TP 13006E

FUTURE DIRECTIVES FOR TRANSPORTATION ERGONOMICS IN CANADA

Prepared for
Transportation Development Centre
Safety and Security
Transport Canada
March 1997

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This report reflects the views of the authors and not necessarily those of the Transportation Development Centre.

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Un sommaire français se trouve avant la table des matières.

Transport Canada / Transports Canada

PUBLICATION DATA FORM

1. Transport Canada Publication No.	2. Project No.	3. Recipient's Catalogue No.
TP 13006E	8768	

4. Title and Subtitle	5. Publication Date
Future Directives for Transportation Ergonomics in Canada	March 1997
	6. Performing Organization Document No.

7. Author(s)	8. Transport Canada File No.
Barbara Cameron and Carmel Murphy	ZCD1450-175

9. Performing Organization Name and Address	10. PWGSC File No.
BCRI 3650 Wesbrook Mall Vancouver, B.C. V6S 2L2	XSD94-00302-(671)
	11. PWGSC or Transport Canada Contract No. T8200-4-4556

12. Sponsoring Agency Name and Address	13. Type of Publication and Period Covered
Transportation Development Centre (TDC) 800 René Lévesque Blvd. West 6th Floor Montreal, Quebec H3B 1X9	Final
	14. Project Officer R. Joly

15. Supplementary Notes (Funding programs, titles of related publications, etc.)

16. Abstract

This report outlines input from Canadian subject matter experts (SMEs) on the current state of transportation ergonomics and its implication for future research directives in Canada. Provided in the report are a working definition of transportation ergonomics and a conceptual framework for the development of a strategic plan to prioritize areas where research should be focused. Information on transportation ergonomics was gathered through a review of TDC projects, national and international literature, and SMEs' responses to a questionnaire. Issues were identified which could affect the development and delivery of transportation systems within Canada. A four-point plan was developed as a framework for TDC to enhance the delivery of transportation ergonomics in Canada. Emphasis was placed on the emerging technologies of the future, and the effects they will have on the delivery of transportation and on the human's ability to work and travel in a safe, comfortable and efficient manner.

17. Key Words	18. Distribution Statement
Transportation ergonomics, human factors	Limited number of copies available from the Transportation Development Centre

19. Security Classification (of this publication)	20. Security Classification (of this page)	21. Declassification (date)	22. No. of Pages	23. Price
Unclassified	Unclassified	—	xii, 24, apps	—

Transports Canada Transport Canada

FORMULE DE DONNÉES POUR PUBLICATION

1. N° de la publication de Transports Canada	2. N° de l'étude	3. N° de catalogue du destinataire
TP 13006E	8768	

4. Titre et sous-titre	5. Date de la publication
Future Directives for Transportation Ergonomics in Canada	Mars 1997
	6. N° de document de l'organisme exécutant

7. Auteur(s)	8. N° de dossier - Transports Canada
Barbara Cameron et Carmel Murphy	ZCD1450-175

9. Nom et adresse de l'organisme exécutant	10. N° de dossier - TPSGC
BCRI 3650 Wesbrook Mall Vancouver, B.C. V6S 2L2	XSD94-00302-(671)
	11. N° de contrat - TPSGC ou Transports Canada T8200-4-4556

12. Nom et adresse de l'organisme parrain	13. Genre de publication et période visée
Centre de développement des transports (CDT) 800, boul. René-Lévesque Ouest 6e étage Montréal (Québec) H3B 1X9	Final
	14. Agent de projet R. Joly

15. Remarques additionnelles (programmes de financement, titres de publications connexes, etc.)

16. Résumé

Ce rapport résume les avis d'experts canadiens sur l'état actuel de l'ergonomie des transports au Canada et sur l'orientation à donner à la recherche dans ce domaine. Il contient une définition pratique de l'ergonomie des transports ainsi que des principes directeurs pour l'élaboration d'un plan stratégique de recherche en fonction des priorités qui s'imposent. L'information sur l'ergonomie des transports provient de diverses sources : examen des projets parrainés par le CDT dans ce domaine, documentation canadienne et étrangère et réponses à un questionnaire soumis à un certain nombre d'experts. Certains facteurs susceptibles d'influer sur le développement et l'exploitation des systèmes de transport au Canada ont été identifiés. Les chercheurs ont élaboré un plan en quatre points qui permettrait au CDT de rehausser l'ergonomie des transports au Canada. Ils ont attaché une importance particulière aux technologies émergentes et à l'impact qu'elles ne manqueront pas d'avoir sur les systèmes de transport et sur la possibilité pour la population de travailler et de se déplacer de manière efficace, en toute sécurité et tout confort.

17. Mots clés	18. Diffusion
Ergonomie des transports, facteurs humains	Le Centre de développement des transports dispose d'un nombre limité d'exemplaires.

19. Classification de sécurité (de cette publication)	20. Classification de sécurité (de cette page)	21. Déclassification (date)	22. Nombre de pages	23. Prix
Non classifiée	Non classifiée	—	xii, 24, ann.	—

ACKNOWLEDGEMENTS

The cooperation of the Transportation Development Centre and the support and advice of Rémi Joly, Transportation Development Centre are gratefully acknowledged. In addition, BCRI would like to express gratitude to Julia Rylands, NRC-IRAP, and Carolyn MacGregor, University of Waterloo for their help in coordinating meetings with the Subject Matter Experts.

EXECUTIVE SUMMARY

This report was prepared for the Transportation Development Centre (TDC) in order to provide input on the current state of transportation ergonomics and its implication for research directives in Canada from Canadian subject matter experts (SMEs). The study was conducted by B.C. Research from April to September 1996.

The rationale for the current study was to provide TDC with a working definition of transportation ergonomics, to establish a conceptual framework for a strategic plan based on input from SMEs, and to prioritize recommended research initiatives. Information was gathered from several sources. TDC projects in transportation ergonomics were examined; a literature search was then undertaken to review national and international research initiatives in the field. A questionnaire was circulated to SMEs and two round table discussions were held. The purpose of both was to obtain input on the key issues for future transportation ergonomics research activities for Canada. Using the current TDC mandate as a reference for discussion, SMEs were asked to identify significant demographic shifts, social and business trends, and expected technological advances which could affect the development and delivery of transportation systems. SMEs who contributed information were primarily private consultants in transportation ergonomics.

A working paper entitled "The State of Ergonomics Within Transport Canada" previously examined the extent and nature of current and planned ergonomic or human factors research within Transport Canada operational groups (Wallersteiner, 1992). That report was based on internal surveys with a wide cross section of the stakeholders within Transport Canada.

From information gathered in the present study, a four-point plan was developed which can be used by TDC to enhance the delivery of transportation ergonomics in Canada. Future research directions for transportation ergonomics were prioritized, with an emphasis on the effect that emerging technologies will have on the delivery of transportation and on the human's ability to work and travel in a safe, comfortable and efficient manner.

Though input from SMEs was gathered by questionnaire and at two separate meetings, the primary issues that were prioritized and identified as key areas for future research were consistent. As well, recommendations from Wallersteiner (1992), which were developed from the perspective of Transport Canada operational groups, reached similar conclusions to those in this study.

In order to proceed effectively, it is recommended that TDC review the information obtained from private sector SMEs, in conjunction with the working paper developed in 1992. TDC can then evaluate the proposed strategies to enhance ergonomics in transportation systems in Canada, and consider the priorization of ergonomics research for transportation in Canada. Because some of the recommendations provided by private sector SMEs in this report may be outside the current mandate of Transport Canada, it will be necessary to review the document internally in order to develop a formal strategic plan, along with an action plan and time line for implementation.

Once a strategic plan has been finalized, it needs to be pursued aggressively to ensure the systematic integration of ergonomics into all aspects of transportation in Canada.

SOMMAIRE

Ce rapport rend compte d'une étude réalisée par B.C. Research entre les mois d'avril et septembre 1996 pour le compte du Centre de développement des transports (CDT), et ayant pour objet de recueillir l'avis d'experts sur l'état actuel de l'ergonomie des transports au Canada, en vue de définir les futurs axes de recherche dans ce domaine.

L'étude avait plus précisément pour but de mettre au point une définition pratique de l'ergonomie des transports, de définir, à la lumière des informations fournies et des avis exprimés par les experts, des principes directeurs pour l'élaboration d'un plan stratégique de recherche, et d'établir un ordre de priorité pour les sujets de recherche proposés. Les chercheurs ont consulté plusieurs sources d'information. Ils ont examiné les projets parrainés par le CDT dans ce domaine. Ils ont ensuite fait une recherche documentaire pour connaître les projets en cours dans ce domaine au Canada et à l'étranger. Ils ont fait parvenir un questionnaire à plusieurs experts et ont organisé deux tables rondes sur le sujet, afin de sonder les avis sur l'orientation à donner aux futures recherches au Canada. Le mandat actuel du CDT servant de cadre à la discussion, les experts ont été invités à s'exprimer sur les principaux changements démographiques, les tendances sociales et commerciales et les progrès technologiques susceptibles d'avoir un impact sur les systèmes de transport. Les experts consultés étaient pour la plupart des spécialistes en ergonomie des transports du secteur privé.

Un document de travail, intitulé «The State of Ergonomics Within Transport Canada», avait déjà été rédigé sur la nature et la portée des recherches en ergonomie et facteurs humains menées au sein des différents groupes opérationnels de Transports Canada, ou prévues à leur programme (Wallersteiner, 1992). L'information avait été recueillie au moyen d'un sondage à l'interne auprès d'un échantillon représentatif des intéressés.

L'information recueillie au cours de la présente étude a permis d'élaborer un plan en quatre points qui permettrait au CDT de rehausser l'ergonomie des transports au Canada. Les axes prioritaires de recherche ont été tracés en tenant compte de l'impact que ne manqueront pas d'avoir les technologies émergentes sur les systèmes de transport et sur la possibilité pour la population de travailler et de se déplacer de manière efficace, en toute sécurité et en tout confort.

Malgré les voies différentes de consultation, soit les questionnaires et les tables rondes, les réponses des experts quant aux priorités de recherche s'accordent et

rejoignent les recommandations du rapport Wallersteiner (1992), lesquelles reflètent l'avis des différents groupes opérationnels de Transports Canada.

Les auteurs de cette étude recommandent que le CDT se penche sur l'information recueillie auprès des experts du secteur privé et la compare à celle contenue dans le document rédigé par Wallersteiner en 1992. Il sera ainsi mieux en mesure d'évaluer les stratégies recommandées pour rehausser l'ergonomie des transports au Canada et de décider des priorités à accorder à la recherche dans ce domaine. Il est possible que certaines des recommandations formulées par les experts du secteur privé ne s'inscrivent pas dans le mandat actuel de Transports Canada. C'est pourquoi il faudra revoir le rapport à l'interne avant d'établir une stratégie de recherche, un plan d'action et des échéances.

Une fois qu'un plan stratégique aura été établi, il faudra le suivre rigoureusement pour faire en sorte que la composante ergonomie soit systématiquement intégrée à l'ensemble des systèmes de transport canadiens.

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1 INTRODUCTION

In March 1996, the Ergonomics and Human Factors Group at B.C. Research Inc. (BCRI) was tasked by the Transportation Development Centre (TDC) to:

- Perform a literature search to identify, from a global perspective, what are the multi-modal ergonomic issues in transportation, with a focus on work and issues of importance to transportation, nationally and internationally;
- Based on the literature search, highlight areas in which ergonomics research has and has not been completed to date in the area of transportation;
- Based on the above and with the assistance of TDC, develop a conceptual framework of what transportation ergonomics might be comprised;
- Obtain input from Canadian Subject Matter Experts (SMEs), in the form of written and/or participation in round table discussions, to evaluate, prioritize, and make recommendations on the key issues for future transportation ergonomics research activities for Canada;
- Incorporate information gathered from SMEs into the conceptual framework to identify strategic directions for ergonomics research in transportation which fall under Transport Canada's current mandate; and
- Develop a report outlining the above process.

The rationale for this study was to identify and prioritize issues which are important to the future of Canadian transportation. By working from recommended guidelines for a strategic plan, TDC should be able to incorporate ergonomics in all aspects of its operations and research priorities. By systematically implementing steps of the strategic plan, TDC should maximize resources, optimize the contribution that it makes to research that is being conducted nationally and internationally, and incorporate the information appropriately into current and future transportation needs.

The report is structured as follows:

- Methodology
- Perspectives on Transportation Ergonomics
- Conceptual Framework for a Strategic Plan
- Appendix A: TDC Research Initiatives in Transportation Ergonomics
- Appendix B: National and International Information Sources

- Appendix C: Literature Search
- Appendix D: Transportation Ergonomics Questionnaire
- Appendix E: Questionnaire—Tabulated Data
- Appendix F: Summary of Questionnaire Comments and Round Table Discussions
- Appendix G: Participating Canadian Subject Matter Experts (SMEs)
- Appendix H: Outstanding Issues in the Development of a Strategic Plan for Research and Development in Transportation Ergonomics

2 METHODOLOGY

To satisfy the tasks assigned by TDC, a three-phase methodology was undertaken involving:

- Literature search;
- Development, distribution and evaluation of a questionnaire on transportation ergonomics;
- Facilitation of two round table discussions with SMEs on transportation ergonomics; and
- Development of a strategic plan and future research directions.

2.1 Literature Search

The process involved a search for research and literature in the area of transportation ergonomics performed in Canada during the past ten years (1985–1996) and internationally for the past five years (1990–1996). The purpose of the literature search was to identify, from a global perspective, the multi-modal ergonomic issues in transportation, with a focus on work and issues of importance to transportation, both nationally and internationally. The literature also catalogued the breadth of the field and direction that ergonomics research is heading in the transportation sector. The TDC library provided assistance by identifying a list of ergonomics-related projects undertaken by TDC and Transport Canada for the years 1985 to 1996. This is provided in Appendix A.

Useful information was obtained from on-line data bases including:

- National Technical Information Service (NTIS);
- Social Sci Search;
- BIOSIS Previews;
- Embase;
- Pascal;
- Sci Search;
- Inspec; and
- Ei Compendex Plus.

Other sources of information included "Current Literature in Traffic and Transportation", local academic library catalogues and the TDC library. Information was also sought from national and international sources listed in Appendix B.

An abstract search at the Ergonomics Information Centre identified research undertaken in the field during the period 1990–1996. These references, provided in Appendix C, have been merged with other references provided by SMEs on their work in the field of transportation ergonomics.

2.2 Transportation Ergonomics Questionnaire

From the information obtained from the literature search, a general questionnaire was developed which addressed research areas of transportation ergonomics (Appendix D). The questionnaire was designed to evaluate each research area in terms of operational demands in the field of transportation today. For specific questions, the rating scale that was used ranged from "mildly important" to "highly important".

Having established broad parameters for the spectrum of ergonomics research in transportation issues, SMEs were asked to evaluate, prioritize and make recommendations on key issues for future transportation ergonomics research activities in Canada. The questionnaire also asked the SMEs to indicate which areas of transportation ergonomics they considered required more research and where major gaps in the knowledge base existed. Results of the questionnaire are presented in Appendix E (Results of Questionnaire—Tabulated Data) and Appendix F (Summary of Questionnaire Comments and Round Table Discussions).

2.3 Workshops with SMEs

Two workshops were conducted (in Vancouver, B.C. and Toronto, Ont.), in which round table discussions were used to obtain information from SMEs. This information was incorporated into the outline of a strategic plan, presented in Section 4. Facilitators from outside of B.C. Research were used for both meetings and a representative from TDC was present at each meeting to provide input on questions relating to the current mandate and TDC's perspectives on research issues. In Vancouver the workshop was facilitated by Ms. Julia Rylands, while Dr. Carolyn MacGregor facilitated the workshop in Toronto.

2.4 Subject Matter Experts

Although there are numerous specialists working on ergonomics research related to transportation in Canada, only a subset of these people could participate in this study due to budgetary constraints. Twenty SMEs completed the questionnaire, and eleven of these individuals attended the round table discussions held in Vancouver and Toronto. A list of questionnaire respondents and round table discussion participants is provided in Appendix G. A summary of comments obtained from SMEs on the questionnaire and during round table discussions is presented in Appendix F (Summary of Questionnaire Comments and Round Table Discussions).

2.5 Development of a Strategic Plan

A working definition of transportation ergonomics was generated from the questionnaires and round table discussions. Information obtained from the above was incorporated into the conceptual framework for a five-year strategic plan for research in transportation ergonomics for the years 1996 to 2001. This framework is presented in Section 4.

3 PERSPECTIVES ON TRANSPORTATION ERGONOMICS

3.1 Literature Search

Results of the literature search are presented in two sections. A chronological listing of TDC research initiatives during the period 1985 to 1996, provided by the TDC librarian, is presented in Appendix A. Reports from these projects are available from the TDC library. In Appendix B, information sources and data bases from which data were obtained are listed. Appendix C provides a reference list of relevant literature which was obtained from sources listed in Section 2.1 and Appendix B. Also included are references provided by participating SMEs on their work in the area of transportation ergonomics. The literature listed in Appendix C is organized in the categories listed in Table 1.

Given the broad range of human factors or ergonomics research being undertaken nationally and internationally it is difficult to identify only a few research areas as "main trends" or "emerging issues". Human factors or ergonomics issues which are being researched widely include:

- Intelligent transportation systems;
- Shiftwork and fatigue effects in all modes of transportation;
- Driver behavior;
- Elderly and disabled transportation in all modes of transportation; and
- Complex system design.

Within the scope of this project it should be emphasized that the literature search was by no means exhaustive. However, the information obtained made it clear that extensive research in transportation ergonomics has been performed previously and many studies are currently underway. The SMEs also identified a major concern, in terms of the dissemination of research data and recommendations in a usable format to the transportation community to allow application of relevant research.

Table 1:
Categorization of literature search (Appendix C).

Mode	Sub-category
General	
Air	Air Traffic Control (ATC) Cockpit Crew Maintenance Training General
Rail	Crew Systems General
Marine	Crew Systems General
Surface	Driver Passenger Vehicle Design Regulations Systems Design Bicycles/Motorcycles General
Elderly and Disabled	Driving Public Transportation Pedestrian Air Rail General

3.2 Summary of Questionnaire Data and Round Table Discussions

The questionnaire developed for this project is included in Appendix D. Of the 22 individuals requested to complete the questionnaire, 20 responded, representing a 90 percent return rate. A subset of those responding to the questionnaire were requested to attend one of the round table discussions. Eleven of the 13 SMEs who were requested to attend the round table discussions were able to participate in one of these two sessions.

A summary of responses from the questionnaire, together with input obtained on specific questions at the round table discussions, is provided in the following sections:

Section 3.2.1: Question 1 – Definition of transportation ergonomics

Section 3.2.2: Question 2 – Human factors applied to transportation modes

Section 3.2.3: Question 3 – Ranking of importance of human factors in transportation ergonomics

Section 3.2.4: Question 4 – Areas for future research in transportation ergonomics

Section 3.2.5: Question 5 – Gaps in current knowledge base

Section 3.2.6: Future directions for transportation ergonomics in Canada

Section 3.2.7: Additional discussion

3.2.1 Definition of transportation ergonomics (Question 1)

Consensus Statement: Definition of Transportation Ergonomics
Transportation ergonomics is the systematic application of human physical, perceptual and cognitive abilities and limitations in the planning, design, development, delivery and usability of transportation systems to ensure quality of life and efficient operator performance, and to optimize the comfortable, safe, secure and efficient movement and delivery of people and goods in various modes of transportation.

The first question to which all questionnaire participants responded was to provide a definition of transportation ergonomics (Appendix F, Question 1). Responses that were received prior to the round table discussions were collated and available for consideration by the SMEs who attended the meetings. The Vancouver panel was asked to reach a consensus response on features that needed to be included in a comprehensive definition of transportation ergonomics. The components of the definition agreed upon in Vancouver were expanded by the Toronto panel.

The above consensus statement on transportation ergonomics was developed from the input from the two round table meetings. The Vancouver definition of transportation ergonomics, which represented a first draft, was:

> *Consideration/application/research of human physical, perceptual and cognitive abilities and limitations based on knowledge from human sciences (psychology, kinesiology, physiology, anthropometry) and engineering design, for safe and efficient movement and delivery of people and goods in various modes of transportation (air/surface/marine).*

The SMEs in Toronto modified the Vancouver statement to include other important features that were relevant to the definition. The final Toronto statement read as follows:

> *Early collaboration and concurrent systematic consideration/application/research of human physical, perceptual and cognitive abilities and limitations based on knowledge, data and methodology from human sciences and engineering design, for safe and efficient movement and delivery of people and goods in various modes of transportation.*

From the workshops it was evident that it would be difficult to agree on a simple, succinct definition of transportation ergonomics. In the choice of words, consideration had to be given to the knowledge and expertise of the intended audience with respect to the scope of transportation systems and the science of ergonomics. In spite of these limitations, a definition of transportation ergonomics was obtained from both round table groups in Vancouver and Toronto, and summarized as the joint consensus statement. Suggestions were also provided on ways to incorporate all critical features into the definition without it becoming too wordy or cumbersome for clients or end users.

For example, to expand the usefulness and clarity of the definition of transportation ergonomics for different end users, future iterations of the definition of transportation ergonomics may be targeted to specific groups.

3.2.1.1 Applying the definition of transportation ergonomics

The above definition of transportation ergonomics can be applied in several areas within TDC. What was deemed most important by SMEs was that the principles of ergonomics are planned into every transportation system and included systematically throughout the process from beginning to end. Specifically, the principles of ergonomics should be included within TDC at three levels including: policy; procedures; and specifications.

In order for TDC to educate its clients to include transportation ergonomics into policy, procedures and specifications and to obtain buy-in from each transportation sector, it may be appropriate to reduce the definition of transportation ergonomics for presentation and marketing in response to the following questions.

- What is transportation ergonomics?
- Why should ergonomics be included in TDC's R & D strategy?
- Who will benefit from transportation ergonomics?
- How can transportation ergonomics be incorporated into transportation systems?
- Where should transportation ergonomics be applied?

What is transportation ergonomics?

- The application and research of human physical, perceptual and cognitive abilities and limitations based on knowledge from human sciences (psychology, kinesiology, physiology, anthropometry) and engineering design in various modes of transportation (air/surface/marine).

Why should ergonomics be included in TDC's R & D strategy?

- To ensure quality of life and efficient operator performance, and to optimize the comfortable, safe, secure and efficient movement and delivery of people and goods.

Who will benefit from transportation ergonomics?

- System designers and managers, transportation managers, transportation engineers, operators, passengers and other transportation personnel and support services as well as the general public can benefit from transportation ergonomics through reduced costs resulting from fewer errors, incidents and accidents as well as improved quality of service.

How can transportation ergonomics be incorporated into transportation systems?

- Using a systems design approach to examine the person and process within the context of the environment and equipment, transportation ergonomics provides early and systematic application of research methodology and knowledge about user (operators, passengers, other transportation personnel and support service) capabilities throughout the development of transport systems.

Where should transportation ergonomics be applied?

- Ergonomics should be applied to all modes of transportation (air, marine, surface, rail) and at all levels (vehicle, terminal, way (roads, skyway)) for people and goods.

3.2.1.2 Further issues for consideration by TDC

Several issues that need to be addressed by TDC in order to incorporate transportation ergonomics into policy, procedures and specifications were highlighted by the SME's.

- Establish objectives for transportation safety, efficiency, usability, comfort and optimization;
- Specify an acceptable level of transportation service by and for people;
- Develop and market an understanding of people as suppliers and users of public and private transportation;
- Obtain input from senior policy and procedures managers to specify policy and procedures that are in place that will be affected by ergonomics; and
- Include ergonomists/human factors specialists as collaborative members within each project team.

3.2.2 Human factors applied to transportation modes (Question 2)

In response to Question 2:

> *Given the above definition, expand on the areas where human factors should be given consideration in the following modes of transportation. We recognize that you will have a greater ability to answer this question as it pertains to your area of expertise.*

areas were identified in which human factors should be given consideration for each mode of transportation. During the round table discussions, the responses were further discussed and expanded. As expected, substantial overlap was evident across various modes of transportation. For organizational purposes, ergonomic issues within the modes were categorized under the headings listed in the Table 2. A complete list of the responses to this question are provided in Appendix F (Summary of Questionnaire Comments and Round Table Discussions).

Table 2:
Areas of ergonomics concern in transportation.

All Modes	• Personnel • Policies, Procedures and Regulations • Systems Design • Other
Air	• Air Traffic Control • Cockpit Crew • Maintenance • Passengers • Support Systems • Terminals • Training • Other
Rail	• Drivers • Crew • Passengers • Systems • Dispatching Centers
Marine	• Crew • Passengers • Systems
Surface	• Drivers • Maintenance • Passengers • Pedestrians • Vehicle Design • Regulations • Enforcement of Regulations • Systems • Bicycles/Motorcycles • Other • Unknown

3.2.3 Ranking of importance of human factors in transportation ergonomics (Question 3)

In Question 3, SMEs were asked to indicate the level of importance of various areas of ergonomics in light of operational demands in the field of transportation today. Individual responses to Question 3 are provided in Appendix E, Table E1. The table is organized in descending order of the areas ranked as "highly important". Responses in the "other" category are listed by frequency but are not included in the general ranking, as it was considered inappropriate because of the diversity of responses. Categories which were rated as "high" by a minimum of 50 percent of respondents were:

- Human error/critical incidents 92%
- Situational awareness 77%
- Human-computer interactions 69%
- Impairment (fatigue, drugs/alcohol) 69%
- Information processing 62%
- Training 62%
- Shiftwork 54%
- Workload 54%

3.2.4 Areas for future research in transportation ergonomics (Question 4)

In Question 4, SMEs were asked to indicate which areas needed further ergonomic research. Responses to Question 4 are indicated in Appendix E, Table E2. The table is organized in a descending order of those areas ranked as "highly important". As described in Question 3, responses in the "other" category are listed by frequency but are not included in the general ranking, as it was considered inappropriate because of the diversity of responses. Categories rated as "high" by a minimum of 50 percent of respondents were:

- Human error/critical incidents 100%
- Human-computer interactions 82%
- Impairment (fatigue, drugs/alcohol) 82%
- Performance limitations 82%
- Situational awareness 82%
- Use of simulators (for training, evaluation of performance) 73%
- Shiftwork 73%
- Screen/display/control design 64%
- Elderly 64%
- Information processing 64%
- Workload 64%
- Training 64%
- Disabled 64%
- Work station design 64%
- Fit for work 55%
- Regulations 55%
- Signage 55%

3.2.5 Gaps in knowledge base (Question 5)

SMEs identified, from an ergonomic perspective, areas in which the main gaps in knowledge base exist in transportation systems. Again, there was considerable diversity of responses, ranging from "predictive models of accidents" to "design of advanced in-car systems on driving performance for the elderly". Complete responses to Question 5 are included in Appendix F. The responses in Appendix F are summarized in the following categories:

- Crew issues;
- Elderly and disabled;
- Human error/critical incidents;
- Regulations;
- Systems; and
- General.

3.2.6 Future directions for transportation ergonomics in Canada

As a starting point for the second workshop, SMEs were asked to envision factors that would affect the direction that transportation would take within a five to ten year time frame. Boundaries were not imposed on the discussion, other than to limit technological advances to those that could reasonably be achieved within the time frame.

Although some issues could have been included in more than one section, the responses were organized in four categories which could affect transportation choices and related research, including:

- Significant demographic shifts;
- Social trends;
- Business trends; and
- Expected technological advances.

Each of the future trends identified in Table 3 has important human factors or ergonomics implications for transportation that could have a significant impact on decisions in the development and implementation of transportation technology. Although the list is incomplete due to imposed time limits during the workshop, the discussion established a valuable frame of reference from which research issues relevant to transportation ergonomics could be subsequently prioritized.

As an example, changes in demographics, social, and business trends suggest that public transportation demands will increase but the user profile will shift to more individuals with special needs (e.g., multicultural and elderly). Technological advances in both personal and public transportation systems (i.e., more computer aided devices and high tech electronics systems) require careful examination of compatibility with the physical and cognitive limitations of the user.

Table 3:
Future trends affecting transportation choices, development and delivery by the year 2006.

Demographics	**Social Trends**
• Demographic changes (aging population, multi-cultural society) • Single parent families • More women users • More elderly users • More travelers	• Employment equity • Two-class system (want to travel vs. need to travel) • Increased service and access for all travelers in all modes • Greater class distinctions (passenger perspective) • Less urban transport (more cocooning) • Increase in recreational vehicles (marine, air, land, off-road) • More emphasis on public transportation, less on personal car • Change in reasons people travel: contact with relatives, work requirements, etc. Technology will change the way this is done. • International community travel (implication and complications for travelers) • Fewer business travelers, more tourist travelers • Less transportation (less need to move, fewer traffic jams) —the global village • Transportation will follow demographics (e.g., baby boom)
Business Trends	**Technological Advances**
• Work at home • More competition among modes (e.g., Greyhound airlines) • Less rail travel—passenger cutbacks in rail • Less government regulation of travel • Privatization of delivery • Pay for use/cost-effective implementation • Freight will become dominant (vs. people) • Less energy costs (more bicycles)	• Video conferences replacing need for travel • Increasing computer-aided decision making • Electronic license plates and toll collection for highways/ central cities • Increased ITS • No transportation—all virtual experience (possibly with increased technology the need for travel will change) • Electronic tracking of dangerous goods • Increased automation—less crew • Removal of barriers for travelers with sensory disabilities • Cleaner transportation (environmentally-friendly, alternative fuels, hybrid vehicles) • Greater availability and use of networks and computers for information and planning (across modes) • Faster types of transport (train, planes, commuter systems)

3.2.7 Additional discussion

Throughout the panel discussions, many issues were tabled which were not brought to full discussion. However, they are important to consider, since each affects, to some extent, the future direction of transportation research and transportation ergonomics in Canada. Some points which reflect trends and technological advances affecting transportation choices, development and delivery by the year 2006 could be included in Table 3. In certain instances, some of these issues are also reflected in the framework for the strategic plan outlined in Section 4 that was developed in the latter stage of each round table meeting.

Issues that were tabled but not discussed are presented as a series of statements and questions in Appendix H. They have been categorized under the following headings, and reflect the opinions of SMEs who attended the workshops. To improve readability some of the comments have been expanded and clarified.

- Queries;
- Certification/Guidelines and Regulations;
- Education;
- Future Advances;
- Jurisdiction of Transport;
- Safety vs. Ergonomics; and
- Strategic Planning/Research Directives.

4 CONCEPTUAL FRAMEWORK FOR A STRATEGIC PLAN

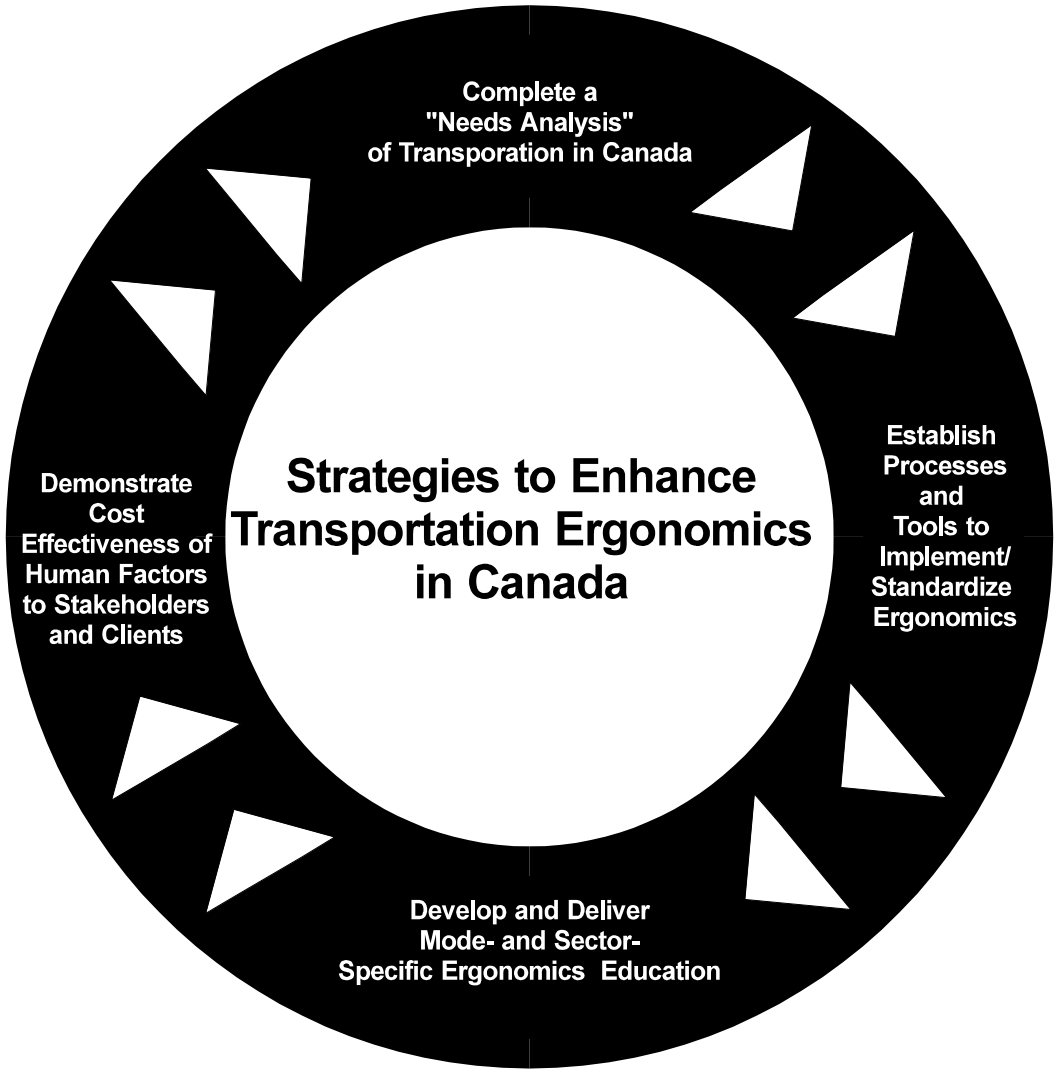

Figure 1:
Four-point strategic plan for the implementation of transportation ergonomics within TDC.

4.1 Strategies for TDC to Enhance Transportation Ergonomics in Canada

The four-point plan (Figure 1) to establish a framework for a strategic plan which should enhance transportation ergonomics in Canada was based on input from SMEs who attended the round table discussions. The recommended strategies are similar to those developed by Wallersteiner (1992), which recommended inclusion of ergonomics in all aspects of Transport Canada's mission.

The major components of the plan include:

- Completion of a "needs analysis" of transportation in Canada;
- Establishment of processes and tools to implement/standardize ergonomics;
- Development and delivery of mode- and sector-specific ergonomics education;
- Demonstration of cost-effectiveness of human factors.

The plan outlines the steps that the TDC should incorporate in strategic planning efforts in order to include and enhance ergonomics within transportation systems in Canada. While not specifically focused on research and development initiatives, the framework provides clear direction of the process through which transportation ergonomics will gain maximum impact.

4.1.1 Completion of a "needs analysis" of transportation in Canada

The SMEs proposed that TDC complete and then utilize a "needs analysis" of stakeholders and transportation clients within Canada to understand fully their ergonomic needs (e.g., Coast Guard, airports, railways). Implied in this analysis are the development and circulation of an organization chart of personnel in each sector who are responsible for policy decisions, allocation of funding and the procurement process.

4.1.2 Establishing processes and tools to implement and standardize ergonomics interventions

Operational groups within Transport Canada use a variety of processes to address ergonomics issues in projects. This may be due to differences between operational groups with respect to the level of awareness of the scope of human factors/ergonomics and how it can be applied (Wallersteiner, 1992).

In order for ergonomics to be delivered consistently and effectively, the SMEs agreed that TDC needs to make a major effort in the development and standardization of processes and tools to be used in the implementation of ergonomics in transportation modes, as well as the development and maintenance of relevant data bases.

4.1.2.1 Processes

TDC needs to establish process standards (e.g., a quality standard similar to ISO 9000) and guidelines for completion of ergonomics work by both internal and external sources. Policy may be directed at senior executives/management for each client or transportation sector, and may take the form of regulations (or consensus guidelines, but guidelines are unlikely to be enough of an incentive to ensure compliance). Ergonomics and human factors in all processes should be contained within the regulations/guidelines, but could also be implemented independently. Ergonomics and human factors specifications and requirements need to be marketed clearly and concisely, both to TDC clients and to external contractors.

4.1.2.2 Data base development

Rather than only spend limited resource money on exploratory research projects, TDC should establish and maintain a Canadian-based transportation ergonomics research data base including, but not limited to:

- Publications (technical reports and scientific literature);
- Accident causes;
- Incidents/near misses; and
- Unpublished and ongoing work.

Although a variety of data bases exist which focus on different aspects of transportation, a comprehensive source of information related to transportation ergonomics is difficult to find. The major benefit of establishing such a data base is to consolidate existing research knowledge so that it can be applied directly to novel developments, without duplication of fundamental research and development.

The data base developed by TDC should use and incorporate information from foreign data bases. However, these need to be selected and reviewed carefully to avoid duplication. Results and recommendations from existing literature and other ergonomic considerations could be incorporated into both regulations and education programs to advance the levels of awareness of the scope of human factors/ergonomics in transportation systems.

4.1.2.3 Human factors tools or ergonomics toolbox

The need for an ergonomics toolbox is highlighted by the SMEs' recommendation (Section 4.1.2.1), that standard processes are required to effectively incorporate human factors/ergonomics into TDC's research and developments efforts. A standardized set of tools should be developed by TDC so that ergonomics can be introduced in a uniform way in each mode of transportation. Suggested tools might include:

- Methodology for task analysis;
- Design checklists;
- HFPP developer;
- CAD tools; and

- Software supported programs.

4.1.3 Education

Education was identified as the most effective means to transfer ergonomics knowledge to other professionals in transportation, both internal and external to TDC. By focusing on education as a primary strategy, TDC would take a leading role to increase the level of awareness and understanding of the use, processes and methodology of ergonomics in transportation systems. The greatest perceived barrier to acceptance of ergonomics within any system including transportation is the lack of communication of the meaning and significance of ergonomics. Also misunderstood is why it is important to include ergonomics principles at all stages of a project (i.e., development of policies, procedures and specifications; design; development; and implementation).

As well, it is evident that extensive research in ergonomics related to transportation systems has been completed but that there has been only limited transfer of that information into product design, organizational systems and other applied areas. Customized education would accelerate knowledge transfer to areas where ergonomics could be used in applied technology development.

Because of the uniqueness of certain transportation issues, ongoing professional development for ergonomists and human factors specialists was also recommended. Before developing its own programs, it will be necessary for TDC to identify and evaluate existing training programs which have been developed to avoid duplication of effort and unnecessary expense.

Cross-fertilization and training to enhance awareness of common ergonomics issues were recommended between transportation modes, or clients within a mode. This could be achieved at several levels including: users and local clients; internal, provincial and national departments; national and international associations. Cooperation and collaboration among groups doing research was encouraged, as well as educating human factors personnel outside of Transport Canada on a specific transportation mode (e.g., marine) by providing training or having the human factors specialist seconded to an observer position within the mode.

SMEs developed recommendations to assist TDC on "How to deliver ergonomics education" (Table 4) and "Targets for ergonomics education" (Table 5).

Table 4:
How to deliver ergonomics education.

- Develop a brief "recipe" book to:
  (i) identify areas where ergonomics is required; and
  (ii) explain how to implement ergonomic considerations (i.e., here's what you need, here's how to use it).
- Conduct seminars for transportation clients, either as stand-alone meetings or in conjunction with conferences and trade shows.
- Deliver 1- or 2-day workshops on ergonomics.
- Design (brief) flyers on specific topics.
- Design courses to sensitize clients about transportation ergonomics.
- Establish provincial advisory group (ad hoc) for each mode of transportation.

Table 5:
Targets for ergonomics education.

• Managers	• Unions
• Regulators	• General public
• Users of transit systems	• Other researchers

Although there is clearly a need for education to increase the awareness of ergonomics in the transportation industry, TDC must address some fundamental questions, such as:

- Is TDC equipped and resourced to provide this service?
- Is this activity within the current mandate of TDC?
- What level of out-sourcing would be required to meet these requirements?

4.1.4 Demonstrate effectiveness and benefit cost of human factors

To effectively sell the concept that ergonomics represents a "value-added" benefit in transportation, it was recommended that the TDC establish case studies to demonstrate the effectiveness and cost benefit of ergonomics and human factors intervention.

Follow-up studies are an important aspect of ergonomics research and development. Initial studies identify ergonomic difficulties and recommend changes to design or process in order to correct the situation. Follow-up studies are essential to evaluate whether the changes are effective or whether they introduce a new, more serious problem. As well, by doing a retroactive analysis to compare the cost of the change to the financial benefits, the financial value of the ergonomic intervention can be quantified. If implemented successfully, a thorough cost-benefit analysis should assist TDC in convincing its clients on the value of ergonomics.

4.2 Future Research Directions for Transportation Ergonomics in Canada

In addition to contributing to the development of the framework for a strategic plan for TDC, SMEs were asked to prioritize ergonomics research applications for transportation systems in Canada. At each round table meeting, the starting point for this discussion was a review of questionnaire responses to Questions 5 and 6 (Appendix F). Priority was established by means of a voting system.

The research applications established by SMEs as being most relevant to the needs of transportation in Canada are ranked in Table 6, in order of descending priority.

Table 6:
Specific research directives for transportation ergonomics in Canada.

Area of Interest	Recommendation for Additional Research
Automation	1. Evaluation of how ergonomics/human factors issues related to information processing, development of mental models, situational awareness and decision making are affected by the introduction of automated processes into transportation systems with automated systems, (e.g., ITS, on-board navigational systems, control systems such as ATC). 2. Research into workload/fatigue as it is affected by changing the level of automated control. 3. Evaluation of automation and its impact on safety in transportation industries. 4. Road-situational awareness/mental workload and the presence of behavioural adaptations (e.g., fatigue) to high-technology devices (e.g., warning systems, collision warning systems, intelligent cruise control, navigation systems). 5. Effectiveness of marine-collision warning systems. 6. Effectiveness of automated control systems. 7. Effectiveness of air-controlled flight systems and assessment of its impact on controlled flight into terrain.

Table 6 (Cont'd):
Specific research directives for transportation ergonomics in Canada.

Area of Interest	Recommendation for Additional Research
Organizational Issues	1. An assessment of organizational issues (from a micro- to a macro-level) that will affect the integration, acceptance and application of ergonomics for an individual client or within a transportation sector. e.g., Level I: Team interaction Level II: Corporate culture Level III: Inter-corporate/government culture The understanding of these issues is critical, for example in the evaluation of an incident such as an aircraft accident, to assess how personal interaction issues and motivation factors affect performance. (N.B., this is NOT intended to reflect such factors as shiftwork and staffing levels).
Measurement Techniques	1. Development of methods and devices to measure attentiveness/inattentiveness/fatigue in transportation personnel (pre-work and during extended work periods). 2. Correlating subjective/objective and primary and secondary task performance. 3. Usability testing and validating design-process oriented research.
Changing Demographics	1. Research to predict the impact that changing demographics and future trends (e.g., elderly/ disabled/children/women/multinational society/ increased foreign travel and communications) will have on accessibility (space and information) and safety (instructions, equipment, evacuation) of transportation systems.
Human Performance Degradation	1. Assessment and prevalence of factors that influence behaviour and performance (e.g., fatigue–outside work; work-related fatigue and shiftwork; driver/pilot work station design; substance abuse (i.e., drugs and alcohol).
Experienced vs. Novice Operators	1. Within each transportation mode, analysis of novices vs. experienced operators in terms of: type and frequency of errors; behavioral and decision-making strategies; and hazard perception. 2. Critical incident analysis of errors made by novice drivers. 3. Determination of differences in behaviour between novices and experienced drivers in order to improve training effectiveness.

5 LIMITATIONS OF STUDY

There are several limitations to the methodology used in the current project and thus to the recommendations that are provided.

- Transportation ergonomics covers such a wide range of issues and areas of expertise that it is difficult to survey in a brief study.
- It was difficult to establish a conceptual framework from which to address all areas of transportation and ergonomics within the context of this project.
- A limited number of private sector SMEs were included in the questionnaire survey and only a subset of these participated in the round table discussions.
- Input from SMEs was not equally represented, based on the relative contribution of each person to either the questionnaire or the workshop.
- Time limitations were imposed on the input from SMEs with respect to their participation in a one-day workshop and their completion of a brief questionnaire.
- By soliciting a private sector perspective of transportation ergonomics, it is possible that some bias may have been introduced by SMEs, based on individual experience or expectation.
- The literature search could only scratch the surface of all research that has been conducted, particularly in the identification of technical reports, both as a result of time required for transportation agencies in other countries to conduct a literature search and the cost proposed by some agencies for their services.
- If round table discussions were held which included stakeholders or clients of TDC, an industry perspective of current or future issues would be more clearly defined.
- The role of educational institutions was not examined with respect to delivering education programs to advance the awareness of human factors/ ergonomics.
- The project was not designed to address the division of responsibilities among jurisdictions in Canada (i.e., municipal, provincial, federal) and the impact this has on transportation ergonomics.

6 CONCLUSIONS

Based on the results of the current project, it is recommended that TDC review the information obtained from SMEs, evaluate the proposed strategies to enhance ergonomics in transportation systems in Canada, and consider the priorization of ergonomics research for transportation in Canada.

The recommendations developed in this report are similar to those developed by Wallersteiner (1992). The latter were based on input from stakeholders within Transport Canada representing a wide cross section of operation groups. As well, the input obtained independently from consultants in the private sector who specialize in transportation ergonomics was consistent with consensus statements and priority issues which were identified at two separate focus groups. Because some of the recommendations provided by private sector SMEs may be outside the current mandate of Transport Canada, it will be necessary to review the document internally in order to develop a formal strategic plan, along with an action plan and time line for implementation. Once a strategic plan has been finalized, it needs to be pursued aggressively to ensure the systematic integration of ergonomics into all aspects of transportation in Canada.

6.1 Success of the Round Table

Hosting a group of private sector ergonomists and human factors SMEs who have worked extensively in the transportation field presented a logistical challenge. The results, however, suggest that this type of forum should be used more frequently to gather input from diverse sources. The round table meetings that were an integral part of this project provided a unique forum from which TDC could obtain input that, to a large extent, was not biased by the current mandate or direction of the TDC. Feedback from participants, particularly two senior consultants who attended the Toronto workshop, indicated that the meetings achieved an enormous milestone by reaching a consensus on the strategic direction that should be considered to implement transportation ergonomics in Canada. While the strategic plan does not provide detailed action items, it achieves a framework from which TDC can deliver ergonomics and human factors expertise within all modes of transportation in Canada.

APPENDIX A

TDC Research Initiatives in Transportation Ergonomics

(categorized by mode of transportation)

Mode	Date	Title
Air	1995	Development and evaluation of a human factors training program for pilot instructors
Air	1995	Flight crew information requirements and human factors: supplemental report
Air	1994	Study for the evaluation of flight crew requirements and human factors related to a cockpit display of aircraft surface during periods of freezing precipitation
Air	1994	The development of a task network model of operator performance in a simulated air traffic control task
Air	1994	A study of the impact of shiftwork and overtime on air traffic controllers: Phase I: Determining appropriate research tools and issues
Air	1993	The pilot's guide to medical human factors
Air	1989	Human performance factors in aviation
Air	1989	A human factors evaluation of the transcribed weather broadcast system
Air	1988	Human factors in aviation
Air	1988	Ergonomically designed work station for training of electronic systems maintenance technicians
Air	1988	Development and evaluation of an ergonomically sound air traffic control work station
Air	1982	Display site equipment human factors study: Phase II report final edition
Elderly and Disabled	1994	Etude de faisabilité sur la création et la modélisation d'une banque de données anthropométriques pour les personnes handicapées et les personnes âgées

Mode	Date	Title
Elderly and Disabled	1993	Translaid: The development and demonstration of a portable communication system
Elderly and Disabled	1992	Operational analysis and ergonomic evaluation of the TESCAR SP4: Working paper
Elderly and Disabled	1992	An ergonomic evaluation of paratransit operators' jobs
Elderly and Disabled	1992	An ergonomic evaluation of a prototype design for an accessible inter-city coach
Elderly and Disabled	1992	COMMUNICAID II: Development of a prototype information system for sensory and speech impaired persons in transportation terminals
Elderly and Disabled	1992	Operational evaluation of Just Mobility flight access system and Wollard passenger access lift
Elderly and Disabled	1991	An ergonomic evaluation of a prototype design for an accessible inter-city coach
Elderly and Disabled	1990	An ergonomic assessment of loop systems for travelers with hearing impairments
Elderly and Disabled	1990	Ergonomics/engineering evaluation of EVACU-TRAC
Elderly and Disabled	1989	Ergonomic assessment of information and communication systems for travelers with disabilities
Elderly and Disabled	1989	Development of a standard interface concept for securing wheelchairs in accessible vehicles
Elderly and Disabled	1987	An ergonomic evaluation of a modified full sized Ford van and a modified Chrysler minivan for disabled drivers
Elderly and Disabled	1984	Human factors of technical aids for communication-impaired travelers

Mode	Date	Title
Elderly and Disabled	1983	An ergonomic evaluation of the Elswick Envoy
Elderly and Disabled	1983	An ergonomic evaluation of the Elswick Envoy: Summary
Elderly and Disabled	1977	An assessment of the human factors of transportation
General	1993	Study of operator performance measurement for different modes of transportation: Part I : Air transportation
General	1991	Ergonomic assessment of the revenue collector job: Final report
Marine	1995	Hearing standards for Canadian Coast Guard seagoing personnel: A preliminary investigation
Marine	1995	Shift schedule comparison for the Canadian Coast Guard
Marine	1994	Vision and work at sea: The relationship between visual acuity and colour vision and performance on deck, engineering and logistics tasks of the Canadian Coast Guard
Marine	1990	Vessel traffic services task analysis: Marine traffic regulator
Marine	1989	Human factors in the naval environment: A review of motion sickness and biodynamic problems
Marine	1989	Work scheduling on Canadian Coast Guard ships: Physiological and psychological impacts: Summary report
Marine	1988	The marine piloting display
Marine	1986	Arctic task analysis and navigability study
Marine	1986	Arctic navigation task analysis: Data base and modeling
Marine	1986	An ergonomic evaluation of STAR-VUE and NAV-Ice
Marine	1985	Ergonomic and research applications in the development of an Arctic shiphandling simulator: Summary report
Marine	1985	Ergonomic and research applications in the development of an Arctic shiphandling simulator: Final report
Rail	1995	The use of EEG and MEG to study rail operator fatigue
Rail	1992	Critical incidents and fatigue in Canadian railway operation reported by locomotive engineers

Mode	Date	Title
Rail	1988	Ergonomics evaluation of CP Rail's new road freight locomotive cab design
Rail	1984	Human factors in rail passenger car design
Rail	1980	Human factors considerations in locomotive cab design
Surface	1995	Crash experience of truck permit holders: Diabetic versus healthy ones
Surface	1995	Medical conditions and the severity of commercial motor vehicle (CMV) drivers' road accidents
Surface	1993	Medical conditions, risk exposure and truck drivers' accidents: An analysis with count data regression models
Surface	1992	Ergonomic study of the driver's work station in urban buses
Surface	1991	Specification of a methodology for investigating the human factors of advanced driver information systems
Surface	1991	Study of operator performance measurement
Surface	1990	Attention and performance while driving with auxiliary in-vehicle displays
Surface	1988	Evaluation of a multipurpose rural vehicle
Surface	1984	Retroflective markings on heavy trucks: Demonstration and seminar
Surface	1983	Ergonomics and skidder operations in Northern Ontario: A preliminary investigation

APPENDIX B

National and International Information Sources

1. Transportation Development Centre Library
   Contact: Meridith Giffin
   Tel: 514-283-0007
   Fax: 514-283-7158

2. Volpe National Transportation Centre:
   Technical Information Centre
   Tel: 617-494-2306

3. Nico Kaptein
   TNO Human Factors Research Institute
   Soesterberg, Netherlands
   Fax: 31-3463-5-39-77
   email: Kaptein@tm.tno.nl

4. Dr. Tom Triggs
   Psychology Dept.
   Monash University
   Clayton, Australia
   email: tom.triggs@monash.edu.au

5. Dr. Heikki Summalla
   Psychology Dept. Univ of Helsinki
   Helsinki, Finland
   Fax: 358-0-191-23468
   email: Heikki.Summalla@helsinki.fi

6. Transport Canada
   Contact: Sharon Moran
   Tel: 613-998-5130

7. Ergonomics Information Analysis Centre
   The University of Birmingham
   School of Manufacturing and Mechanical Engineering
   Edgbaston
   Birmingham, B15 2TT
   England
   Ergonomics Abstracts 1990-1996
   Contact: C Stapleton
   Tel: 021-414-4239
   Fax: 021-414-3476

8. David Shinar
   Ben-Gurion University
   Beer-Sheva, Israel
   email: shinar@bgumail.bgu.ac.il

9. Peter Cairney
   Australian Road Research Board
   South Vermont, Australia
   Fax: 03-9887-8104

APPENDIX C

Literature Search

General

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Air

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APPENDIX D

Transportation Ergonomics Questionnaire

1. In your opinion what would be a comprehensive definition of transportation ergonomics?

2. Given the above definition, expand on the areas where human factors should be given consideration in the following modes of transportation? We recognize that you will have a greater ability to answer this question as it pertains to your area of expertise.

   a) Air

   b) Rail

   c) Marine

   d) Surface

3. The areas listed below have been developed from an initial review of the literature within this field. Please indicate your opinion on the level of importance this topic has in light of operational demands in the field of transportation today.

a)	Anthropometry	none ❑	mild ##	moderate ▯	high ##
b)	Disabled	none ❑	mild ##	moderate ##	high ##
c)	Elderly	none ❑	mild ##	moderate ▯	high ##
d)	Fit for work	none ❑	mild ##	moderate ##	high ##
e)	Hearing	none ❑	mild ❑	moderate ❑	high ❑
f)	Human error/critical incidents	none ##	mild ##	moderate ##	high ##
g)	Human-computer interactions	none ❑	mild ❑	moderate ❑	high ▯
h)	Impairment (fatigue, drugs/alcohol)	none ##	mild ##	moderate ##	high ##
i)	Information processing	none ❑	mild ❑	moderate ❑	high ##
j)	Performance limitations	none ##	mild ##	moderate ##	high ❑
k)	Regulations	none ##	mild ##	moderate ##	high ##
l)	Screen/display/control design	none ##	mild ##	moderate ##	high ❑
m)	Shiftwork	none ❑	mild ▯	moderate ##	high ##
n)	Signage	none ❑	mild ❑	moderate ##	high ❑
o)	Situational awareness	none ❑	mild ❑	moderate ##	high ##
p)	Training	none ❑	mild ❑	moderate ❑	high ❑
q)	Transportation of dangerous goods	none ❑	mild ##	moderate ##	high ##
r)	Use of simulators	none ❑	mild ##	moderate ##	high ##
s)	Vision	none ❑	mild ❑	moderate ##	high ❑
t)	Work station design	none ##	mild ##	moderate ##	high ❑
u)	Workload	none ##	mild ❑	moderate ❑	high ##
other:_____		none ##	mild ❑	moderate ❑	high ❑
other:_____		none ##	mild ##	moderate ##	high ❑
other:_____		none ##	mild ▯	moderate ##	high ❑

4. Indicate which of the following areas you consider to need more research?

a) Anthropometry	yes ##	no ❑
b) Disabled	yes ##	no ❑
c) Elderly	yes ##	no ##
d) Fit for work	yes ##	no ##
e) Hearing	yes ❑	no ##
f) Human error/critical incidents	yes ❑	no ##
g) Human-computer interactions	yes ##	no ##
h) Impairment (fatigue, drugs/alcohol)	yes ##	no ##
i) Information processing	yes ##	no ##
j) Performance limitations	yes ##	no ##
k) Regulations	yes ▯	no ##
l) Screen/display/control design	yes ##	no ##
m) Shiftwork	yes ##	no ##
n) Signage	yes ##	no ##
o) Situational awareness	yes ##	no ##
p) Training	yes ##	no ##
q) Transportation of dangerous goods	yes ##	no ##
r) Use of simulators	yes ❑	no ❑
s) Vision	yes ##	no ##
t) Work station design	yes ##	no ##
u) Workload	yes ❑	no ##
other:_____	yes ##	no ##
other:_____	yes ##	no ##
other:_____	yes ##	no ##

5. If you answered "yes" to any of the areas indicate what you consider to be the main gaps in our knowledge.

6. In your opinion, what ergonomic questions or concerns should be addressed in Canada in the near future (next five years). Please list the areas below and provide, or attach, a brief rationale for rating.

7. Are you currently involved in research transportation ergonomics?

   yes ##

   no ##

8. If yes, please describe.

9. Are you planning any research in this area within the next 5 years? (Please describe)

10. Please list any published or unpublished information that you have contributed to that pertains to this field. If you have unpublished information that you are prepared to share, it would be appreciated if you would send copies with your return.

11. If there are any of your responses that you wish to **remain confidential to us**, please tick the box against the appropriate question number below:

Q1 ##	Q6 ##
Q2 ##	Q7 ##
Q3 ##	Q8 ##
Q4 ##	Q9 ##
Q5 ##	Q10 ##

APPENDIX E

Results of Questionnaire: Tabulated Data

Table E1: Frequency and percentage of responses in Question 3, ranked in order of descending importance.

Table E2: Frequency and percentage of responses in Question 4, ranked in order of descending importance.

Table E1:
Frequency and percentage of responses in Question 3 (*Question 3: Please indicate your opinion on the level of importance this topic has in light of operational demands in the field of transportation today.*), ranked in the order of descending importance.

	Frequency of Response/Percentage of Total (n=20)									
	Level of Importance									
	No Response		**None**		**Mild**		**Moderate**		**High**	
Category	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
f) Human error/critical incidents	0	0	0	0	1	5	1	5	18	**90**
i) Information processing	0	0	0	0	1	5	3	15	16	**80**
g) Human-computer interactions	0	0	0	0	2	10	3	15	15	**75**
o) Situational awareness	0	0	1	5	2	10	2	10	15	**75**
p) Training	0	0	0	0	3	15	6	30	11	**55**
h) Impairment (fatigue, drug/alcohol)	0	0	0	0	2	10	8	40	10	**50**
m)Shift work	0	0	1	5	1	5	8	40	10	**50**
u) Workload	0	0	0	0	3	15	7	35	10	**50**
c) Elderly	2	10	0	0	3	15	6	30	9	**45**
d) Fit for work	1	5	0	0	5	25	5	25	9	**45**
j) Performance limitations	0	0	0	0	1	5	10	50	9	**45**
l) Screen/display/control design	0	0	0	0	2	10	9	45	9	**45**
t) Work station design	0	0	0	0	5	25	6	30	9	**45**
k) Regulations	1	5	0	0	6	30	6	30	7	**35**
s) Vision	2	10	1	5	3	15	8	40	6	**30**
a) Anthropometry	3	15	0	0	10	50	2	10	5	**25**
b) Disabled	2	10	0	0	4	20	9	45	5	**25**
n) Signage	1	5	0	0	4	20	10	50	5	**25**
r) Use of simulators	0	0	0	0	3	15	12	60	5	**25**
e) Hearing	4	20	2	10	5	25	5	25	4	**20**
q) Transportation of dangerous goods	1	5	2	10	11	55	3	15	3	**15**
other:_____*	10	50	0	0	0	0	2	10	8	**40**
other:_____*	12	60	0	0	0	0	1	5	7	**35**
other:_____*	14	70	0	0	0	0	2	10	4	**20**

* **Responses to "Other" include: Interaction (high); Human resources administration (high); Groupware–emergency response (high); Network control (high); Maintenance (moderate); Communication (high); Automation (high); Function allocation (moderate); Safety system design (high).**

Table E2:
Frequency and percentage of responses in Question 4 (*Question 4: Indicate which of the following areas you consider need more research.*), ranked in the order of descending importance.

Frequency of Response/Percentage of Total (n=18)

	Responses					
	No Response		Yes		No	
Category	**Freq.**	**%**	**Freq.**	**%**	**Freq.**	**%**
f) Human error/critical incidents	0	0	18	**100**	0	0
g) Human-computer interactions	0	0	16	**89**	2	11
h) Impairment (fatigue, drug/alcohol)	0	0	15	**83**	3	17
j) Performance limitations	0	0	15	**83**	3	17
l) Screen/display/control design	0	0	14	**78**	4	22
m) Shift work	0	0	14	**78**	4	22
o) Situational awareness	1	0	14	**78**	3	17
c) Elderly	0	0	13	**72**	5	28
i) Information processing	0	0	13	**72**	5	28
r) Use of simulators	0	0	12	**67**	6	33
u) Workload	1	6	12	**67**	5	28
d) Fit for work	1	9	11	**61**	6	33
p) Training	0	0	11	**61**	7	39
b) Disabled	0	0	10	**56**	8	44
k) Regulations	0	0	10	**56**	8	44
n) Signage	0	0	10	**56**	8	44
t) Work station design	1	6	10	**56**	7	39
s) Vision	2	11	8	**44**	8	44
a) Anthropometry	1	6	6	**33**	11	61
q) Transportation of dangerous goods	1	6	5	**28**	12	67
e) Hearing	2	11	4	**22**	12	67
other:_____*	10	56	6	**33**	2	11
other:_____*	11	61	5	**28**	2	11
other:_____*	12	67	4	**22**	2	11

* **Responses to "Other" include: Groupware; Network Control; Maintenance; Operator selection; Incentive schemes; Communication issues; Automation; Function allocation-hybrid tasks; Usability criteria; Safety systems.**

APPENDIX F

Summary of Questionnaire Comments and Round Table Discussions

The following is a summary of the information received in response to a questionnaire on transportation ergonomics circulated by the Transportation Development Centre. The questionnaire (Appendix D) was designed as a tool to gather information and opinions from subject matter experts (SMEs) in ergonomics and human factors in relation to transportation in Canada. Responses to the questionnaire were circulated to two groups of SMEs who subsequently met for discussions in Vancouver (July 25, 1996) and Toronto (July 29, 1996).

Detailed responses are provided to each of the following questions:

Question #1: In your opinion what would be a comprehensive definition of transportation ergonomics?

Question #2: Given the above definition, expand on the areas where human factors should be given consideration in the following modes of transportation? We recognize that you will have a greater ability to answer this question as it pertains to your area of expertise.

Question #5: If you answered "yes" to any of the areas indicate what you consider to be the main gaps in our knowledge.

Question #6: In your opinion, what ergonomic questions or concerns should be addressed in Canada in the near future (next 5 years). Please list the areas below and provide, or attach a brief rationale for rating.

The statements contained in this summary are, in most cases, verbatim from the questionnaires that were received. Occasionally, clarification of a response was required and obtained from the individual who submitted the response.

Question #1: In your opinion what would be a comprehensive definition of transportation ergonomics?

"A subject dealing with unique issues relating to operators and customers using any form of physical transportation."

"Transportation ergonomics is the study of the factors and the interaction of factors (people, environment, machines, procedures) influencing the safe and effective working of people engaged in the delivery of safety-sensitive services."

"The study of humans in a work environment where they can conduct manual and intellectual tasks in a natural fashion."

"Ergonomics studies human activity that is directed towards the performance of goal oriented tasks and consists of procedures, techniques and data that enable ergonomists to analyze and optimize such activities. Transportation ergonomics is the application of this body knowledge to transportation systems that consist essentially of vehicles and guideways. Human activity in transportation systems includes designing, operating, maintaining and using (traveling on) vehicles and guideways and managing vehicle movements to achieve successful, conflict free, outcomes."

"Transportation ergonomics is the physical and mutual interaction of users with transportation equipment, procedures, environment and other humanoids."

"Transportation ergonomics is the understanding of human (as operators, passengers, pedestrians, bystanders) interaction with the transport system (all modes, all interfaces: way, vehicle & terminal) through the application of scientific system analysis techniques."

"Optimizing safety and human performance in the face of forces produced by economics, society, law and personnel mobility."

"The technology concerned to optimize the relationships between people and their activities by the systematic application of the human sciences, integrated with the framework of system engineering."

"Anytime humans are involved."

"Application of ergonomics knowledge and methods to human equipment/ environment interface for the operation and/or user in all types of transportation modalities, including the operational environment as applicable."

"Transportation ergonomics describes a field of research and application which involves the consideration of human physical, perceptual, and cognitive limitations as they impact operator performance and design of workspaces, tools, displays, and controls."

"The study of the relationship between people and their mode or means of transportation (being conveyed from place to place) and efforts to improve the efficiency, correct, and safe use of same.

"The application of ergonomic knowledge (viz. human abilities, limitations and characteristics) to the design of tools, machines, systems, tasks, jobs and environments for safe, comfortable, and effective transportation."

"The application of knowledge about human capabilities and limitations to transportation systems."

"The design of transportation hardware and operating procedures for the purpose of enhancing user productivity, comfort, safety and satisfaction."

"The study of, and design and evaluation for those aspects of a transportation system, equipment, facility, space, job, process or product with which humans interact with the aim to improve such interactions."

"Research into, and application of knowledge about, human abilities and limitations as they relate to person-machine interface within physical and social environments, in the broad field of transportation. This includes machine design and use (e.g., vehicles), built environments (e.g., terminals), information systems (e.g., traffic signs), infrastructure (e.g., roadway design), safety (e.g., accident investigation), human performance decrement (e.g., influence of fatigue, human error), and the impact of environmental factors such as illumination and weather on operator performance."

"The systematic application of life science knowledge about:

- Drug and alcohol effects
- Selection based on job demands (Human Rights considerations)
- Perception and information processing of <u>all</u> operators/users—not just elderly, impaired, novices
- Impact of environmental factors (especially cold weather and darkness) on operator performance
- Operator mental models of automated, CRT based systems
- Cultural/ethnic expectations/attitudes
- Provincial/national/international expectations re: regulations/signage
- Varying injury tolerance levels with different ages, physiques, etc.
- Changes in performance with experience
- Cognitive capacities and information processing rate
- Perceptual capacities e.g. vision (acuity, static and dynamic contrast sensitivity, depth vision, colour vision), hearing (thresholds, frequency, range)

- Development and validation of measures of performance

###Effect of psychological and physical stress on human performance and the psychological, physical and social attributes of human beings to the design, development and use of identified transportation systems, as a whole or in part, to benefit well-being and performance of all users and operators of those systems."

"The evaluation and optimization of the interrelationship between people, processes, equipment and environments in current and future transportation systems in order to improve system performance, decrease accidents and increase system usability."

"Ergonomics seeks to optimize the fit between people and their work. Transportation ergonomics would then address the fit between the operator and his/her environment in terms of the priorities of transportation (e.g., safety and efficiency)."

Question #2: ***Given the above definition, expand on the areas where human factors should be given consideration in the following modes of transportation? We recognize that you will have a greater ability to answer this question as it pertains to your area of expertise.***

The following section summarizes the answers to Question 2. The responses were organized into the categories provided in **Section 3,** Table 2. A summary of answers relevant to all categories is given first, followed by lists specific to each mode of travel

All Modes of Transportation

Personnel

- Special needs persons, the elderly and disabled
- Fatigue
- Workload
- Age related sensory perceptual, cognitive and motor changes
- Transportation and injury control systems to accommodate the anthropometric characteristics of the entire occupant population
- Training and selection

Policies, Procedures and Regulations

- Development/evaluation of training procedures
- Maintenance manuals
- Personnel training and selection
- Scheduling
- Policies requiring application of ergonomics knowledge in design of equipment
- Manuals for correct use of safety systems
- Emergency preparedness manuals
- Usage instructions
- Development/evaluation of operational procedures
- Regulations to prevent operator overload in use of high technology devices
- Development of regulations which take into account human capabilities and limitations
- Develop policies to incorporate ergonomic considerations into systems specification and regulations
- Qualifications of people who deliver training and education
- Criteria for "ease of correct use" in regulations
- Inclusion of ergonomic requirements in regulations/standards

Systems Design

- Decision making, information processing
- Control/display panels
- Improved signage
- Evaluation/usability of new products and procedures
- Development of measurement tools/protocols to assess usability of new products/procedures
- Optimal/improved presentation of public travel information such as departure time, gate number , etc., to ensure passengers find correct departure time/place
- Design & construction
- Instruments, equipment and documents
- Communications
- Emergency planning
- Environmental protection
- Work-site risk factors
- Effective tolerance controls
- Work cards for aircraft, train, ship inspection tasks
- Thermal discomfort and effect on decision making, human error, etc.
- Better implementation of known remedial measures
- Automation
- Information and handling systems
- Proper evaluation of existing and new information systems
- Feedback—keeping the "operator in the loop"
- Correct use of safety systems (injury control)
- Develop user-centered design approaches
- Maintain uniformity of design across different systems
- Intuitive display design
- Analysis of human error leading to incidents and accidents
- Displaying situationally relevant information (not overloading the operator with too much information)
- MMEA—Misuse Mode and Effects Analysis (e.g., likelihood of incorrect seat belt use and injurious consequences of each misuse type)

Other

- Principles of the new economy (e.g. doing more with less)

Air

Air Traffic Control

- Performance criteria for controllers
- Air traffic services
- Aeronautical telecommunications
- Meteorology information
- Aeronautical charts
- Units of measurements internationally
- Free Flight environments
- Shiftwork scheduling
- Coordinate Canadian Air Traffic Control (ATC) procedures with changes occurring in the U.S. and internationally
- Incorporating ergonomics consideration into the design of ATC systems
- Train operators to prioritize incoming information
- Manuals, ongoing evaluation, assessment, employee guidelines
- Moving from semi- to fully automated
- Simulators
- Improved prediction of future performance based on selection criteria
- Issue of failure detection in an automated system (e.g., moving from a semi-automated system to an automated system impacts the time it takes for an operator to detect a failure)
- Impact of automation on human performance
- Design and evaluation of air traffic control centres and towers
- Improved prediction of future performance based on selection criteria
- The evaluation of air traffic control systems and performance of operators, especially as related to any recent changes in ATC procedures in North America
- Control room design—impact of new systems (e.g., Canadian Automated Air Traffic System—CAATS)

Cockpit Crew

- Pilot fatigue & scheduling algorithms & countermeasures
- Study of ergonomics/human factors issues in the design and operation of advanced air navigation systems (e.g., FANS)
- Study of fatigue in pilots in a simulated flight environment, examining social, psychological, health and performance consequences
- Mode confusion in automated aircraft
- Pilot selection as based on psychometric (not EEG) multitasking analyses
- Use of part-task simulators in pilot training

- Cultural norms/corporate culture and its effect on safety
- Aeronautical telecommunications
- Instruments, equipment flight documents
- Meteorology information
- Aeronautical charts
- Units of measurements internationally
- Free flight environments
- Fatigue/shift scheduling
- Diagnosis related to clear air turbulence
- Need for valid and reliable measurement techniques
- Crew effectiveness in emergency situations (evacuation of passengers)
- Cockpit resource management
- Relationship between situation awareness and workload
- Proper use of safety checklists prior to take off
- Proper post flight check and reporting of near and real incidents, mechanical dysfunction
- Training crews in strategies for managing workload (i.e., chunking information)
- Age limits for licensing pilots
- Performance and age criteria for pilots
- Create conditions which enhance flying pilot's adherence to procedures. Disregard for procedures, frequently triggered by time or economic pressures, is the prominent cause of aviation accidents (David L. Huntzinger, Ph.D., Boeing, Seattle; personal communication—G. J. S. Wilde)
- Usability of specialized clothing and equipment (e.g., constant wear life jackets)
- Assessment of (change of) personnel performance over time (not just during shift but each year, etc.)
- Effect of use of personal safety equipment on performance
- Special needs of physically impaired pilots
- Integration of systems in the cockpit and the crew areas
- "Jet lag" effects on crews—shiftwork/ rotations
- Design of shift schedules for employees
- Automation issues/supervisory control, complacency, boredom, high mental workload and low physical workload, keeping the pilot "in the loop", demands of the pilot, monitoring workload, situation awareness, failure detection
- Fatigue
- Controlled flight into terrain, accidents

Maintenance

- Effects of fatigue on aircraft maintenance engineers
- Maintenance manuals

- Diagnosis and decision making
- Coordinated design of equipment/machines so that number of tools are minimal (e.g., Comanche engine)
- Quality control of the work that they have done
- Design of systems for ease of maintenance
- Design for ease of access in maintenance
- Proper safety checks
- Work environment layout for maintenance on aircraft
- Work environment of maintenance personnel
- Tools
- Design and evaluation of maintenance areas and tools used for aircraft maintenance
- Maintainability assessments of aircraft
- Do not overload the limits of human mental capabilities
- Maintenance inspections and verification (e.g., self inspection, inspection by others, verification of key steps in assembly and repair vs. verification by operation only)

Passengers

- Information and handling systems: ground facility passenger
- Passenger access and egress
- Visibility and location of signage
- Design of seating on airplane
- Lifevest design and utilization
- Emergency procedures (egress, equipment and seat design)
- Bathroom access for normal and disabled
- Adequacy of safety procedure cards in commercial aircraft
- Passenger behaviour in emergency situation (e.g., how they reach and behave)
- Improving procedure for evacuating passengers
- Reality of safety systems (e.g., holding infants during takeoff/landing vs. restraints)
- Transport passengers from airport doors to correct craft safely
- Control/enforce procedures re: size and weight of "carry on" luggage in overhead bins
- Design of egress chutes
- Transport of children

Support Systems

- Slip and fall injuries/back injuries

- Evaluation of physical loading on baggage handlers
- Aerodrome emergency planning
- Rescue and fire fighting
- Evaluation of physical loading on baggage handlers
- Design of baggage handling systems
- Information baggage mass
- Awareness of reduced decision making of fatigued travelers
- Safety equipment used by rescue and fire fighters
- "Stop lights" in plane parking re: reaction time required to turn/stop plane
- Using type of data which "Black Box" record (i.e., human performance for accident recreation)
- Interaction between pilots/ground crew
- Design of information systems on-board aircraft, in terminals and control centres

Terminals

- Input of air crew (pilots/hostess) to airport design
- Assistance for elderly/disabled/parents in airports
- Design and accessibility issues for the elderly and handicapped in airports, on aircraft and on associated ground transportation systems
- Way finding (signs/maps) in terminals
- Accessibility of aircraft terminals for elderly/disabled

Training

- Use of part-task simulators in pilot training
- Use of whole task simulators
- Relation of job demands to training content
- Use of aircraft data monitoring of operator performance in evaluation and training and system design
- Correct interpretation of instructions, manuals, international symbols
- Re-current training
- Training based on real-world incidents and accidents

General

- Modeling crew resource management tasks, air traffic control tasks, aircraft piloting tasks, ground crew maintenance tasks, etc.
- Aircraft flight performance
- Useability of the HCI of safety critical software

- Ergonomics issues of scheduling and hours of work (time of day and duration)
- Access to "near miss" data
- Job design and injury prevention
- Macroergonomic issues (organizational and management issues affecting work done and procedures)
- On-line data collection to look at trends over time (e.g., particular procedures can be modified based on consistent/ongoing performance)
- Cues for self-awareness of reduced performance (e.g., from fatigue)
- Design and safety of ultra-light aircraft
- Study of human error causation and processes
- Survey (social, psychology, health, performance) of the impact of shiftwork and overtime on aircraft maintenance crews, commercial and recreational pilots, air cabin crews, and flight service operators
- Study of sleep and activity log data collected by aircraft maintenance crews, commercial and recreational pilots, air cabin crews and flight service operators
- Planning, monitoring, recording of performance of crew
- Design of seating/workstations

Rail

Driver

- Driver behaviour at at-grade crossings

Crew

- Incentive schemes
- Design and evaluation of locomotive cabs (controls/displays, interior layout, HCI software and lighting, air conditioning and noise levels)
- Study of the impact of fatigue on the health, psychological well-being, social well-being, and performance of engineers, conductors, maintenance crews, and operators in command, control and communication centres
- Simulation training
- Comfort and systems
- One-man operation
- Evaluation of fatigue countermeasures
- Causes of human error in rail systems and study of ergonomics/human factors issues of system safety design
- Evaluation of new braking system
- Evaluation of new implemented technologies
- Multitasking aspects of operators task
- Noise effects

- Slip and fall injuries/back injuries
- Emergency preparedness for derailment, avalanche, washout, environmental catastrophes
- Effects of vibration on crew performance and fatigue
- Work schedules/shiftwork
- Railway control devices and signage and engineer response
- Create a vigilance device for locomotive crew which does not only ensure that the operator is awake, but is also paying attention to crucial elements of the task of train driving (Wilde, G.J.S. and Stinson, J.F. The Monitoring of Vigilance in Locomotive Engineers. Accident Analysis and Prevention, 1983, 15, 87-93).
- The impact of work schedule and fatigue on rail operations
- Shift schedules
- Automation systems—advanced train control systems (ATCS), radio communication systems, planning, monitoring, recording
- Shiftwork, work schedules
- The physical environment

Passengers

- Access/egress for passengers
- Comfort and systems
- Noise effects
- Effective communications between crew and passengers
- Study of accessibility issues for the elderly and handicapped in train stations, on trains and on ground transportation systems
- Environmental effects of vibration, noise and temperature
- Clarity of announcements in moving trains
- Safety/emergency procedure for explanations/signage
- Accessibility of cars and terminals

Systems

- Hi-speed train systems
- Automation of systems to avoid human error (e.g., red lights trigger brakes on the train)
- Crossing improvements
- Cognitive modeling of engineman and operators in command, control and communication centres
- Usability of the HCI of safety critical software
- Ergonomic issues of scheduling and hours of work (time of day and duration)
- Job design and injury prevention

- Macroergonomic issues (organizational and management issues affecting work done and procedures)
- Anti-vandal systems
- Usability of advanced systems for passenger screening, flight data management, etc.
- Visibility of trains at night
- Maintainability of rail equipment and systems
- Pedestrians at at-grade crossings, pedestrian expectations re: number and directions of incoming trains, pedestrian response to warning signals and barrier movements
- Radio communication systems
- Timely and correct identification of hazards (e.g., little and big animals)

Dispatching Centres

- Effective communications (consistency in communications)
- Shift scheduling
- Work station design
- Design and evaluation of control, command and communications centres.

###Identification of hazardous cargo in a derailment/crash by emergency personnel

- Control room design and information processing

Marine

Crew

- Study of the impact of fatigue on the health, psychological well-being, social well-being, and performance of bridge, maintenance and engine crews
- HCI design for bridge personnel
- "Installation" of wheelhouse with regards to the layout of electronic equipment
- Integration of diverse electronic equipment
- Psychometric analyses of multitasking aspects of operator's task
- Automation
- CRM (Cockpit/Bridge resource management) research and training
- Decision making in emergency situations if pollutant cargo
- Seating of watchkeepers
- Work schedule/fatigue among crew members
- Shiftwork/shift scheduling
- Motion effects on performance including: slow wave, vibration, impact/ slamming

- Noise/vibration effects on performance
- Motion sickness effects on performance
- Perceptual problems of the operator (concerning vision, attention, noticing other vessels)
- Design of safety equipment for small craft users (e.g., to encourage use)
- Alcohol use by crew and recreational boaters
- Drug and alcohol effects on performance and attitude
- Maintenance of alertness in monotonous environments
- Identification of warning systems to other users in small craft zone
- Licensing/registration of pleasure craft (drivers/"pilots")
- Safety education of small craft/recreational users
- Effects of environment on performance (e.g., noise, vibration, sea state, etc.)
- Work station design
- Create a vigilance device for ship's crew which does not only ensure that the operator is awake, but is also paying attention to crucial elements of the task
- Shift schedules in Coast Guard; effective search patterns
- The impact of work schedule and fatigue on marine operations
- Physical environment
- Design
- Human error
- Accidents
- Rostering
- Maintenance and technical upkeep
- Management
- Training

Passengers

- Access for the elderly and disabled travelers, esp. emergency evacuation warnings & procedures
- Wayfinding/signage on ferries (especially emergencies)
- Anthropometric consideration in design (height of walkways, strength requirements to open doors, operate equipment)
- Identification of areas of greatest marine transportation-risk of ergonomic needs
- Height consideration in bunks

Systems

- Computer assisted decision making

- Design and evaluation of bridge and command, control and communications systems
- Maintainability design and evaluation of marine vessels
- Design and evaluation of port facilities and support systems for loading and unloading marine vessels
- Design and evaluation of harbour and channel traffic control systems
- Design and evaluation of safety systems and equipment (life jackets, rafts, survival kits and suits)
- Integration of diverse electronic equipment
- "Installation" and physical configuration of boats and ships
- Usabilty of emergency system by all ranges of people
- Integration of systems on bridge and in engine control areas
- Maintainability, design and evaluation of marine vessels
- Ergonomics issues of scheduling and hours of work (time of day and duration)
- Job design and injury prevention
- Macro-ergonomic issues (organizational and management issues affecting work done and procedures)
- Control room design
- Impact of decreased manual lighthouse stations
- Communication

Surface

- Height consideration in bumper design (i.e., anthropometric features of pedestrians in designing vehicle exteriors)
- How age or special needs related sensory, perceptual, cognitive and motor changes affect safe transportation (drivers, pedestrians, cyclists)
- User information—readability, comprehension, legibility
- Drug and alcohol effects

Driver

- User groups—military, agricultural, commercial, pleasure etc.
- Study of the impact of fatigue on the health, psychological well-being, social well-being, and performance of drivers (all types) commercial vehicle maintenance crews, etc.
- Electronic information and traffic handling systems
- Useability studies and an understanding of driver mental models for in-vehicle devices such as navigation systems intelligent cruise control systems, and collision warning systems
- Driver training on handling elderly and disabled passengers, esp. on wheelchair securement and transfer procedures

- Medications for elderly and driving performance
- Skill maintenance/deterioration for the elderly
- Substance abuse esp. drinking-driving
- Efficacy and safety of ITS technology
- Modulating (training) safe and unsafe driving behavior
- Specialized training
- Warning and barrier devices used at railway crossings
- Grade crossing accidents
- Rural intersection accidents at night
- Urban intersection accidents in high density traffic
- Community knowledge and awareness of specific vehicle safety features such as airbags and anti-lock braking systems
- Promoting consumer demand for safer vehicles through education
- Risk factors for agriculture transportation related injuries
- Fitness for duty testing for trucking companies
- IVIS & intelligent in-vehicle systems (especially as they affect the E&D)
- Small-scale highly controlled truck driver fatigue studies
- Evaluation of drivers' fatigue countermeasures
- Truck driver fatigue, scheduling, incentive schemes
- Adaptation of drivers to new in-vehicle information systems
- Driver awareness of pedestrians during turning movements
- Driver behaviour—hazardous thought patterns (risk taking)
- Driver detection/identification of roadway hazards
- Perceived driver limitations/ability to change (e.g., steering wheel vs. alternate system)
- More adequate education of new drivers re: information processing and decision making
- Use of simulators for specialized training and assessment (e.g., assessment of brain damaged subjects, training novice drivers in hazard perception)
- Distractions (e.g., children, drunk passengers)
- Unique driver skills for different road vehicles (e.g., little car, big truck, motorcycle)
- Control of drunk passengers
- Driver skill under sub-optimal conditions (winter/darkness/rain/fog)
- Design of traffic control devices with elderly drivers in mind
- Validation of simulators to predict on-road performance
- Driver response (speed, acceleration) to roadway design (sight distance, curvature, lane work, shoulder width, clearance zones, intersection layout)
- Driver awareness of high way hazards

- Driver perception and information processing
- Limitations of the elderly driver
- Stressors (fatigue, alcohol, stress, physical conditions)
- Driver behaviour
- Situational awareness
- Workload
- Fit for work

Maintenance

- Vehicle maintenance
- Design of vehicles/systems/tools for ease of maintenance (general maintenance)
- Maintenance for continued safe operation (general maintenance)
- Design of manuals for ease of use (general maintenance)
- Decision making on road-worthiness of vehicles post-crash
- Safety system continued usability

Passenger

- Electronic information and traffic handling systems
- Urban bus access
- Securement for wheelchairs
- Boarding equipment for rural stations
- ITS and effect on elderly and disabled drivers, passengers & pedestrians
- Driver training on handling elderly and disabled passengers, esp. on wheelchair securement and transfer procedures
- Community knowledge and awareness of specific vehicle safety features such as airbags and anti-lock braking systems
- Promoting consumer demand for safer vehicles through education
- Instructions for selection and correct use of safety systems (e.g., head restraints)
- Proper use of seat belts, headrests, SRS
- Use of passengers as navigators
- Better selection and fitting of safety systems
- Safe accommodation of all sizes and all ages, animals and baggage

Pedestrians

- Walking conditions in snow/slush re: older pedestrians
- Visibility of pedestrians at night
- Curb height perception, for elderly, small children, special needs

- Pedestrian estimates of visibility at night
- Reaction time and walking speed in design of pedestrian crossings
- Pedestrian height in design of pedestrian barriers
- Visibility of pedestrian (e.g., little children, baby carriages) behind vehicles in parking lots
- Safe accommodation of all sizes and all ages, animals and baggage

Vehicle and Road Design

- Reflective markings on vehicles
- Design of safety systems to accommodate entire population (e.g., head restraints, seat belts, air bags)
- Instructions/symbols for correct use of manual safety equipment (seatbelts, child restraints)
- Standardization of auto design for ease of transfer from one vehicle to another (e.g., rental cars)
- Uniformity of control system
- Studies should be undertaken to investigate the actual safety effects (per km driven as well as per hour of exposure) of "intelligent" highway and automobile design. There are reasons for fearing that the safety benefits will be much smaller than is often assumed (Wilde, G.J.S. Véhicule information et sécurité routierè. Recherche-Transports-Sécurité, No. 26, Juin, 1990, 29-36).
- Design of child restraint systems
- Roadway design with ergonomics in mind (positive guidance)
- Design/illumination of crosswalks for pedestrian safety
- Design of sidewalks re: disabled (e.g., conflict of needs between wheelchair and blind individuals)
- Traffic signal visibility problems (e.g., glare, colour blindness)
- Visibility and safe crossing of roadway by pedestrian (no off-road obstructions, e.g., pedestrian stop barriers, trees, etc.)
- Identification of road hazards okay to hit vs. not hit (e.g., crushable drum vs. tree)
- Windshield and side window light transmission and driver needs
- Design of warning devices (e.g., turn signals, hazard lights, high mounted stop lights)
- Design of symbols for dashboards
- Rear vision mirrors (different types)
- Vehicle features for prevention of use by drunk drivers (e.g., interlock)
- Design of headlight systems

- Design and integration of ITS devices (e.g., collision warning, navigation, intelligent cruise control and consideration of reaction times of a wide range of drivers and information processing rates)
- Adaptive control design
- Standardization of controls and displays between vehicles

Regulations

- Modulating (training) safe and unsafe driving behaviour
- Procedures for standard road safety audits for identification of potential problems related to human use, errors, misuse
- Medical conditions and medication
- Regulations for safety systems that accommodate entire road user population
- Regulations to incorporate criteria for usability of safety systems
- Meaningful regulations which are correctly interpreted
- Harmonization and involvement with ISO groups
- Selection and fitting of safety systems
- Regulatory control of driver behaviour (e.g., drunk driver)
- Driver maintenance re: training and vision checks
- Consistent approach to driver education/graded licensing for new drivers/ new Canadians
- Regulations re: operation of non-task related equipment (e.g., cellular phones)
- Regulation of devices which promote design of better fitting safety systems (e.g., Belt Fit Test Device)
- Quality of driver instruction and qualifications of driving instructors
- Truck driver safety (fatigue, alcohol and drug use)

Enforcement of Regulations

- Driver perception of fairness of enforcement
- Driver/passenger perception of safety strategies regulatory potential (through education)
- Emergency signaling and response systems for remote locations
- Modification of driver behaviour through enforcement strategies
- Compliance to safety regulations (gap between attitude and behaviour)

Systems

- Electronic information and traffic handling systems
- Emergency signaling and response systems for remote locations
- Warning and barrier devices used at railway crossings
- Grade crossing accidents

- Rural intersection accidents at night
- Urban intersection accidents in high density traffic
- Risk factors for agriculture transportation related injuries
- Standardization of directions/signage for clarity, consistency (e.g., provinces—green flashing lights)
- Comprehension and legibility of traffic signs
- Signage/information load, legibility, user comprehension, conspicuous, driver response, user preference
- Intelligent vehicle system design: design of systems to prevent information overload and too many attentional demands
- Ergonomics issues of scheduling and hours of work (time of day and duration)
- Job design and injury prevention
- Macro-ergonomic issues (organizational and management issues affecting work done and procedures)
- The impact of ITS in future motor vehicle operation and safety (how drivers will adapt to new technologies)
- Design of ITS systems for all potential users (disabled and able-bodied)
- Simulators

Bicycles/Motorcycles

- Violation of road safety rules by bicyclists (esp. couriers)
- Visibility of bicyclists at night
- Separate road systems for bicyclists
- Helmets to meet anthropometric and tolerance characteristics
- Thermal comfort of helmets and other safety equipment
- Effect of helmets on operator performance
- Design of leg guards for protection of all users
- Visibility of bicyclists and motorcyclists to drivers
- Driver training—cyclists and motorcycles
- Motorcyclists ability to perform emergency handling

General

- Self regulation as knowledge base for further research
- Ergonomics examination of trucking accidents over the last five years
- Improvement of the design of railway crossing signals
- Safety in highway workzones

Question #5: If you answered "yes" to any of the areas indicate what you consider to be the main gaps in our knowledge.

Crew

- Cold weather issues
- Study the potential impact of FANS on air traffic control and pilot performance and safety
- Study the impact of automation on operator performance in all modes
- Develop/adapt methods for assessing human error, performing cognitive task analysis, modeling cognitive activities, etc., to support the design of advanced systems
- Situational awareness
- Theoretical work is needed in this area: applicable to driver training and evaluation, allowing a better assessment of the progress of novice drivers, the adequacy of different training programs for preparing drivers, the evaluation of drivers with medical conditions, particularly brain injuries such as strokes, or conditions such as Alzheimer's disease.
- CRM (Cockpit/Bridge resource management)
- Macro ergonomics of transportation systems
- Performance measurement techniques are not sensitive enough to pick up factors related to human information processing, especially under multitasking situations
- Work station design in general
- Vehicle maintenance
- Materials handling
- Information processing in general
- Technology changes to the task of driving
- How a group of persons may work together to achieve effectively a common goal
- Need for anthropometric data on specialized populations
- Work station and screen/display/control design
- The development of equipment for the monitoring and alerting of operator vigilance in a variety of operational control situations (e.g., transport, control rooms in industrial plants, security surveillance). Rationale: the proximal cause of accidents often appears to result from a lack of wakefulness or lack of task-oriented attention on the part of operators. This has long been realized and has given rise, among other things, to the development of the "dead man" in rail operations. One of several problems associated with current vigilance monitoring equipment is that it may, under favourable circumstances, correctly assess whether an operator is awake or not, but it fails completely in

determining whether an operator is actually paying attention to the task at hand. This problem ought to be remedied.

- Application of cognitive models to safety critical operations such as locomotive operation, command, control and communications operation, maintenance troubleshooting and marine navigation.

Fit for Duty

- No one has yet demonstrated clearly that performance on any given test is predictive of on the job performance. Because of the benefits of a reliable [test] such research should continue in this area.

Impairment (Fatigue, Drug/Alcohol)

- Fatigue in general
- Investigation of the advantages of napping strategies, number and duration of breaks, diet and physical activity for improvement of performance and job satisfaction (for all modes).
- Circadian rhythm, sleep disorders and shiftworking in single vehicle accidents
- Increased research is required with respect to fatigue levels, sustained and resultant performance decrements with various shift schedules on board marine vessels, inter-city buses and rail.
- Validate laboratory tests of driving skills
- The impact of fatigue, operator workload and work schedules on performance and safety

Situational Awareness

- The general idea of using computer display of information to aid situational awareness and support the cognitive needs of people operating in a team environment, particularly for planning and execution of plans over a period of hours, days and weeks rather than just minutes. Also methods for identifying those cognitive needs and then using or developing new technology to support those needs.

Shiftwork

- Evaluate the effectiveness of schedules which are preferred based on physiological knowledge
- 12 hour schedule information is particularly lacking
- How changes have been successfully brought about in various workplaces
- Better understanding of optimal shift schedules on board marine vessels and rail.
- Interaction with broad range of operational environment/tasks

Training

- Training in general
- What behaviours differentiate a novice from an experienced driver

- Training methods that assist a novice in progressing more quickly to an experienced level.
- Transfer of training effects in the use of simulators
- Emergency response and preparedness
- Research on "to what extent do people get fatigued if they receive poorer quality training, are not valued as a person, have no sense of control and have no support systems".

Fit for work

- Development of a better understanding of task requirements for employee selection purposes. Development of testing procedures. Vision standards, fatigue tolerance etc. particularly on board marine vessels and rail.
- Performance limitations

Information processing

- A more vigorous application of information processing principles is required within all terminals and transportation vehicles. In addition, continued research is required about information processing needs of specific user groups such as travelers with cognitive disabilities (various types), foreigners and children.
- Human-computer interactions

Elderly and Disabled

- Elderly and Disabled in general
- Incident/accident data on elderly and disabled
- Design of facilities and transportation systems for handicapped and elderly users
- Disabled-performance/environment design for emergency/stress situations
- Designing advanced in-car systems on driving performance of elderly
- Elderly-performance/environment design for emergency/stress situations
- The limitations, abilities and motivations of the elderly that have implications for the design of equipment, job aids and procedures. Rationale: design that takes better account of the abilities and limitations of the elderly will be useful to a growing proportion of the population. Moreover, design that helps the elderly is also likely to help other population subgroups.
- Limitations of older operators
- Disabled/elderly: interaction with new technology that would improve mobility/understanding (e.g., Smart card technology; "Smart" terminals, other emerging technologies)

Human Error/Critical Incidents

- Human error studies in all modes of transportation
- Human error-improvement in error detection/display and recovery mechanisms
- Sources of operator errors and methods to control them
- The influence of perception and cognition to operator error
- Appropriate measures of effectiveness of safety countermeasures
- Human error/critical incidence: development and application of models to predict human error within transportation systems in addition to analysis of accidents after the fact
- Workload: more research is required as this relates to fatigue, human error/critical incident and shift schedule design
- Workload in relation to human error/critical incidents

Regulations

- Hours of work re-assessed to include time-of-day considerations
- High technology devices, particularly when several unintegrated devices may be used simultaneously in applying HF/Ergonomics to systems design
- Product design in general
- How best to incorporate ergonomic considerations into product specifications and regulatory requirements.
- Identification of the design factors that allow road users to proceed at higher speeds without changing the accident rate per hour of exposure. Rationale: considerable progress has been made in reducing the traffic accident rate per 100 million km driven, while the traffic accident rate per head of population has not shown a similar favourable trend (if the effect of the business cycle is controlled for). The number of km driven per accident is, of course, a measure of the amount of mobility that is achieved at a given loss. Enhancement of this mobility is important to the productivity of the nation. Hence my feeling is that it is important to determine what factors exactly enhance the number of km that people can drive without an attendant increase in the traffic accident rate per head of population.
- Regulations: It is important that transportation regulations be scrutinized and improved so that they support ergonomics/human factors principles.
- Testing protocol standardization: increased efforts should be made to develop standardized protocols for testing of various products/interfaces used within transportation systems.

Systems

- Information processing in general
- Effective design criteria for information display in advanced and automated systems

- Integration of functions into controls and associations designs (future VRS)
- Macro ergonomics of transportation systems
- Technology changes to the task of driving
- Work station and screen/display/control design
- Incorporating ergonomic considerations into product specifications and regulatory requirements

Automation

- Automation in aviation
- Phenomenon of trust, automation in task allocation, communication errors generally by communication/negotiation in automated systems.

Human-Computer Interactions

- Human-Computer Interaction in general
- The influence of today's wealth of information and advanced computer technology (and increasing dependence on same) is having on operator and user performance
- Human-computer interactions: increased understanding of HCI issues is required within all transportation control rooms and within operator workstations, particularly as task-specific software is developed.
- Screen/display/control design: Ergonomic/human factors principles should be applied to all workstations within transportation systems. Task analyses should be conducted of critical workstations to determine task needs so that comprehensive checklists (or other aids) can be developed to assist designers/engineers in selection or development of controls and displays.
- Operator mental models of system operation, and how this is affected by system design and by training

Signage

- To meet the needs of a multi-lingual and aging population
- Guidelines for sign design and evaluation in such settings
- Regulations for when a new terminal is built ensuring usability of signs.

Simulators

- Research about simulators is not necessarily required, however, research about task demands and performance should make use of laboratory facilities which can simulate transportation environments and monitor dependent variables, particularly in the rail and surface transportation modes.

Work station design

- On-going research into work station design is important. A lot of effort has focus on cockpit design. More information is required for other operators of other modes. Also for workstations used by other employees such as flight attendants, conductors, etc.

ITS

- This is an emerging area in which a lot more research is required. Information about users needs and task demands is required for all users. In particular, little information is available about the needs of disabled users.

General

- Predictive models of accidents
- Study organizational and procedural practices followed in transportation systems, focusing on safety issues and improvement of these practices and the design of supporting equipment and facilities
- Selection instruments generally do not incorporate items testing for facility for the digital electronic technology used in today's transportation systems
- Investigate all ergonomic aspects of maintenance activities in all modes, particularly fatigue, shift scheduling, injury prevention, trouble shooting (advanced systems) and job-aid design
- The effective application of existing knowledge
- Child restraint: more research is required as to optimal child restraint devices on board all types of vehicles. Ergonomic/human factors issues include safety, comfort, usability and information processing issues.

Question #6: In your opinion, what ergonomic questions or concerns should be addressed in Canada in the near future (next five years). Please list the areas below and provide, or attach a brief rationale for rating.

Regulations/Standards

- Whole issue of requirements for ergonomic/HF certification of operational system designs. There are no formal requirements to show usability in most applications.
- Regulatory control of human behaviour (e.g., drunk driving, speed cameras).
- Standards for the harmonization/uniformity of safety system design (e.g. method of attachment of child restraint systems to vehicle, seat belts for adults).
- An evaluation is required of transportation regulations to determine where they are consistent with ergonomics/human factors principles. Efforts can then be made to modify regulations to incorporate good ergonomics practices.

Design

- Selection of best means of measuring fatigue and comfort-related features in order to evaluate different seat designs (e.g., suspension seat characteristics for long-distance truck/bus/train travels).
- Highway engineering—road junctions, traffic signals, pedestrian crossing time, visibility, traffic patterns).
- Ability of people to use adjustable seat correctly including head restraint.
- Improved comfort to promote use of safety systems (e.g., shoulder belt fit, ventilated motorcycle helmet).
- Better informed selection and fitting of safety systems and better design of same (e.g. cyclist are not well informed about fitting helmet—but helmets are not well designed to fit people).
- Development of intelligent safety systems.
- Enhancement of fitting process (e.g., helmets) by shape of child's head rather than just circumference per se.
- Assess current and future in-vehicle information systems with regard to their ease of use and safety, since vehicle design will change rapidly in the next few decades and driver capabilities will not.
- More research is required into work station design issues. A lot of effort has focused on cockpit design. More information is required for operators of other modes. This is also required for work stations used by other employees such as flight attendants, conductors, etc.

Information/Communication

- Ergonomic layout of work stations in the marine world, including integration of different electronic navigation equipment in order to have them to provide relevant information in a manner that the human brain can easily process.
- Development of personal, interactive communication managers for travelers using public transportation.
- Evaluation of human performance in work station and screen/display/control design. Rationale is to increase situational awareness and help prevent this type of accident.
- Develop/adapt methods for assessing human error, performing cognitive task analysis, modeling cognitive activities, etc. to support the design of advanced systems.
- Evaluation of human information processing and performance limitations when using computers, to determine if information systems have been developed beyond the comprehension and safe operation of too many operators and end-users.
- Passenger considerations including: improved information for checking in/ locating correct terminal, etc.; and information readability, information context, information organisation in vehicles, public transportation systems and highway signage.
- Cognitive ergonomics: need to investigate the impact of automation on human processing.
- Interface design: design that displays situationally aware information.
- Evaluating performance within a complex system.

Signage

- Electronic, telecommunications and computer opportunities for navigation and traffic control in remote areas (rail and surface).
- Streamlining airport operations, including: access to terminals, ticketing, boarding displays/terminal environment for human use has not kept up with the increased demands/increased time to process. These may not all be ergonomics issues but many involve ergonomics design issues.
- Passenger considerations including: improved signage, placement, visibility.
- Road transport information for enhancing driver capabilities and decision making.
- Uniformity of driver control and safety systems standardized location and meaningful recognition symbols/pictograms.
- Development of meaningful warning symbols (e.g., warning not to use rear-facing infant restraint in seat with passenger-side airbag).
- National harmonization of signage in regulations for safe transportation and correct use of safety systems (e.g., different meanings of flashing green light in different provinces, lack of understanding about airbags).

Training

- Air traffic controllers: stricter selection & training would lead to significant increase in success rate and hence cost reduction.
- Driver training on speed estimation of other vehicles.
- Instructions for selection and correct use of appropriate child restraint system.
- Development of instructions/symbols for correct use of manual safety equipment (e.g., seat belts with shoulder belt in front of torso and not under arm).
- Study the impact of automation on operator performance in all modes.
- Study the potential impact of systems such as CAATS and FANS on air traffic control and pilot performance and safety.

Manual Materials Handling

- Design variables which influence postures and work load of baggage handlers.
- Usability of trolleys and other manual handling aids for transporting materials.
- Investigate all ergonomic aspects of maintenance activities in all modes, particularly fatigue, shift scheduling, injury prevention, troubleshooting (advanced systems) and job-aid design.
- Passenger considerations including: baggage retrieval and handling (access ease of lift off/carrying from conveyer belt at end of trip) [for passengers].

Fatigue

- Operator fatigue and human error: most significant gain in safety may come from this area.
- Investigation of the advantages of napping strategies, number and duration of breaks, diet and physical activity for improvement of performance and job satisfaction (for all modes).
- Factors pertaining to fatigue, shiftwork and human error/critical incident analysis. A great deal of research has been carried out on the impact of alcohol and methods to reduce the combining of alcohol and driving. Fatigue is as important a factor in truck accidents as alcohol is in car accidents, and deserves immediate attention. Fatigue is also an important and under-reported factor in car accidents.
- Awareness of failures of attention, fatigue [on performance].
- Indicators of driving behaviour to distinguish fatigued from alert drivers.

Aging

- Elderly drivers & pedestrians: rapid increase in aging population, corresponding increase in accidents and costs.
- Safer transportation of elderly as drivers, users of public transport, pedestrians.

- Although a considerable amount of research has already been conducted into the needs of elderly and disabled travelers, there is a need to continue this research as new technologies emerge which can facilitate travel for this user group and improve the operation of transportation systems for all.

Disabled

- Interface of sensory and mobility impaired travelers (drivers, passengers, transit users, pedestrians) with integrated vehicle systems.
- Design of facilities and transportation systems for handicapped and elderly users
- Safety and security issues of mobility impaired travelers using urban and intercity buses.

Organizational

- Fatigue, Automation, Training, Cultural Norms (every company has a culture onto its own. I think that culture very much affects the way humans behave within it. As far as I know, no one has ever studied this in an airline).
- Study organizational and procedural practices followed in transportation systems, focusing on safety issues and improvement of these practices and the design of supporting equipment and facilities.
- Establish better ways to define unsafe behaviour and to measure operator error. Measurement of error (including accident data and statistics) has room for improvement.

Safety

- Bicycle/motorcycle/pedestrian visibility.
- Application of cognitive models to safety critical operations such as: locomotive operation; command control and communications operation; maintenance troubleshooting; and marine navigation.
- Development and improvement of usable advanced passenger screening systems.
- Very little research has been conducted into child restrain on-board all transportation modes. Issues which require clarification include safety, design, usability and operational impact (e.g., on-board aircraft infant restraint might require fare payment for children under 2 years).

Strategy

- Determination of the priority of ergonomics research most relevant to the interests and needs of Canada. Issues that might be considered important include: winter conditions; safety on rural roadways; influence of darkness on surface transportation safety; operator fitness for duty; countermeasures to operator fatigue. This is essential, as Canada does not have large numbers of researchers in some areas, nor does it have sufficient funds to pursue research

in more than a few select areas. Where we lack expertise, cooperation at the international level should be promoted. A great deal of research has been, and is being done on ergonomics in transportation. We must make better use of this work, especially as it relates to Canada's interests and needs.

- Research on the importance of "personal sense of control" "working/corporate culture" and "peer pressure" as important determinants of transportation ergonomics.
- A research and application agenda should be developed (articulated) that leverages the strengths of Canadian expertise against problems that have statistical support. For example, where life and limb (or the potential for) are lost, resources that have the potential to produce reduction (prevent) in accidents should be concentrated.
- First priority is to implement existing knowledge to product design and safety issues and spend time to determine how best to do this. As part of this immediate goal:
  - to establish and maintain a Canadian based transportation ergonomics research data base/publications network; and
  - to incorporate findings and ergonomic considerations into regulations (e.g. usability criteria to promote correct use of seat belts by all occupants, the belt-fit test device (BTD) to promote better lap belt fit over range of vehicle occupants, fixed head restraints of correct position, development of effective and compulsory training of transport operators).
- Place more emphasis on safety in operation of large trucks, as the use of rail in Canada will decrease, while transportation of goods by truck will increase.
- Increased effort should be made in understanding the impact of ITS technology on users, tasks and future product development. This encompasses information processing, HCI and work station issues, among others. A clearer definition of users needs, particularly special user groups such as the elderly and disabled is required.
- The lack of usability testing labs/simulators which can be used to test transportation systems should be addressed. This is particularly important for rail and surface modes. Support of the development of these facilities is required.
- To date there is a considerable amount of ergonomics/human factors research conducted in many areas. However, it is not accessible to those people who require the information, such as: engineers, designers and operators. Research should be conducted to synthesize design guidelines already developed in an effort to develop checklist and other aids to ensure that our research gets incorporated into the design of systems. Gaps in research can also be determined and filled.
- Increased efforts should be made to develop ergonomics/human factors testing protocols for transportation systems. Much of the research that has been conducted has brought about significant answers. Methodologies employed by those studies will be useful in other applications or for testing similar products. For example, recent testing of child restraint systems has resulted in a push to develop an ISO usability testing protocol.

APPENDIX G

Participating Canadian Subject Matter Experts (SMEs)

Questionnaire Respondents (listed in alphabetical order)

Anne Kristina Arnold	ErgoSystems Canada Inc.
Allen Bilodeau	DFO/Coast Guard
Leslie Buck	Humansystems
Jeff Caird	University of Calgary
Robert Carrier	Genicom Consultants
Paul Carson	Transport Canada: Aviation Services
Bob Dewar	Western Ergonomics Inc
Annette Dunlop	Transport Canada: Air Navigation Services
Kathyrn Graham	Quality Assurance, WCB Alberta
Ruth Heron	Heron Ergonomics Inc
Norman Leblanc	Transport Canada: Aviation Services
Tim G. Moore	Nortel Technologies
Jocelyn Pedder	RONA Kinetics
Julia Rylands	NRC—IRAP
Wayne Rhodes	Rhodes and Associates Inc.
Uwe Rutenberg	Ruttenberg Design Inc
Alison Smiley	Human Factors North
Paul Stager	HFE Consultants
Bob Webb	Human Systems

Gerry Wilde	University of Toronto

Vancouver Round Table Participants

Leslie Buck	Humansystems
Bob Dewar	Western Ergonomics Inc
Kathyrn Graham	Quality Assurance, WCB Alberta
Rémi Joly	Transportation Development Centre
Jocelyn Pedder	RONA Kinetics
Alison Smiley	Human Factors North

Toronto Round Table Participants

Anne Kristina Arnold	ErgoSystems Canada Inc.
Robert Carrier	Genicom Consultants
Tim G. Moore	Nortel Technologies
Uwe Rutenberg	Ruttenberg Design Inc
Paul Stager	HFE Consultants
Ling Suen	Transportation Development Centre
Bob Webb	Human Systems

Faciliators

Vancouver: Julia Rylands	NRC—IRAP
Toronto: Carolyn MacGregor	University of Waterloo

APPENDIX H

Outstanding Issues in the Development of a Strategic Plan for Research and Development in Transportation Ergonomics.

1. Queries

1. How can TDC demonstrate that human factors/ergonomics is worthwhile in transportation system?
2. In the context of the questionnaire, what is "research"? Answer: This is research applied to transportation. Pure research would include quantitative or usability studies of specific systems/products.
3. What type of research is referred to for topics in the questionnaire? Literature review, field study, etc. More information is needed to focus on topics i.e., to fully respond to the questions.

2. Certification/Guidelines and Regulations

1. Ergonomics needs to be included early and throughout the process.
2. Guidelines alone do not suffice (i.e., regulations are required for compliance).
3. There needs to be human factors certification of design/methods and regulation.
4. Human factors needs to be incorporated in the design cycle. The way human factors is normally expressed is too academic to collaborate with designers.
5. TDC needs to include in its research directives a process of how to include human factors in the development cycle! (This deals with prioritization issues.)
6. TDC needs to develop a system that is able to react to the changes in the system.
7. Ergonomics/human factors needs to be expressed in non sexist terms.
8. Regulations: The process for human factors in design should focus on performance specifications, not technical specifications.

3. Education

1. One of the major issues facing TDC is deciding between generating knowledge vs. getting "designers"/managers/policy makers to use the knowledge (e.g., shiftwork, schedules).

2. TDC needs to address training in two ways:

   (i) training to help designers understand and use human factors tools; and

   (ii) training to help human factors specialist/designers understand transportation (and user) environments.

4 Future Advances

1. What will be the impact of advanced technologies on human performance: e.g., aviation free-flight which increases discretion vs. in-flight systems which reduce discretion?

2. How will communication technologies or the introduction of new complex technologies alter transportation patterns?

5 Jurisdiction of Transport

1. The approach to choice of human factors issues to be prioritized should follow (not lead) national priorities for transportation (we don't have those priorities).

2. There is a need to determine if fitness for duty tasks predicts in-vehicle performance.

3. There is a need to determine the impact of circadian rhythms on multi-and single vehicle accidents in Canada.

6 Safety vs. Ergonomics

1. Cluster analyses should be completed to determine what the major "drivers" are that impact transportation systems (safety, quality of experience, risk mitigation): short-term operator degradation (fatigue, alcohol); long-term impact of changes (formal/legal/regulatory); incorporation of human factors/ergonomics process/procedures in system design/testing.

2. Terminology needs to be considered. There is never an “accident”.

7 Strategic Planning/ Research Directives

1. TDC needs to develop methods/software to help the process of applying human factors in design cycle (e.g., comfort, safety, link with the current TDC mandate, user needs, "experience of traveling").

2. TDC needs to incorporate human factors in existing risk assessment procedures.

3. An important requirement is to ensure ergonomic process by regulation of design and development that incorporates human factors/ergonomics knowledge/procedures/usability testing etc. The human factors issues in novel new systems will be addressed by required human factors/ergonomics procedures.

4. TDC should continue to assist in refining existing transportation incident/accident data bases in Canada.

5. TDC should assist in standardizing an accident data base related to transportation.