Canada. Our ultimate aim is to enable decision-makers to develop funded research programs in critical areas of concern for ITS development.

If you agree to join the Canadian ATLANTIC network as an expert member, kindly let us know by return e-mail with your complete coordinates and information about your activities related to Work Group 3.2 and other Work Groups of your choice. Alternatively, you can complete and return the questionnaire in **Attachment 1**. If you have any questions, please contact either of the undersigned or one of the Core Team members listed on the next page.

We would like to take this opportunity to thank you in advance for your participation and your anticipated contributions.

Yours sincerely,

WG. 3.2 LEADER

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Attachment 1

A Thematic **L**ong-term **A**pproach to **N**etworking for the **T**elematics and **I**TS **C**ommunity (**ATLANTIC):**

The Canadian Network

Expert Members' Questionnaire

All responses will be treated confidentially.

Part 1: About You

Name: ____

Company / Organisation:

____

Your position in Company / Organisation:

____

Company Address:

____

____

____

Telephone No:

____

Fax. No.____

Email address:

____

If you have any files or reports summarizing experiences or results that are relevant to the ITS Work Group 3.2 Human Machine Interface, please list them (use extra pages if required):

A number of important issues have emerged from attempts to evaluate the impact of in-vehicle ITS or telematics on safety and system performance. The purpose of this questionnaire is to sample human factors experts to determine if any consensus has been reached within the community of researchers in North America and Europe about the measurement and interpretation of safety and system performance. Your responses will be synthesised and made available to others as a paper through the ATLANTIC network.

A hypothetical evaluation context is briefly described followed by a series of open-ended items. The open questions, into which you can type a response, ask you to: list the dependent variables you would use to evaluate the context as specified; what the variable results would mean in terms of safety and system performance; and if you made or used any assumptions, definitions, or literature sources in your answers.

The questions are not necessarily easy to answer so it will take some time to think each one through. If you feel that current data does is insufficient, indicate so and mention whether research in the area is a low, medium or high priority. If an evaluation context does not fall into your domain of expertise, please say so.

Once you have completed the questionnaire, please send it to: jkcaird@ucalgary.ca by **October 7th, 2003**. If you have questions or suggestions, you can use the same email. We would like to thank you for taking the time to answer all the questions.

1) To determine the visual demands associated with driving and interacting with an in-vehicle ITS device.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

2) To examine the cognitive distraction potential of a system.

What variables would you measure to determine performance with a system and safety using it?

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

3) To determine the effects of fatigue on driving performance and strategic use of in-vehicle ITS device.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

4) To examine the <u>comprehension, reliance and potential confusion</u> between existing road signs and in-vehicle signing information.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

5) To identify the impact of <u>new and novel uses</u> of a device by younger drivers.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

6) To determine the <u>cognitive and physical impacts</u> of a system on older driver safety and mobility.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

7) To increase driver underload or decrease driver overload while using a system.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

8) To determine the loss of reliability of a system on driver performance.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

9) To determine potential physical or cognitive conflicts between new ITS controls and existing conventional in-vehicle controls (e.g., HVAC, radio, etc.).

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

10) To determine the tradeoffs among <u>visual, auditory and/or haptic modalities</u> of ITS presentation.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

11) To determine the degree to which an ITS application is <u>accessible and useful</u> to range of users with functional limitations.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

12) To determine, from a set of functions or the overall product, whether or not a product will be <u>accepted</u> by users.

What variables would you measure to determine performance with a system and safety using it?

What mean and/or range of the dependant variable(s) do you consider to be safe and usable?

What mean and/or range of the dependent variable(s) do you consider unsafe or not usable?

Did you make any assumptions, use any explicit definitions, or rely on published or unpublished literature in your answers? If so, what?

Part 2: About Others

Please suggest other people for us to contact whom have the expertise to fill out this questionnaire:

Name ________________________________
Email _______________________
Institution _____________________________
Tel.__________________________
Fax. __________________________

Name ________________________________
Email _______________________
Institution _____________________________
Tel __________________________
Fax. _________________________

If we contact any of the individuals listed above, may we mention your name?

□Yes □No

Thank you for taking the time to reply to this questionnaire.

Once you have completed the questionnaire, please send it to: jkcaird@ucalgary.ca by **October 7th, 2003**. If you have questions or suggestions, you can use the same email.

We would like to thank you for taking the time to answer all the questions.