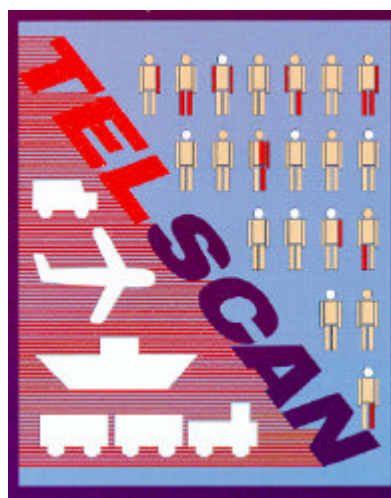


TELSCAN

TElematic Standards and Coordination of ATT systems in relation to elderly and disabled travellers

TRANSPORT TELEMATICS PROJECT N°.: TR 1108



Draft Guidelines Concerning E&D Issues:

The TELSCAN Handbook of Design Guidelines for Usability of Systems by Elderly and Disabled Drivers and Travellers

Status: Working Draft, Version 2

Distribution: Public

Document ID Deliverable No. 5.1

Date: March 1997
First Version submitted in November 1996

Commission of the European Communities
Telematic Applications Programme - Transport Sector

Draft Guidelines Concerning E&D Issues:

TELSCAN Handbook of Design Guidelines for Usability of Systems by Elderly and Disabled Drivers and Travellers

Editor:

C. Nicolle
HUSAT Research Institute

Contributors:

The TELSCAN Consortium:

| | | |
|-------------------|---|----|
| A. Naniopoulos | Aristotle University of Thessaloniki (AUTH) | GR |
| T. Nanthanall / | TRD International | GR |
| P. Christidis | | |
| E. Bekiaris | HELGECO SA | GR |
| Els de Vries | Mobility International | BE |
| S. Cicerchia | Guidosimplex | IT |
| C. Nicolle / | HUSAT Research Institute | UK |
| T. Ross / | | |
| G. Burnett / | | |
| L. Stapleton/ | | |
| M. Maguire | | |
| R. Veenbaas | TNO/Vehicle Dynamics Department | NL |
| W.B. Verve | TNO / Institute for Perception | NL |
| J. Brekelmans | De Langstraat | NL |
| R. Schopp / | Univ. of Stuttgart/IAT | DE |
| H. Widloither | | |
| B. Peters | Swedish Road and Transport Research Institute (VTI) | SE |
| B. Nielsen | AMU Gruppen | SE |
| A. Stahl | Lunds Universitet | SE |
| C. Marin-Lamellet | INRETS-Lesco | FR |
| A. Simoes | Tech. Univ. Lisbon (UTL/FMH) | PT |
| P. Oxley / | Cranfield University | UK |
| P. Barham | | |
| P. O'Neill | Traffic Solutions Ltd. | UK |

Project Coordinator: Dr. A. Naniopoulos
Aristotle University of Thessaloniki
School of Technology
Transport Engineering Laboratory

54006 Thessaloniki, Greece
Tel: +30 31 991560/992636
Fax: +30 31 991564/262784
Email: telis@vergina.eng.auth.gr

Contents

| | Page |
|--|-------------|
| Introduction | |
| Aim of the Handbook | 2 |
| Who is this Handbook for? | 3 |
| How were the guidelines selected? | 3 |
| How are the guidelines structured? | 4 |
| How to use the TELSCAN Handbook | 6 |
| Disclaimer | 7 |
| Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers | 8 |
| Part 2. Usability Principles and Code of Good Practice | 15 |
| Part 3 Guidelines for All Telematic Systems | 22 |
| A. Control of All Systems | |
| General | 22 |
| Implementation | 23 |
| B. Display of Information | |
| General | 26 |
| Implementation | 28 |
| C. Training and Documentation | 31 |
| D. Other Issues | 32 |
| Part 4. Guidelines for Telematic Systems for Drivers | 33 |
| A. General Guidelines - Drivers | 33 |
| Control of the System - Drivers | 37 |
| Display of Information - Drivers | 40 |
| Other Issues - Drivers | 44 |
| B. Guidelines for Route Guidance and Navigation Systems | 45 |
| C. Guidelines for Adaptive Cruise Control Systems | 46 |
| D. Guidelines for Collision Avoidance Systems | 50 |
| E. Guidelines for Reversing and Parking Aids | 51 |
| F. Guidelines for Travel and Traffic Information Systems | 54 |

| | | |
|---------------------|--|------------|
| Part 5. | Guidelines for Telematic Systems for Travellers | 55 |
| 5.1 | Specific technologies | 55 |
| 5.1.1 | Smart Cards (to be continued) | |
| 5.2 | Specific applications or systems | 56 |
| 5.2.1 | Travel Aids | |
| 5.2.2 | Information Systems | |
| 5.2.3 | Self-Service Systems (to be continued) | |
| 5.3 | Next Steps | 58 |
| Part 6. | Multi / Cross Modal Interaction | 59 |
| Part 7. | References and Bibliography | 60 |
| Appendix 1 - | Car Adaptations for Drivers with Disabilities | 69 |
| Appendix 2 - | Summary Descriptions of Advanced Transport Telematic Systems | 72 |
| Appendix 3 - | Summary Descriptions of earlier Simulator Testing and Field Trials in TELAID and EDDIT projects (To be regularly updated with the results of TELSCAN) | 73 |
| Appendix 4 - | Application of the TELSCAN Guidelines to HARDIE Guidelines for Route Guidance and Navigation Systems | 78 |
| Appendix 5 - | Application of the TELSCAN Guidelines to HARDIE Guidelines for Collision Avoidance Systems | 109 |

Introduction

The TELSCAN project (TELEmatic Standards and Coordination of ATT systems in relation to elderly and disabled travellers) is part of the Transport Sector of the Telematics Applications Programme of DG XIII of the CEC (TR 1056). The project aims to ensure that the needs of elderly and disabled drivers and travellers are taken fully into account in the development and application of advanced transport telematics (ATT). ATT systems can very simply be defined as computerised or intelligent technology for transport, but people who could most benefit from their use are sometimes excluded from the design and evaluation process.

The TELSCAN Handbook of Design Guidelines recommends guidelines for designing systems so that they are easy to use by elderly and disabled drivers, using their own cars, or travellers, whether it be as a passenger in a car or in various modes of public transport. This is a **living, working document** and chapters of the Handbook will be enriched through TELSCAN testing and survey results over the course of the project.

Usability principles applicable to all systems are recommended, followed by general guidelines on controls, displays, training/documentation and other issues. Guidelines for telematic systems specifically for drivers are followed by guidelines for a selection of specific ATT systems. For some systems (e.g. in the case of Route Guidance) the TELSCAN guidelines are applied to existing guidelines to emphasise the importance of a design-for-all principle (See Appendices 4 and 5). For other systems (e.g., in the case of Adaptive Cruise Control) specific guidelines are suggested based on earlier simulator testing or road trials (Part 4C). Guidelines for systems in other modes of transport will continue to emerge from data capture and testing with the TELSCAN project. Readers will notice the changing nature of the entire Handbook on the World Wide Web over the life of the project as further guidelines are developed or tested. TELSCAN's WWW address is:
<http://hermes.civil.auth.gr/telscan/telsc.html>

The basis of this Handbook was first developed as a working draft by the CEC DRIVE II TELAID project (TELEmatic Applications for the Integration of Drivers with Special Needs) to provide design guidelines for the usability of in-vehicle systems by drivers with disabilities. Now in TELSCAN, TELAID has been joined by members of the EDDIT consortium (Elderly and Disabled Drivers Information Telematics). The Handbook, still very much in draft, has now been revised to include systems for elderly and disabled drivers and travellers. Our intention is to disseminate what guidelines we have early in the life of TELSCAN so that other projects can benefit, comment and contribute.

The earlier TELAID guidelines for Advanced Transport Telematic (ATT) systems evolved through a number of activities:

- **Field Study of Requirements of Drivers With Special Needs**
The constraints, limitations and requirements of drivers with special needs were identified in a field study (Nicolle et al, 1992). The impairment groups included in the data collection were visual, reading, hearing, speech, lower limb, upper limb, upper and lower limb, upper body, sudden loss of control, and cognitive.
- **Identification of Design Issues**
From the problems experienced by drivers with special needs, design issues were identified which need to be considered in the design of in-vehicle systems.
- **Simulator testing**
Simulator testing within the TELAID project with drivers having upper and/or lower limb disabilities helped to verify or modify some existing guidelines or to develop new ones. (See Appendix 3 for a short description of the tests.)
- **Survey of Existing Guidelines**
A survey of existing guidelines and standards which may be relevant to vehicles, ATT systems, and drivers with special needs concluded that:

There are large gaps in knowledge. To fill the holes, further testing is required before new guidelines, or improvements to existing guidelines, can be recommended, which will include the wide ranging and often changing requirements of elderly and disabled drivers and travellers.

TELSCAN is helping to fill these gaps, through complementary testing within the Transport Telematics projects of the 4th Framework Programme.

A multitude of guidelines constitute good design practice and are equally relevant for all travellers regardless of age or any disability. This Handbook does not attempt to repeat all those guidelines on usability from other sources which are equally acceptable to design for travellers with special needs. However, it does highlight those design issues which are particularly important to certain user groups. In such cases, these user groups are noted and examples given to emphasise this need for careful design. The Handbook also points designers towards sources of general guidelines, where appropriate.

Some of the Handbook guidelines recommend testing with particular user groups (e.g. people with visual impairments) to verify appropriate system configurations (e.g. display text size). It is beyond the scope of this version of the Handbook to prescribe specific testing procedures, but during the course of the TELSCAN project, test methodologies and test tools will be compiled or developed to fill this gap. Subsequent versions of the Handbook will make these available.

Aim of the TELSCAN Handbook

The aim of the TELSCAN Handbook is to raise awareness within the ATT design industries of the need to include elderly and disabled people in the design and evaluation process. Accessibility to systems for drivers and travellers should be considered early in the design process, just as much as other features such as the need for security, communications capabilities, and low maintenance costs (Nordic Committee on Disability, 1993).

Ideally telematic systems should be designed from the very beginning to be usable by everyone. However, the wide ranging and diverse characteristics of elderly and disabled people may make this impractical. A key recommendation is, therefore, that systems should be flexible enough and easy to adapt to individual user requirements (e.g., see Guideline 2A.4 in Part 2, Usability Principles and Code of Good Practice).

The TELSCAN Handbook of Guidelines will help to ensure that the needs of elderly and disabled people are considered. Following the guidelines, however, will not in itself guarantee a perfect system. User testing must always be done, following an evaluation methodology which will include different impairment groups who may be likely to use the system.

Who is this Handbook for?

The TELSCAN Handbook serves five purposes:

- i) System manufacturers can use the Handbook as a guide in the design and development process.
- ii) System manufacturers can use the Handbook as a checklist during the evaluation process, in order to accommodate elderly and disabled drivers and travellers.
- iii) Car adaptation manufacturers can use the Handbook to help ensure that a particular ATT system is installed so that it is usable by a particular traveller with special needs and compatible with other car adaptations for that particular driver.
- iv) Human-factors experts will find the Handbook useful for evaluating systems for drivers and travellers against criteria for Human-Computer Interaction.
- v) Researchers and standards bodies can use the Handbook to identify areas where knowledge or standards exist and those areas where further research is required.

In each case, users of the TELSCAN Handbook will come closer to achieving usability of ATT systems not only for older or disabled travellers, but for everybody by following the design-for-all principle.

How were the guidelines selected?

Some guidelines for the design of ATT systems exist already and some are under development, although they are not aimed specifically for elderly and disabled people. There are also guidelines for other applications that could be useful in this area, for example, guidelines for computer accessibility by disabled and elderly people (e.g., Nordic Committee on Disability, 1993; Vanderheiden, 1992), or standards for equipment use in an office environment (e.g., ISO 9241, and EEC 90/270). However, due to the complexity of the travelling task and a changing environment whilst travelling, it is not easy to apply these guidelines to systems for travellers without some interpretation being necessary.

With reference to guidelines such as the Nordic Guidelines for Computer Accessibility (Nordic Committee on Disability, 1993), we wish to emphasise that these guidelines were developed with a view to be used for traditional PC applications in offices, schools, and homes, etc. The Nordic Committee on Disability do not, therefore, take responsibility for the applicability of the requirements in other environments such as vehicles. TELSCAN assumes such responsibility, recognising that such guidelines serve as a helpful starting point to our work and indicate where further testing may be required.

References are provided at the end of the Handbook for existing guidelines that are relevant to elderly and disabled drivers and travellers. Some of the TELSCAN guidelines are suggested based specifically on TELAID's simulator testing with drivers with disabilities and EDDIT's testing of systems with elderly drivers (for a description of these tests, see Appendix 3).

The Handbook will be regularly updated through extensive literature reviews and with the results of the simulator and road trials of systems and guidelines within the Transport Telematics projects and specifically within the TELSCAN project.

How are the guidelines structured?

In this version of the TELSCAN Handbook, the vast majority of the guidelines are applicable to all systems for elderly and disabled drivers and travellers, since up until now there has been very little testing with specific systems with these user groups. Currently the Handbook consists of seven parts, although some sections are still in their early stages.

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

This section presents a summary of results from TELSCAN's recent data capture activities, published as Deliverable 3.1, Inventory of ATT System Requirements for Elderly and Disabled Drivers and Travellers (Nicolle, et al., March 1997).

Part 2. Usability Principles and Code of Good Practice

This section discusses the concepts of usability and user-centred design and their application to designing for elderly and disabled travellers. Remember that adherence to these principles constitutes good design for all users.

Part 3. Guidelines for All Telematic Systems

This section specifies guidelines which are applicable to all telematic systems for elderly and disabled drivers and travellers, whether by car or by public transport, with regard to controls, displays, training/documentation, and other important issues.

Part 4. Guidelines for Telematic Systems for Drivers

This section begins with some general guidelines for systems for drivers, and then covers controls, displays and other important issues. Application-specific guidelines are then presented - as far as is possible at this stage in the project - for Route Guidance and Navigation Systems, Adaptive Cruise Control Systems, Collision Avoidance Systems, Reversing and Parking Aids, and Travel and Traffic Information Systems.

In the case of 4B Route Guidance and Navigation Systems and 4D Collision Avoidance Systems, we apply the more general TELSCAN guidelines in Parts 2, 3 and 4A to existing guidelines produced by the DRIVE II HARDIE project (Ross et al., 1996). This process - found in Appendices 4 and 5 - illustrates how the TELSCAN guidelines can be more widely applied to specific systems and how it can readily be used with guidelines for systems other than those included in this Handbook. The remaining chapters of the HARDIE Design Guidelines Handbook (covering Traffic and Road Information, Autonomous Intelligent Cruise Control and Variable Message Signs) will be reviewed over the course of TELSCAN.

With respect to 4C Adaptive Cruise Control and 4E Reversing and Parking Aids, guidelines are suggested based on testing during the TELAID and EDDIT projects. As more testing is conducted within the 4th Framework Programme and specifically within the TELSCAN project, a more comprehensive compendium of guidelines will be generated so that systems are more usable by elderly and disabled drivers and travellers.

Part 5. Guidelines for Telematic Systems for Travellers

Guidelines for travel and traffic information systems for drivers are emerging from the literature review which is now in progress. This section will be extended over the course of TELSCAN, following review of existing systems and guidelines and relevant testing for systems used in different modes of public transport, eg bus/tram, metro/train, ship and airplane.

Part 6. Multi / Cross Modal Interaction

This section begins to introduce key issues concerning multi- or cross-modal interaction, that is, using more than one type of transport or moving between vehicles (e.g., driving by car to a train station) to complete a journey from point of origin to destination.

Part 7. References and Bibliography

This section provides references and additional sources, including guidelines/standards for in-vehicle systems and systems for travellers, examples of guidelines/standards for computer/product accessibility by disabled and elderly people, and examples of office environment or equipment guidelines/standards that might be applicable to travellers.

Appendices

Appendix 1 describes some of the common car adaptations used by drivers with disabilities which are referred to in the Handbook, whilst Appendix 2

provides a brief description of specific ATT systems for drivers and travellers. Appendix 3 gives a summary of earlier simulator testing and field trials held during the TELAID and EDDIT projects, and will be regularly updated with the results of TELSCAN. Appendix 4 and Appendix 5 apply the TELSCAN guidelines to the guidelines on information presentation for route guidance and navigation systems and collision avoidance systems, respectively, from the DRIVE II HARDIE Project V2008 (Ross et al., 1996). We hope these will prove helpful examples of how the TELSCAN guidelines can be more widely applied to specific systems or existing guidelines.

How to use the TELSCAN Handbook

All users of this TELSCAN Handbook should be familiar with the guidelines in Parts 2 and 3, as they relate to all systems and of course will constitute good design for all users. Parts 4 and 5 will point the reader to guidelines for specific types of systems for drivers or travellers. If the specific system that you are designing is not already found in Part 4 or 5, the examples given may prompt questions and the need for advice on your application area.

The *TELSKAN Handbook of Design Guidelines for Usability of Systems by Elderly and Disabled Drivers and Travellers* fills many of the gaps in current general guidelines. It will be further developed through TELSCAN's empirical evaluation of other guidelines and system prototypes, so please visit us on the World Wide Web for regular updates at the address given below. At the end of the project, the Handbook will also be available in diskette, CD Rom and hard copy.

Inclusion of travellers with physical, perceptual and cognitive impairments in the design, development and evaluation of ATT systems will make the use of such systems safer for everyone. And remember that "designing for all" will make YOUR travelling easier in the year 2030!

To help us develop the guidelines further, please contact us with your questions and comments:

Dr. A. Naniopoulos (Project Coordinator)
Aristotle University of Thessaloniki
School of Technology
Transport Engineering Laboratory
54006 Thessaloniki, Greece
Tel: +30 31 991560/992636
Fax: +30 31 991564/262784
Email: telis@vergina.eng.auth.gr
TELSKAN WWW address: <http://hermes.civil.auth.gr/telscan/telsc.html>

or

Colette Nicolle (Editor of the Handbook)
The HUSAT Research Institute

Loughborough University
The Elms, Elms Grove
Loughborough, Leics. LE11 1RG UK
Tel. +44 1509 611088
Fax. +44 1509 234651
Email c.a.nicolle@lboro.ac.uk

Disclaimer:

This Handbook presents the results of a careful collation of available evidence regarding guidelines for the design of ATT systems to ensure their usability by elderly and disabled travellers. Nevertheless, neither the TELSCAN project partners, nor the institutions of the European Union, nor the authors whose work is quoted accept any responsibility for any use which may be made of the material contained herein.

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

This section presents an overview of the user requirements identified in TELSCAN's recent data capture activities, published as Deliverable 3.1, Inventory of ATT System Requirements for Elderly and Disabled Drivers and Travellers (Nicolle, et al., March 1997). The main objectives of this work were:

- To develop an assessment method to identify the needs of elderly and disabled (E&D) travellers, and
- To identify and update the user requirements of E&D drivers and travellers, particularly in relation to Advanced Transport Telematic (ATT) systems

One of the results of our investigation is a summary of the requirements of elderly and disabled travellers using different modes of transport, including private cars (integrating the results of TELAID and EDDIT), buses/trams, metros/trains, ships and airplanes. Data was collected through individual interviews, focus groups and observations with experts and travellers having a range of impairments, including:

- Skeletal - Motion of lower limbs
- Vision
- Hearing
- Language and Speech (Communication)
- Intellectual/Psychological/Cognitive
- Elderly

TELSCAN follows a functional classification of impairments, based on the International Classification of Impairments, Disabilities and Handicaps (World Health Organisation, 1993). With this focus, we can see that the same types of problems would be identified, for example, for a person with an impairment in the lower limbs, whether caused by an accident as a child or arthritis in old age. With such a functional classification, it is clear that elderly people should not form a separate group for data capture or analysis. However, the requirements of an elderly person with mobility problems can be very different from a young wheelchair user, both in the type of assistance required and whether or not it is even thought necessary. For this reason, TELSCAN included further investigation specifically on the needs of elderly travellers, covering a gradual deterioration of physical, perceptual, and cognitive abilities.

TELSCAN Deliverable 3.1 provides a generic user requirements specification, summarised below, which can guide the design of all transport telematics systems. Our data collection methods, tools and techniques, including the E&D Functional Classification and Definition of the Travelling Task, are available to other projects to capture a more detailed definition of user requirements for their own specific application area or system. These tools will also be integrated within future versions of this Handbook.

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

1.1 Car/van

A matching of requirements for disabled (from TELAID) and older (EDDIT) drivers provided the majority of the results for this mode of transport. A comprehensive set of requirements can be found in Deliverable 3 of the TELAID project (Nicolle et al., 1992) and the Final Report of the EDDIT project (Oxley and Mitchell, 1995). The following emphasises the key points from these deliverables, and from further findings from the TELSCAN data capture specifically in relation to telematic systems.

Skeletal - Motion of lower limbs

Travellers with mobility-related impairments experience a number of problems in driving cars/vans, which are relevant to ATT systems, for example:-

- Trip planning - obtaining relevant information, turning pages of maps
- Toll collection - passing money through windows at toll plazas
- Primary vehicle control - turning body when viewing gaps in traffic (particularly when entering traffic, e.g. T-junctions)
- Secondary controls - finding, reaching, overload on limbs and residual mental capacity
- Vehicle maintenance - paying for fuel
- Trip information - overload on residual mental capacity, looking for information to side of road
- Parking - turning body to look behind, using ticket machines

Navigation systems/ travel and traffic information systems have the potential to benefit drivers in many of these tasks. Gap acceptance systems, speech recognition systems and parking aids may also be useful to drivers within this impairment group. The use of smart cards may enable disabled people to pay tolls, fuel costs and parking fees without getting out of the vehicle.

Vision

People with severe visual impairments cannot/are not permitted to drive. However, there are several forms of visual impairment which are permissible (e.g. reduced visual acuity, colour blindness, glare sensitivity). The visually-impaired driver subsequently has problems in the following areas:-

- Trip planning - understanding colour coding for maps
- Secondary controls - finding controls, particularly when driving at night
- Navigation tasks - seeing road signs/street names, estimating distances
- Judging gaps and viewing indicators (most important when entering/ leaving traffic and overtaking other vehicles)
- Driving in poor weather conditions (fog, heavy rain, snow etc.)
- Parking - estimating gaps between objects

A number of different ATT systems may aid in visual-related elements of the driving task, and thus aid the visually-impaired driver, e.g. in-vehicle navigation, gap acceptance, speech recognition, collision avoidance, parking aids, and vision-enhancement. However, visual accommodation between an

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

in-vehicle display and the road ahead may cause problems for drivers with some of these systems.

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

Hearing/Language and Speech

Drivers in this impairment group experience numerous difficulties which are relevant to ATT systems, for example:-

- Trip planning - reading any text within travel information sources
- Hearing information relevant to the driving task (e.g. engine noise, indicators, warnings, other traffic)
- Navigation tasks - reading road signs, hearing directions from passenger
- Obtaining up-to-date traffic/weather information (e.g. radio)
- Using emergency phones, particularly on motorways

ATT systems such as in-vehicle navigation, travel and traffic information, tactile feedback and emergency alert will be of assistance to drivers within this impairment group, if the interfaces are designed appropriately.

Intellectual/Psychological/Cognitive

The limitations that drivers with cognitive impairments have in general information processing and memory functions have a number of implications for aspects of the driving task, for example, use of complex spatial information (e.g. a map), reacting to the sudden appearance of hazards, driving over bridges and/or through tunnels (due to phobias), estimation of the speeds/distances of the surrounding traffic, navigating in an unknown area, lining up car with kerb when parking. Well-designed, easy-to-use ATT systems have the potential to aid drivers within this impairment group, for example in-vehicle navigation, collision avoidance and parking aids.

Elderly

Elderly drivers experience many of the same problems encountered by individuals within the other impairment groups. For example, in using maps, entering and leaving traffic, driving in poor weather conditions, finding their way in unknown areas, locating secondary controls (particularly at night), looking behind and estimating gaps when parking and using phones in the event of emergency/ breakdown. Various ATT systems have the potential to help the older driver, for example in-vehicle navigation, gap-acceptance, vision-enhancement, speech recognition, parking aids and emergency alert.

1.2 Bus/Tram

Skeletal - Motion of lower limbs

For this mode of transport, travellers with mobility-related impairments experience greatest difficulties in entering and exiting from the bus/tram. As was found to be the case for most modes of transport in relation to this impairment group, ATT systems do not offer relevant solutions for such access problems, and current practices generally suffice or should be further extended, for example low-floor entrances/exits. ATT could assist by ensuring that relevant information on accessibility, etc., is available to make decisions, eg in trip planning.

Vision

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

Travellers with visual impairments experience numerous difficulties when using buses and/or trams. Timetables (whether on paper or at a stop) often utilise very small text, and it may be difficult to identify whether the desired bus/tram has arrived at a particular stop. ATT systems which utilise a speech input/output interface are of greatest relevance to this group and already exist in some countries.

Hearing/Language and Speech

Travellers with hearing, language or speech-related impairments encounter numerous difficulties in planning a bus/tram journey and buying a ticket. Furthermore, dealing with changes in the bus/tram schedule can be a particular problem, as they are usually through auditory announcements. ATT systems which employ spatial forms of communication (e.g. symbols, icons) will be of greatest relevance to this group and are under development within the current Telematics Application Programme.

Intellectual/Psychological/Cognitive

As a result of the numerous limitations that travellers with cognitive impairments possess (e.g. information processing and memory functions), the use of all modes of transport can be particularly difficult. With respect to buses/trams, individuals can encounter specific problems in various aspects of:-

- trip planning (e.g. deciding when to travel, what bus/tram changes are required, understanding timetables),
- ticketing (e.g. using machines, communicating with the driver),
- access (e.g. locating correct stop and incoming bus) and
- trip information (e.g. identifying the correct stop, dealing with changes in the bus/tram schedule).

A number of ATT systems under development are being designed to aid in alleviating such problems (e.g. computer-based trip planning systems, hand-held information systems, smart card payments).

Elderly

Many of the problems that elderly travellers face when using buses/trams are also encountered by individuals with specific impairments, notably skeletal (lower limbs), vision and/or cognitive. For example, difficulties arise when planning a trip, using ticket machines, reading timetables, identifying the stop and incoming bus/tram and entering and exiting the bus/tram. Elderly people also encounter some particular problems - travelling to and from the stop, waiting at stops and coping with bus/tram movements during the journey. Modifications to vehicles and the road environment are the only feasible solutions to some of the above problems. However, various ATT systems have the potential to aid elderly people in other aspects of the travelling task, for example, trip planning systems, smart card payments and information systems at the bus/tram stop and on the bus.

1.3 Metro/Train

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

Skeletal - Motion of lower limbs

Travellers with mobility impairments experience many of the same difficulties when using this mode of transport as they do with buses/trams, e.g. entering and exiting the metro/train. In addition, such individuals encounter problems in manoeuvring their wheelchairs within the metro/train to access, for example, toilet and restaurant facilities. As a general point, there appears to be a lack of awareness of existing support systems and also the potential of ATT - this is the case for all impairment groups. As for buses and trams, ATT systems have little potential to alleviate access problems for this impairment group, but could assist in other aspects, eg through providing relevant information on accessible travel routes.

Vision

The visually impaired individual encounters many of the same problems for this mode of transport as for buses/trams, e.g. using timetables. In addition, differences in station environments (e.g. platform length, positioning of ticket machines/windows) and the design of metros/trains (e.g. number of steps, location of doors) can cause numerous problems, particularly when travelling on novel journeys. Standardisation of stations and metros/trains would be the most helpful solution for this group. ATT solutions are also feasible, for example trip planning systems that provide information regarding the layout of stations and metros/trains, and ticketing systems that utilise speech input/output.

Hearing/Language and Speech

Individuals from this group encounter many of the same difficulties for this mode of transport as for buses/trams, for example communicating with ticketing staff and other passengers and dealing with changes in the travel schedule. In addition, specific problems are experienced in hearing and comprehending announcements, both at stations (particularly during poor weather conditions) and whilst travelling on a metro/train. ATT systems which present complementary visual announcements at the station and on the metro/train would resolve such concerns. The use of symbols and icons would greatly increase the usability of such systems for this group.

Intellectual/Psychological/Cognitive

Travellers with cognitive impairments encounter most of the same difficulties in using metros and trains as they do for buses and trams, for example, deciding when to travel, what changes are required, using ticket machines, identifying the correct station and dealing with changes in the travel schedule. ATT systems under development (e.g. computer-based trip planning systems, hand-held information systems, smart card payments) will help to resolve such problems.

Elderly

Older travellers experience many of the same difficulties with this mode of transport as encountered for buses and trams and by other impairment groups, for example, planning a trip, reading timetables, using ticket machines, waiting on platforms, entering and exiting the bus/tram and

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

hearing announcements on the metro/train. ATT systems, such as trip planning systems, smart card payments and visually-based announcements will aid in alleviating some of these problems. A specific difficulty encountered by elderly people when using metros and trains concerns their wish to retain independence despite their need for help. Support where needed without accentuating 'disabilities' will assist these individuals.

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

1.4 Ship

Skeletal - Motion of lower limbs

No specific problems were identified during data collection for mobility-impaired travellers using ships. This was due to time constraints and the priority areas established by the travellers given their most significant and most frequent problems.

Vision

Visually-impaired travellers experience considerable difficulties in finding their way within the open plan layout of ships. Improved means of navigation (e.g. tactile signing) on ships would aid these individuals. ATT navigation systems may also be of assistance, although difficult to implement on a moving base such as a ship. Travellers with visual impairments are also fearful of falling overboard on ships - more secure and obvious perimeters to ship's decks will reduce such concerns.

Hearing/Language and Speech

The majority of problems encountered by this group when making journeys by ship arise because verbal communication is required (e.g. when planning a trip, purchasing a ticket, seeking assistance). Hearing and comprehending announcements whilst on the ship can also be a problem, as can be dealing with changes in the regular travel schedule. Hand-held communication devices for use in planning and obtaining trip information (utilising symbols and icons) are examples of ATT systems that have the potential to aid this impairment group.

Intellectual/Psychological/Cognitive

Problems encountered in using ships by travellers with cognitive impairments are similar to those found for other modes of transport. For example, it can be difficult to make and summarise travel-related decisions such as departure and arrival time or understand instructions given by a ticket machine. Computer-based trip planning systems and improved means of purchasing a ticket (e.g. smart card automatic debiting) are examples of ATT systems which may aid this impairment group.

Elderly

Older travellers experience similar problems in using ships as do those with cognitive impairments, for example in trip planning and using existing ticket machines. Computer-based planning systems (either hand-held or accessible from home) and smart card payment systems could also aid the elderly traveller.

1.5 Airplane

Skeletal - Motion of lower limbs

Travellers with mobility-related impairments encounter specific difficulties in establishing the procedures and layout of airports prior to making the journey. Information systems accessible from home or at travel agents may help

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

alleviate this problem, particularly if virtual reality technology is employed to provide 'dry runs'. Individuals within this impairment group also experience difficulties in gaining access to toilets on the airplane - improved airplane design is the most likely solution to this problem.

For this mode of transport, problems are also experienced by the airport organisations themselves which affect travellers with a mobility impairment (and disabled and elderly people in general). For example, airports are often not informed as to an elderly or disabled person's special needs, and subsequently staff cannot organise the most efficient assistance. Intelligent booking systems are a potential solution to this difficulty, so that impairment details are logged at the ticket purchase stage.

Vision

Visually-impaired travellers often experience problems in finding their way within airports and in finding toilets on the airplane. Sources of navigation information (e.g. tactile flooring, braille on signs) will help in these tasks, although it must be remembered that only a small minority of people with visual impairments can read braille. Portable navigation systems may also assist. Concerns also exist regarding procedures employed for emergency situations. For example, visual alarms warn that fire shutters are dropping in the airport, an illuminated strip is used on the airplane to indicate the location of emergency exits, and safety instructions cannot be read. Use of auditory and/or tonal information and braille safety instructions will assist the visually-impaired traveller in these situations.

Hearing/Language and Speech

Travellers within this group experience difficulties in trip planning and the purchasing of tickets, since verbal communication is often required. Computer-based planning systems and smart card-based ticketing systems are examples of ATT systems which will aid such individuals. Hearing and comprehending announcements on airplanes can also be a problem for this group, since most information is provided using the auditory modality - complementary visual information would ensure announcements are accessible.

Intellectual/Psychological/Cognitive

Few specific problems were identified during data collection for cognitive-impaired travellers using airplanes. Disabled people with cognitive impairments often travel by airplane with friends/colleagues, thus eliminating any potential problems. This was found to a lesser extent with other impairment groups.

Elderly

Elderly people encounter a number of the same problems experienced by other impairment groups (e.g. finding way within the airport, accessing toilets on the airplane, hearing announcements). In addition, similar to mobility-impaired travellers, elderly people like to be sure of procedures at the airport prior to travel. Information systems accessible from home or at travel agents

Part 1. Overview of User Requirements for Elderly and Disabled Drivers and Travellers

are a potential solution to this problem. Elderly travellers also experience problems in booking taxis in advance for when they return from a destination. A longer-term booking system or an easy-to-use, short-term booking system accessible from abroad is required.

Part 2. Usability Principles and Code of Good Practice

Introduction

Usability is concerned with all aspects of a product or system with which a user may interact. This not only includes the hardware, such as the screen and controls of a system, but also the software user-interface in terms of the screen layout, ease of navigation, user support and error handling.

A definition of usability was first attempted by Miller (1971) in terms of measures of 'ease of use'. This has evolved towards a formal definition of usability by Shackel (1991):

'the capability, in human functional terms, to be used easily and effectively by the specified range of users, given specified training and user support, to fulfil the specified range of tasks, within the specified range of environmental scenarios'.

This has now been simplified within the Esprit MUSiC (Bevan and Macleod, 1994) project and the International Standards Organisation (ISO 9241-11) to be:

'the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use'.

The importance of these definitions is that they recognise that usability is not an intrinsic quality which is the same for all situations. The features that make a system usable will depend on the situation or context in which it is used. For example, a public information system will be judged as usable if it can be operated by travellers without extensive skills or experience with computers, and also by users who are disabled or elderly. A route guidance and navigation system is regarded as usable if destinations can be found effectively, efficiently and safely, while the usability of a collision avoidance system will focus on preventing the user making serious errors.

The importance and benefits of usability

Usability is now widely recognised as critical to the success of an interactive system (Shackel and Richardson, 1992; Eason, 1984; Whiteside et al, 1988; Nielsen, 1994). Many poorly designed and unusable systems exist, which users find difficult to learn and complicated to operate. This results in their becoming under used, misused or even to fall into disuse as frustrated users return to their original working, or travelling, methods. The outcome is costly, or dangerous, for the person or organisation using the system, and harmful to the reputation of the company who developed and supplied it.

There are a number of benefits in considering usability in the design of ATT systems for travellers. These are reflected in the quality of the user interface to the system (Maguire, 1997):

Part 2. Usability Principles and Code of Good Practice

- *Increased Efficiency.* A system designed to sound human factors principles and tailored to the users' preferences will allow the traveller to operate effectively and efficiently rather than lose vital time struggling with a poorly designed user interface, which for in-vehicle systems could be highly dangerous.
- *Improved Productivity.* A usable system will allow the user to concentrate on the travelling task, rather than the human-computer interface, arriving at his or her destination safely, with least effort and on time. If the interface is designed inappropriately, it can extend rather than reduce the time to perform a task, as well as directly affecting other aspects of performance or quality.
- *Reduced Errors.* A significant proportion of so-called 'human errors' can be attributed to a poorly designed user interface. Avoiding inconsistencies, ambiguities or other interface design faults will reduce user error.
- *Reduced Training.* A poorly designed user interface can prove a barrier to an otherwise technically sound system. A well designed interface can reinforce learning, thus reducing training time and effort.
- *Improved Acceptance.* This is not usually the primary objective in improving the interface, but is nevertheless an important outcome. Most users would rather use and would be more likely to trust a usable human-computer interface which provides the information in a format which is easy to assimilate and use.

To realise these benefits for elderly and disabled users requires consideration of their constraints and limitations in the design and evaluation process, and TELSCAN can help projects do this.

Main activities in designing for usability

There are a number of essential user-centred design activities which should take place during the design process, as described by Eason (1982), Gould and Lewis (1983) and Bevan (1996). These are:

- *Understanding and specifying the context of use:* the nature of the users, their goals and tasks, and the environment in which a product will be used
- *Specifying the user requirements* in terms of effectiveness, efficiency and satisfaction; and the allocation of function between users and the system
- *Designing the user interface* to meet the user requirements and context of use.

Part 2. Usability Principles and Code of Good Practice

- *Prototyping the user interface* allowing users to visualise the system design and to demonstrate how it would operate.
- *Performing user based assessment* to obtain feedback on the prototype as a basis for redesign if necessary.

Some specific guidelines that are particularly relevant to elderly and disabled drivers and travellers are now given below under those headings.

Understanding and Specifying the Context of Use

The context in which the system will be used should be identified in terms of *the characteristics of the intended users, their tasks and the environment.*

Relevant characteristics of the users may include knowledge, skill, experience, education, training, physical attributes, habits and motor and sensory capabilities. A specific guideline in this respect for elderly and disabled travellers is:

2A.1 Workload on residual capabilities

Take care not to overload a user's residual abilities - offer alternative means of input or output. Elderly or disabled travellers are often working closer to the limits of their abilities. Physical impairment induces higher workload due to over-taxed or limited residual abilities.

For example, the visual channel must not become overloaded for people with hearing impairments. Similarly, the tendency to use synthetic voice and other acoustic output might lead to some people *becoming* drivers or travellers with special needs if they are not able to hear a message or warning from the system.

Specifying user requirements

Requirements elicitation and analysis is widely accepted to be the most crucial part of software development. Indeed, the success of the user-centred approach largely depends on how well this activity is done. The RESPECT project provides general help and support for these activities (Maguire and Kirakowski, 1997), and the TELSCAN project can provide data collection methods, tools and techniques specifically for the Transport Telematics sector. See Part 1 for an overview of requirements and the tools used to capture them.

A specific example of a guideline for transport applications is as follows:

2A.2 Including elderly and disabled travellers in design

Part 2. Usability Principles and Code of Good Practice

Specify user requirements in terms of the needs and characteristics of all potential users.

Certain user groups may require specific information from a travel and traffic information system, for example whether a roadside café is accessible to people who use wheelchairs.

User groups may have different feedback requirements, especially in critical situations. For example, a person with hearing impairments may not be able to use auditory warnings (type of feedback), or an elderly driver may wish to hear/see a warning earlier than other travellers (timing of feedback).

Consider a modular system design, whenever possible, where system components could form building blocks which can be interchanged to meet specific and changing users' needs.

Designing the user interface

There are a number of sources of guidance for designing usable systems. Shneiderman (1987) for instance, presents eight 'golden rules' for interface design:

1. Strive for consistency
2. Enable frequent users to use shortcuts
3. Offer informative feedback
4. Design dialogues to yield closure (feedback and satisfaction in completing a group of actions)
5. Offer simple error handling
6. Permit easy reversal of actions
7. Support internal locus of control (allow users to initiate and feel in control of actions)
8. Reduce short term memory load.

Another well known, practical source of information is Galitz (1980) who has produced specific guidelines for screen design.

However, it is important to relate guidelines to the particular application area in which the design is taking place. The following guidelines, for instance, are applicable to elderly and disabled travellers:

2A.3 Ease of use for more people

Design should be optimised for the cognitive, perceptual, and physical capabilities of elderly and disabled people. In general, simplicity is preferable to complexity.

Part 2. Usability Principles and Code of Good Practice

Remember that a good design for an elderly or disabled driver or traveller is also often better for the rest. In other words, follow the “design for all” principle.

Part 2. Usability Principles and Code of Good Practice

2A.4 Flexibility / Adaptability

Systems should be flexible enough and easy to adapt to individual user requirements, e.g., calibration of display intensities for people with perceptual impairments.

Certain safety critical or intricate adaptations of systems should be done by a competent specialist.

2A.5 Ease of learning

During the design process, the required skills and capabilities of the intended users should be identified, with the aim to redesign if necessary to include all potential users and their varied abilities. These then should be specified in the system documentation (ICE Ergonomics, 1994). Necessary skills and capabilities are also valuable criteria for the evaluation of the system. (See 3C. Training and Documentation.)

This is important for all users, but could be critical for people with cognitive limitations, such as learning disabilities and memory impairments.

2A.6 Familiarity/Conformance to expectations

Ensure that the system controls/displays feel familiar and conform to the expectations of the user. This is especially important for people with perceptual and cognitive impairments, and for elderly people who may be slower at learning new techniques or absorbing new information.

2A.7 Comfort in operation

Evaluate comfort aspects of use. This is even more crucial for elderly and disabled drivers and travellers who often show higher levels of physical or cognitive fatigue and workload.

2A.8 Compatibility with other aids and systems

Standard hardware and software should be designed so that assistive devices can be easily connected and used as alternative modes of input or output (Nordic Committee on Disability, 1993).

Part 2. Usability Principles and Code of Good Practice

Prototyping the user interface

In carrying out evaluations of a user interface design, a valuable technique is the use of computer simulations or rapid prototypes of the future system. This may consist of a series of screen layouts and a partial database allowing potential users to interact with, visualise and comment on the system. Such simulations or prototypes can be produced both quickly and easily in the early stages of the system development cycle for evaluation by human factors experts, user representatives and members of the design team.

Changes to the design may then be made rapidly in response to user feedback so that major problems with the design can be identified before system development begins. This helps to avoid the costly process of correcting design faults in the later stages of the development cycle.

Performing user-based assessments

User-based assessment is an essential activity in user-centred design. Assessment can be used to:

- provide feedback which can be used to improve design.
- provide evidence that user and organisational objectives have been achieved.

Early in design the emphasis will be on obtaining feedback (typically consisting of a list of usability defects) which can be used to guide design, while later when a realistic prototype is available it will be possible to measure whether user and organisational objectives have been achieved.

In the early stages of the development and design process, changes are relatively inexpensive. The longer the process has progressed and the more fully the system is defined, the more expensive the introduction of changes will be. It is therefore important to start evaluation as early as possible.

The assessment of usability should normally include analysis of both the users' performance and the users' attitudes as these provide complementary information. Since elderly or disabled travellers may already be working closer to their limits of strength and capability than most non-disabled people (Haslegrave, 1988), their performance and attitude to the system should be crucial.

A specific guideline related to this aspect follows:

Part 2. Usability Principles and Code of Good Practice

2A.9 Elderly and disabled travellers included in evaluation

System evaluation should include elderly travellers and travellers with disabilities.

Use methods and tools for requirements capture and evaluation which will facilitate the process of including special needs (e.g., Richardson et al, 1995).

Test methodologies and test tools are being developed within TELSCAN, and subsequent versions of the Handbook will make these available.

Part 3. Guidelines for All Telematic Systems

3A. Control of All Systems - General

3A.1 Choice of input mode

Consider which skills and capacities are required by users to operate the system and whether there is an alternative mode of operation.

For example, although speech recognition is not common at present as an input device, voice input has much potential for people with physical impairments.

Persons with mobility impairments may have limited range, reduced strength or reduced precision in their movements. They may find it difficult or impossible to grasp and turn certain sizes or shapes of knobs. In such cases, push buttons and sliding mechanisms may be preferable (Nordic Committee on Disability, 1993).

More detail on the implementation of controls is given in Control of all Systems - Implementation.

3A.2 Simplicity of control tasks

Usability design goals, crucial for everyone, are even more important for disabled and elderly drivers and travellers.

Try not to use the same controls or keys for different functions (e.g., Denno et al., 1992). However, a person with limited range or reduced strength may benefit from integrating functions into a reduced, but usable, set of controls. In this case, testing with disabled and elderly people is essential.

Guidelines for computer accessibility for disabled and elderly people stress the need for sequential operation of tasks for people with reduced abilities (Nordic Committee on Disability, 1993; Trace R & D Center, 1988). Such guidelines are safety critical for many travellers with special needs, but would also benefit elderly and disabled people using other forms of ITS for travellers, especially on an occasional basis.

3A.3 Consistency

Streamlined solutions, whereby aids would be combined to form a single system, should be used whenever possible in order to provide consistent operation of the system.

3A. Control of All Systems - Implementation

3A.4 Types of controls

Consider the use of alternative types of input to meet the needs of elderly and disabled travellers.

For example, speech recognition has much potential as an input device for people with physical impairments who might be working to the limits of their physical capabilities.

Ensure that the size, shape and surface of controls are designed so that the elderly or disabled person can easily grasp them (Nordic Committee on Disability, 1993).

Ensure that the type of control (e.g., push button, switch, latch, control knob, etc.) is easy to find, reach, and use for as many people as possible (Nordic Committee on Disability, 1993).

Single, sequential, finger-operated or palm-operated push buttons are suitable for many applications.

Simultaneous operations with different fingers should be avoided, both for stationary tasks, and especially whilst driving. This also applies to remote control units.

Auto-repeat activation (as the push-button or key is held down) should be avoided (Denno, et al., 1992).

Avoid the use of controls that need to be pushed and rotated at the same time (Kanis, 1993).

Controls which have to be pushed and pulled at the same time are not recommended (Denno, et al., 1992).

Membrane touch keys are not recommended unless:

- the keys have a matt, nonslip surface,
- the edges are raised,
- the keys are clearly coded, for example by colour,
- a positive click is felt when the key is pressed.

(Denno, et al., 1992).

Keypad keys, like those found on a telephone or calculator, are not recommended for use by a driver while the vehicle is in motion (ICE Ergonomics, 1994) since visual and auditory confirmation of hitting the correct key is required.

As in all good control panel design, all safety-critical controls should be easily differentiated by feel, although not in a position to cause injury if occupants are thrown forward in a collision.

In emergency applications a mushroom-shaped button would facilitate rapid and positive action for many people, as such a button

3A. Control of All Systems - Implementation

could more easily be struck with the fist or whatever residual ability or force is available (Boff, et al., 1986).

This design would benefit people with upper limb impairments, impairments in dexterity, coordination, or force and also those who have visual impairments or slower reaction times.

3A.5 Location and grouping of controls

Consider the reach capabilities of people with various physical impairments (e.g., short arms, small stature) when designing and assessing system controls. In effect, design for the least able.

Standards (e.g., ISO 4513, ISO 3958 and ISO 4040) could be used for locations of controls but these may not apply to certain impairment groups. Performance-based testing is, therefore, recommended with people with different skeletal impairments.

As in all good control panel design, all safety-critical controls should be easily differentiated by feel, although not in a position to cause injury if occupants are thrown forward in a collision.

Related controls should be grouped for easy identification. However, they should still be placed separate enough from each other so that they are easy to grasp, avoid confusion, and so that people do not activate them by mistake (Nordic Committee on Disability, 1993).

Groups of keys should be separated by distinct spaces with a distance of at least half a key (Nordic Committee on Disability, 1993).

3A.6 Size of control buttons

The size of control buttons should be designed and tested considering the needs of people with skeletal, vision and cognitive impairments.

3A.7 Size and clarity of text or symbols on control buttons

Large lettering, the use of lower case lettering and high contrast between the letter/symbol and background facilitates readability. For example, avoid low contrast combinations like light grey on slightly darker grey (Trace R & D Center, prepared by Vanderheiden, 1992).

Text on the keys should be printed in sans-serif characters, which are considered easier to read than other typefaces (Nordic Committee on Disability, 1993).

Lettering or symbols which use most of the surface of the key top facilitates readability (Trace R & D Center, prepared by Vanderheiden, 1992).

3A. Control of All Systems - Implementation

Remember that larger, easily readable lettering or symbols, designed with special requirements in mind, improves the learning process and efficiency of occasionally-used equipment for non-disabled users as well (Trace R & D Center, prepared by Vanderheiden, 1992).

3A.8 Ability to distinguish controls

Primary and hazard controls should be identifiable both visually and by touch. Such redundancy is more crucial for the elderly and people with disabilities, so as not to “design out” some user groups.

Controls should be easy to distinguish by location, shape, texture, colour, size, labelling, illumination or mode of operation (Galer & Simmonds, 1984).

As in all good control panel design, all safety-critical controls should be easily differentiated by feel, although not in a position to cause injury if occupants are thrown forward in a collision.

A control should not be “smoothed away,” and there should be no obstructions nearby which would prevent the user from easily making contact with the control (Kanis, 1993).

3A.9 Co-ordination, dexterity and force required for operation

Consider the wide variation in characteristics when using hand-operated controls, e.g., persons with impaired hand functions, such as reduced strength, small movements, or sweeping movements. This is crucial for elderly and disabled travellers, especially those of short stature or with limb impairments (Trace R & D Center, prepared by Vanderheiden, 1992).

A control should not require force of more than 2 Newtons (Nordic Committee on Disability, 1993).

3A.10 Compatibility with natural movements

The direction of movement of the control should clearly relate to the change that it effects in the associated display (Galer & Simmonds, 1984). This concept may not apply if the traveller does not have the appropriate ability/force to operate the device/control following the natural movement direction.

3B. Display of Information - General

3B.1 Choice of output mode

Consider which skills and capacities are required by users to obtain information from the system and whether there is an alternative mode of output to meet the needs of elderly and disabled travellers.

Offer a choice of mode of information presentation to meet special needs.

For example, haptic “displays” have much potential as an output device for people with hearing impairments.

Auditory displays can only be backup to visual displays and must not be the sole source of information, as travellers with hearing impairments would not be able to safely and effectively use the system.

Any information presented in auditory form should also be provided, even if redundantly, in an appropriate visual form (eg Trace R & D Center, 1988).

Provide a “feedback preference” setting or “user with hearing impairment” flag that a user could set when visual support is required. The system could then provide full visual redundancy for all audio output when the flag is set (Trace R & D Center, 1988).

In more advanced systems, the use of a smart card holding user characteristics could perform the same function.

The presence of a headphone jack provides the opportunity to plug in a small LED that would provide a visual cue whenever sound was emitted from the speaker. Another method is to wire in a small LED in parallel with the speaker to provide visual feedback of auditory activity (Trace R & D Center, 1988).

3B.2 Choice of output format

Where alternative formats for presenting information are available (e.g., text vs. symbols, alternative symbol sets, etc.), provision should be made for users to select their preferred option.

In more advanced systems, the use of a smart card holding user characteristics could perform the same function.

Alternatively, clear documentation should be provided for a specialist to customise the system.

3B. Display of Information - General

3B.3 Feedback

Investigate the feedback requirements for all users (e.g., type of feedback, frequency of feedback), especially in critical situations.

A choice of feedback (visual and auditory) should be offered to protect the user from actual or perceived risk and give confidence that the required action has been successful (Trace R & D Center, 1988).

Feedback and prompts should be adjustable according to experience and user preferences.

3B. Display of Information - Implementation

3B.4 Location of output

The optimal positioning of displays should consider the different anthropometry of travellers (e.g., short arms, small stature).

The display should be easily adjustable vertically and horizontally (tilted and turned) to meet individual needs.

3B.5 Density of information

Avoid screen clutter.

This is even more crucial for travellers whose cognitive processes have slowed or are slowing. Elderly people find it more difficult to select appropriate information from complex displays, increasing not only errors but also reaction times (Graham & Mitchell, 1996).

3B.6 Size or intensity of output

It should be possible to attach a larger display (for systems dedicated to certain user groups) or to enlarge the image in order to adapt the visual output to individual users' needs (Trace R & D Center, 1988).

The size of characters on the display should be tested with all types of users, especially those with visual impairments.

In the EDDIT project, the minimum size used as symbolic guidance information was 5 cm, and it is recommended not to go below this dimension (Oxley et al., Dec. 1994).

It should be possible to adjust the sound volume. The means of doing this should be very obvious and easy to use.

Pitch and frequency of speech should be modifiable in parallel with a change in the rate of delivery of the words. Users will also want to be able to vary the volume and the balance between the upper and lower registers.

Tone signals should be subject to adjustment in frequency/pitch as well as volume.

3B.7 Clarity and contrast of output

Displays should use high contrast between background and character or symbol.

The contrast and brightness should be easily adjustable and adaptable to the user's needs and the travelling environment.

3B. Display of Information - Implementation

The clarity and contrast of text on the display should be tested with all types of users, especially for persons with visual impairments.

3B.8 Ability to distinguish signals and warnings

Warnings should be made available in alternative forms - auditory, visual or tactile. This will allow travellers with visual or hearing impairments to adapt the warnings to their own individual abilities (Nordic Committee on Disability, 1993).

Warning signals should be evaluated with people who have perceptual and cognitive impairments.

Where more than one system is in simultaneous operation, alarms or warning signals for the different systems should be distinct and not lead to confusion.

Auditory signals/warnings

Volume, pitch and frequency of auditory output should be adjustable.

If the user has chosen auditory output, ensure that all signals and warnings will be heard against variable ambient noise and be easily distinguishable from each other.

Audible tones, especially for alarms and urgent messages, should use frequencies of no higher than 2000 Hz, since the higher frequencies are the first to deteriorate due to age or exposure to industrial noise.

Audio or voice output in isolation may make the task even more difficult for someone with even a slight hearing impairment. Therefore, a complementary or alternative mode of output should be made available to meet specific needs. It should also be adjustable to accommodate all levels of sensitivity.

Visual signals/warnings

Visual signals should be placed where they can be seen easily (e.g., Nordic Committee on Disability, 1993).

Warnings and similar alert messages must remain stable for a sufficiently long time to be discovered by the user (See 4A.17 Timing of information/response times).

3B.9 Use of colour

If a display uses colour coded information, a user should be able to select the most appropriate colours to meet specific needs and preferences (e.g., Nordic Committee on Disability, 1993; Trace R & D Center, 1988).

3B. Display of Information - Implementation

Systems should be capable of providing a variety of colour saturations - for example, through the use of a colour contrast control.

Start the design in black and white, adding colour later, and not relying on colour as the sole source of important information. Remember that in conditions of low light, even if colours have been chosen with care, colour perception will be markedly reduced.

Text should not be displayed in red/green and blue/yellow colour combinations. This will assist the 8-10% of males and 0.4% of females who are colour-blind (e.g., ICE Ergonomics, 1994; Nordic Committee on Disability, 1993).

If coloured areas such as symbols are to be presented on a coloured background, it is recommended that the symbols be outlined in black. This will increase discrimination when the ambient environment is bright (Stokes, et al., 1990; Ross, et al., 1996).

3B.10 Use of symbolic language

Three objectives need to be reached when designing symbolic language: symbols should be understood by users, choice of symbols should minimise learning time, and there should be no overlapping in meaning to avoid confusion with other symbols (Vernet, et al., 1992). These aims should be considered for all travellers, including people with different impairments and also people with cultural or language differences.

Use symbols where possible rather than words or abbreviations, but keep the number of symbols manageable and easy to learn. This is especially important for people with perceptual and cognitive impairments, e.g., learning difficulties (Green, 1993).

The use of common symbols is recommended in all countries to ensure that each symbol has the same meaning wherever it is encountered.

User testing is needed to ensure that all travellers find the symbols easy to see, read, and understand.

Consider, for example, a driver who has memory lapses. An information or route guidance system with purposeful and tested symbology, designed with such needs in mind, may enable this person to continue travelling for a few more years.

See also 3A.7, Size and clarity of text or symbols on control buttons.

3C. Training and Documentation

3C.1 Consideration of user needs in training

Consider the needs of elderly and disabled travellers when developing the training procedure for ATT systems.

3C.2 Easy to understand

The documentation should be written in a language that is easy to understand.

This is beneficial for all users, but especially for persons with sign language as their first language, for persons with aphasia, and for people speaking different languages or coming from different cultural backgrounds (Trace R & D Center, prepared by Vanderheiden, 1992).

3C.3 Specification of skills or capabilities

System documentation should specify the skills or capabilities the user requires to operate the system (ICE Ergonomics, 1994). These skills and capabilities will also be valuable criteria for the evaluation of the system.

3C.4 Specification of system failure procedure

System documentation should clearly specify the correct procedure to follow in case of system failure (ICE Ergonomics, 1994). This guidance should be easily accessible and readable for all.

3C.5 Documentation binding

While stationary, to ensure that the documentation can easily be read by persons with upper limb impairments, the documentation binding should allow the user to place the documentation open on a surface and turn the pages with one hand (Nordic Committee on Disability, 1993).

3C.6 Memory aids

Memory aids could be provided through the use of a quick reference card, useful for all travellers, but especially for people with a slight degeneration in cognitive functions.

3C.7 On-line help

Where possible, provide on-line help on the system itself.

3D. Other Issues

3D.1 Updating the aid

Consider a modular design for systems, which lends itself to adaptability to meet specific needs and easier updating.

3D.2 Material composition

Designers of systems should be aware of potential problems with certain materials.

For example, the induction pick-up coil on a hearing aid could be interfered with by the electromagnetic characteristics of the equipment (Nordic Committee on Disability, 1993).

The surface of the controls or any item which may be in contact with the skin (e.g., something that is worn) should not contain chromium, nickel or other material which may cause allergy (Nordic Committee on Disability, 1993).

3D.3 Power supply

Extra attention should be paid to power supply and power consumption, as an assistive device for travellers with special needs may use additional power, thus increasing the risk of overload and risk of fire (Nordic Committee on Disability, 1993).

Consider a backup system in case of failure - elderly and disabled travellers may be more reliant on the system than others travellers (See 4A.1 Safety in controlling a vehicle).

3D.4 Reflections or glare from the equipment

Provide protection of the display from reflections and from the sun's glare. Older travellers are especially susceptible to slower accommodation to sudden changes in light levels and also to glare, whether it be from car headlights or a visual display, due to the increased lens opacity of the older eye. This was confirmed in the EDDIT trials with route guidance systems (Oxley, et al., Dec. 1994).

3D.5 Interoperability and Compatibility

Standard hardware and software should be designed to facilitate the connection of, interaction with, and use of assistive devices for adaptive input and output devices, using industry standards as far as possible (Nordic Committee on Disability, 1993; Trace R & D Center, 1988). This would better ensure that alternative modes of input/output could easily be installed to meet the needs of different users.

Part 4. Guidelines for Telematic Systems for Drivers

4A. General Guidelines - Drivers

4A.1 Safety in controlling the vehicle

Designers should be aware of safety implications due to the introduction of in-vehicle systems (e.g., a driver's delayed action or missing an action) .

Better guidance should reduce the risk of accidents due to indecision or last moment changes in intention, thus increasing safety. However, the availability of additional information increases the potential distraction of the driver from the basic driving task. (Briggs et al., 1992, on Route Planning/Guidance System Incorporating RDS-TMC).

If too much information is presented, an elderly driver will have difficulty to absorb it, retain it and react to it when necessary. This would thus create a further problem rather than resolving the initial one of driver uncertainty and indecision. (Briggs et al., 1992, on Dual Mode Route Guidance).

Safety implications should be assessed in the light of special needs. The designer should consider how the elderly or disabled driver interacts with the system, and the degree of risk imposed by the traffic or situation. (e.g., Grayson, 1993; ICE Ergonomics, 1994)

An elderly or disabled driver may rely on a system more than other drivers. Therefore, ensure either:

that there is a back-up system in the event of system failure (where a vehicle is being custom-modified for a particular user and where cost may be of secondary importance), or

that careful attention is given to the implications of system failure, in order to ensure that the consequence is predictable and will not result in a safety hazard (where a standard product is being designed with the needs of elderly and disabled users in mind).

Performance testing is recommended with drivers from different impairment groups to ensure safety in controlling the vehicle.

4A. General Guidelines - Drivers

4A.2 Workload on residual capabilities

The ease of use of a particular control is more important for drivers using adaptations for manual control, as it appears more difficult for them to simultaneously accelerate or brake while using some other control than for able-bodied drivers who can use their feet and their hands. In other words, it is easier to perform two independent tasks with a foot and a hand than with two hands (due to capacity interference). (See 4A.8 Compatibility with other aids and systems) (Tested by TELAID, Verwey, 1995).

Touchscreens place a high visual workload on the driver and could interfere with the primary driving task (ICE Ergonomics, 1994), especially for elderly or disabled drivers, who may be working to the limits of their abilities. (see also 4A.9 Choice of Input Mode)

4A.3 Flexibility/Adaptability

Designers should make all vehicles and aids adaptable or easier to adapt through modular design wherever possible.

The system should be easy to customise by the driver or, where safety is crucial, by a competent specialist. For example, a driving instructor can help the driver analyse his or her requirements and choose the best possible options and modes of operation.

In EDDIT's testing on gap acceptance systems, using the electronic device significantly increased the number of near misses experienced by subjects, which implies that some on-going indication of the proximity of a possible collision with an on-coming vehicle might be useful. It was suggested that the threshold for advising the driver to initiate a manoeuvre would need to be tailored to the requirements and capabilities of the individual (Oxley et al., Jan. 1995).

In addition to an "adaptable" system which can be customised, consider where possible an "adaptive," automated system, which will automatically conform to the user's requirements (See 4A.10 Automatic operation of systems).

4A.4 Ease of adjustment while stationary

A driver should be able to adjust the parameters of the in-vehicle telematic system only while stationary (ICE Ergonomics, 1994).

Although this is important for all drivers, it is critical for: disabled drivers with high workload on particular residual abilities, or for elderly drivers who will have more difficulty in dividing their attention between different situations or tasks.

4A. General Guidelines - Drivers

4A.5 Ease of adjustment while driving

If the driver is required to interact in any way with the telematic system while driving, it must be at a minimum and kept simple, if possible eliminated entirely, in order to prevent overload.

Although this is important for all drivers, it is critical for: disabled drivers with high workload on particular residual abilities, or for elderly drivers who will have more difficulty in dividing their attention between different situations or tasks.

Accidental adjustment of information system settings/default parameters should not occur while driving, but it is vital that such adjustment should not occur to safety-critical driving adjustments.

Temporary adjustments (such as loudness/balance, brightness/contrast) should be easily made while on the road because conditions are constantly changing.

4A.6 Adjustability

Consider the fact that drivers with special needs, especially those with lower limb impairments, may require different H-point measurements to define and to install an ATT display in its optimum position (ISO 6549). The system display should be adjustable enough to meet these different requirements.

4A.7 Comfort in operation

Ring accelerators are preferred over segment accelerators. (See Appendix 1 for a description of these car adaptation aids for drivers with disabilities.) This holds for drivers with disabilities driving with or without telematic applications because of the discomfort associated with the segment accelerator.
(Tested in TELAID, Verwey & Veenbaas, 1993; Verwey, 1995)

4A.8 Compatibility with other aids and systems

Given the possible number of car adaptations for drivers with disabilities, the implementation of visual/auditory/tactile controls and displays needs to be integrated through a systems approach followed by a whole-vehicle test procedure.

While evaluating the use of controls with drivers with disabilities, special attention should be paid to capacity interference and structural interference (Tested by TELAID, Verwey, 1995).

4A. General Guidelines - Drivers

Example:

Due to capacity interference similar limbs (driving with hand operated controls) are more difficult to use for independent movements (accelerating and activating control elements) than different limbs.

Adapted accelerators (e.g., segmented accelerator), which require continuous operation by one hand, limit the number of possible locations of input controls (structural interference). With adapted accelerators which can be operated by the left or right hand at preference, the disadvantage for drivers with disabilities is less (See 4A.12 Location and grouping of controls).

(See Appendix 1 for a description of these car adaptation aids for drivers with disabilities.)

When fitting the system, consider the design of all car adaptations for drivers with disabilities, as they may increase the risk of injury due to their sharp or awkward projections.

When ATT systems are fitted into a vehicle for a driver with a disability, ensure that the system is compatible and conforms with electric cables for any adaptations required for that driver. Consider the necessary power consumption and the possibility of magnetic interference (See 3D.2 Material Composition and 3D.3 Power Supply).

4A. Control of the System - Drivers

4A.9 Choice of input mode

Consider which skills and capacities are required by users to operate the system and whether there is an alternative mode of operation, for example, the potential of voice input (See Section 3A.1).

The use of head controls is recommended for drivers with physical disabilities as they result in faster responses than rotary switches and push buttons of various diameters. However, caution is needed as steering frequency increases somewhat. People with disabilities also show little preference for head controls, so they may not choose to purchase or accept them.

(Tested by TELAID, Verwey, 1995).

Knobs on the head-restraint, the driver's elbow, and voice activated secondary controls are modalities that should be reviewed as essential or alternative input modes for various groups of drivers with disabilities.

Touchscreens place a high visual workload on the driver and could interfere with the primary driving task (ICE Ergonomics, 1994), especially for elderly or disabled drivers, who may be working to the limits of their abilities. This is supported by EDDIT's trials with a route guidance system using a touch-sensitive screen to programme the system: 9 of the 30 subjects in the trial did not find using the touch screen easy (Oxley, et al., Dec 1994).

It is suggested that touchscreens are only used when the vehicle is stationary and that a secondary keyboard designed for special needs can be attached, if required. (see also 2A.1 and 4A.2, Workload on residual capabilities).

This is particularly relevant for drivers with hand coordination problems (e.g., due to Cerebral Palsy or arthritis) where the reaction speed of the touch screen and the absence of tactile feedback may be problematic.

4A.10 Automatic operation of systems

Provide adaptive, automated systems where possible and appropriate.

For example:

Different criteria could be used for system activation :

- when a specified criterion is reached,
- when the driver initiates the system,
- continuously

(PROMETHEUS, 1991)

4A. Control of the System - Drivers

Remember, though, that automation could lead to a misunderstanding of the situation and lead to additional problems, e.g., if automatic systems misunderstand the conditions (Stokes, et al., 1990; Wierwille & McFarlane, 1993).

4A.11 Types of controls

Keypad keys, like those found on a telephone or calculator, are not recommended for use by the driver while the vehicle is in motion (ICE Ergonomics, 1994) since visual and auditory confirmation of hitting the correct key is required.

Combined with the use of hand operated primary controls (accelerator, brake), discrete rotary controls are preferred in situations requiring precise speed keeping (short following driving task) , although a higher operating force is needed (contra-indication: drivers with special needs with reduced strength, see 4A.15 Co-ordination, dexterity and force required for operation.) (Tested by TELAID, Verwey, 1995).

Drivers with very limited or absent hand functioning can operate only a minimum number of controls in total. During driving these controls are used for safety crucial functions, e.g., operating indicators, lights, horn, wiper/washer. When not in use for primary functions these controls could be assigned a secondary ATT control function (e.g., through double clicking). The safe and correct use of such a set-up should be thoroughly tested and training in correct use provided to ensure no interference with the primary functioning occurs.

4A.12 Location and grouping of controls

To support safe and easy operation, the following order of priority is recommended when locating controls (ICE Ergonomics, 1994):

1. Controls for primary visual tasks
2. Primary controls associated or interacting with primary visual tasks.
3. Controls positioned near associated displays.
4. Controls that are to be used in sequence.
5. Controls that are used frequently.
6. Consistency with other system layouts.

Priorities are likely to be the same for drivers with special needs, but location still needs to be tested with drivers from different impairment groups, e.g., whether it is practicable in every case to place the controls near associated displays. Therefore, consider adjustable placement of controls to meet specific needs.

4A. Control of the System - Drivers

Optimal positioning of controls may need to consider the location of other aids for drivers with special needs, e.g., adaptable control aids or mobility and car adaptation aids. For example, for people with lower limb disabilities, ring accelerators are preferred over segment accelerators when the telematics system is to be used by the same hand as the accelerator (See 4A.8 Compatibility with other aids and systems).

(Tested by TELAID, Verwey, 1995).

4A.13 Size of control buttons

Larger buttons (around 24 mm) are preferred to smaller buttons (around 4 mm) because they require less looking at the button before it is activated. However, the effect on driving safety may be similar for small and large buttons in that large buttons may tempt the driver to activate the button immediately whereas activation of smaller buttons is postponed until a demanding driving situation has finished. Hence, larger buttons are preferred for tasks of higher priority.

(Tested by TELAID, Verwey, 1995).

4A.14 Size and clarity of text or symbols on control buttons

It must be remembered that safely controlling the vehicle is the primary task, not the use of the system. Therefore, exact size measurements of text or symbols depend on the task being performed and must be tested with people with visual impairments.

4A.15 Co-ordination, dexterity and force required for operation

A user should only be required to hold a control down for a long time when safety requires it, such as in a "dead man's handle" (Kanis, 1993). (A dead man's handle is engaged continuously and activates brakes when let go, e.g., as a result of the driver collapsing). Even with such a system, some tolerance is desirable, eg by allowing a short delay before activating an emergency stop.

French railway practice requires that the driver makes frequent moves to bring together a moving and a flexible ring, activating an emergency stop within about 1.5 seconds. This might be longer than desirable on the road, but the principle is worth considering and testing.

Elderly and disabled drivers may have variable strength in various directions or movements (e.g., twist, push, pull movements, etc.), so controls should be able to be adapted so that they can be operated in the direction of maximum strength and/or capacity.

4A. Control of the System - Drivers

4A. Display of Information - Drivers

4A.16 Choice of output mode

Auditory signals, with the option of strong visual feedback, should be used to automatically alert drivers to errors that require immediate action.

An alternative to presenting visual information on a traditional dash mounted display exists in the possibility of utilising Head-Up-Display or Mid-Head-Display technology. This technology can present displayed information on or below the line of gaze of the driver by reflecting an image off the inside of the car windshield. Furthermore, the display can be focused at a distance in front of the car. This reduces time taken to refocus and redirect gaze, and would be particularly useful for elderly or visually impaired drivers, especially those with bifocal glasses. However, if such displays overlay the forward scene rather than the car bonnet, care should be exercised to avoid a cluttered display that would unduly distract the driver from looking forward (Weintraub & Ensing, 1992).

“The presentation of information with a Head-Up Display has the advantage over On-Dashboard Display that the driver is not being compelled to adapt his vision. However, this system presents the drawback of displaying information in a road scene which already contains a great deal of visual information, which is not necessarily relevant. Thus, as elderly drivers find it difficult to pick out the relevant signal (selective attention), they may encounter some problems when using such devices.”
(Briggs et al., 1992, on Route Guidance Systems)

EDDIT's driving simulator testing to compare HUD with LCD on-dashboard display confirmed that response time is reduced when information is presented in HUD form (Marin-Lamellet et al., Feb., 1994). Using an audible signal to warn that a visual message was about to be displayed had further effects, including to induce a more relaxed attitude among the subjects.

4A.17 Timing of information/response times

Some users may require earlier messages to compensate for slower reaction times. Therefore, default times should be easy to customise by a specialist, e.g., a trained driving instructor should be able to help the driver analyse his or her requirements and choose the best possible timing. This would be particularly relevant for drivers with skeletal, visual, auditory, and cognitive difficulties.

4A. Display of Information - Drivers

All systems should present information in a timely manner.

Systems should not present messages unnecessarily early so that drivers will forget the instruction or will tend to prepare and execute actions while negotiating complex driving situations. (Tested by TELAID, Verwey, 1995).

If an instruction is presented too late, it could cause a dangerous, forced response or a missed opportunity.

Exact timings of messages still need to be tested. For example, the DRIVE II HARDIE project recommended timings of route guidance information, but these ranges have not been tested with elderly drivers or drivers with disabilities (Ross et al., 1994; Ross et al., 1996). (See HARDIE guideline on Timing of Instruction for Route Guidance and Navigation Systems, Part 4B).

Elderly drivers, whose speed of cognitive processing is slower, would particularly benefit if the display time of messages on the screen could be increased or if a "repeat last message" facility could be provided (Graham & Mitchell, 1996).

Prioritisation of driver attention is, as a rule: 1. driving task, 2. audible messages, and 3. visual messages requiring glance at the fascia rather than at the road. Given these priorities, a memory buffer in the in-vehicle unit is essential, the only exception being turning-movement instructions which are driven by the position of the vehicle rather than by any timing event.

Some RDS-TA receivers already incorporate a memory feature (up to perhaps 30 seconds) allowing the driver to demand repetition of a message. Something analogous for text (whether driven by TMC or other digital channel) is highly desirable.

If a short break is made between screens of a message, it would allow drivers to re-orient themselves to the road environment, reduce pacing and avoid excessive glance frequencies over short periods (Graham & Mitchell, 1996).

Reaction time on ATT control messages is seriously influenced by the type of controls used by drivers with disabilities (e.g., there is a much shorter reaction time when using an accelerator ring than a segmented ring - reaction time even shorter than for the non-disabled driver.

(Tested by TELAID, Verwey & Veenbaas, 1993).
(See also 4A.9 Choice of input mode.)

4A. Display of Information - Drivers

4A.18 Location of output

The optimal positioning of in-vehicle displays should consider the different anthropometry of drivers (e.g., short arms, small stature).

Other aids for drivers with disabilities (e.g., a lever for acceleration/braking) must not obstruct the view of the road ahead or output from in-vehicle systems. Likewise, in-vehicle systems must not obstruct access to other driving aids.

Displays must be adjustable enough to be located as near as possible to each driver's line of sight. This is even more important for an elderly or disabled driver, who may not be able to bend towards the display, or indeed should not be expected to do so for safety reasons.

The use of parallel displays should be tested with elderly and disabled drivers to ensure that workload levels do not increase.

The specific location of output for each system should be evaluated with drivers with different types of impairments.

4A.19 Density of information

Use only the simplest three-element messages (Ross et al., 1996) to ensure safety, usefulness, driver acceptability and driver's ability to remember. An example of 3 message "elements" might be "roadworks," "speed limit 30 m(km)ph" and "3 miles (km) ahead."

Since elderly drivers have more difficulty dealing with complex situations or tasks, remove where possible the road numbers of junctions, as these tend to increase complexity of the information (Graham & Mitchell, 1996).

Illustrations of complex junctions need to be simple without in themselves creating confusion (Briggs et al, 1992, on Route Planning/guidance system incorporating RDS-TMC).

Results obtained from EDDIT showed that there is an age-related interaction between the complexity of the driving task and the complexity of guidance systems (Oxley, et al., Dec. 1994).

4A.20 Size or intensity of output

The size of the characters on the display must be large enough and the contrast high enough so that the driver does not need to bend toward the display to read the information.

For older drivers who are wearing driving glasses, but not their reading glasses, it should not be necessary to peer over their

4A. Display of Information - Drivers

glasses in order to accommodate the close proximity of the display (Graham & Mitchell, 1996). (See 4A.18 Location of output.)

It must be remembered that safely controlling the vehicle is the primary task, not the use of the system. Therefore, exact measurements of the size or intensity of output depend on the task being performed and must be tested with people with visual or hearing impairments, depending on the mode in question.

Provide a “zoom in” or screen enlargement feature wherever possible. However, whilst driving, the driver should not be required to manually zoom in and out to different scale levels. Instead, the system should automatically present the optimum amount of usable information.

4A.21 Ability to distinguish signals and warnings

Where more than one in-vehicle system is in simultaneous operation, alarms or warning signals for the different systems should be distinct and not lead to confusion.

Auditory signals/warnings

Abruptly rising waveforms should not be used in the first 0.2 seconds of a signal, so as not to startle the driver (ICE Ergonomics, 1994).

These might be hazardous for certain drivers with disabilities, e.g., sudden noise could cause muscle spasticity for some people with disabilities (Nicolle, et al., 1992, Annex IV).

4A. Other Issues- Drivers

4A.22 Power supply

Extra attention should be paid to power supply and power consumption, as an assistive device for drivers with special needs may use additional power, thus increasing the risk of overload and risk of fire (Nordic Committee on Disability, 1993) (See also 3D.3 Power supply).

This is especially the case for cars of drivers with limited strength, where further engine power backup is used by servo-assisted controls. This may additionally consume as much as 15% of overall engine power. If an auxiliary system demands significant power, enhanced fuel consumption with a slightly greater throttle opening (or equivalent with injection systems) are needed for a given performance when used in parallel with ATT aids.

Apart from the risk of fire, assistive devices may discharge the vehicle's battery more quickly. Many elderly and disabled drivers travel short distances which may make it difficult to retain charge, at least in winter, unless they can and do connect a trickle charger - exactly what these drivers may be unable, and should not need, to do.

Consider a backup system in case of failure - elderly and disabled drivers may be more reliant on the system than others drivers (See 4A.1 Safety in controlling a vehicle).

4A.23 Portability

Fitting should be both secure and adaptable within a particular vehicle (ICE Ergonomics, 1994) and, if possible, between vehicles.

4B. Guidelines for Route Guidance and Navigation Systems

Appendix 4 applies the TELSCAN guidelines from Parts 2, 3 and 4A to the guidelines on information presentation for route guidance and navigation systems from the DRIVE II HARDIE Project V2008 (Ross et al., Chapter 2, 1996). The Appendix provides an example of how the TELSCAN guidelines can be more widely applied to specific systems or existing guidelines.

Appendix 4 is under review, as well as other existing guidelines, for example, Green, et al. (1995) which covers navigation input as well as output. The next version of the handbook will capture specific guidelines on designing route guidance and navigation systems that will be more usable by elderly and disabled drivers.

For example, the timing of instructions given in the HARDIE guideline (page 83) was derived from a study in which no disabled or elderly drivers took part. It is likely that drivers who have slower response times, either as a result of age or a particular impairment, require messages to be presented earlier, but not too far in advance so as to forget it before action is due. More testing is recommended before specific timings can be given, but there is some data already available.

Green and George (1995) conducted a road-based study which aimed to establish the optimum timing of voice-based route guidance messages. Driver age was included as an independent variable, and it was found that older drivers required guidance messages to be presented significantly further back from a decision point, as compared with younger drivers. The finding was incorporated within a specific guideline (which took the form of a regression equation) to aid in the design of route guidance systems that account for the needs of elderly drivers.

Permission has been granted to reproduce this guideline as part of TELSCAN's Handbook. The next version of the Handbook will include this specific guideline and others based on our continued review.

4C. Guidelines for Adaptive Cruise Control Systems

Introduction

The following section summarises the guidelines for ACC systems suggested by the TELAID simulator tests (Peters, 1995a).

The purpose of this phase of testing in TELAID was to investigate how ACC driving would influence workload, comfort and driving behaviour of drivers with lower limb disabilities, given the type of hand control the driver used for accelerating and braking. (See Appendix 3 for a fuller description of the simulator testing.) The test found that the ACC system was well received, wanted and trusted by the subjects, and ACC driving had the same influence on the driver regardless of the type of hand control system used. It was concluded that the ACC system substantially contributed to decrease the workload experienced by drivers with lower limb disabilities. From this phase of the TELAID testing, it has not always been possible to provide specific guidelines on appropriate feedback or comfort in operation for an ACC system. In order to do this, it would be necessary to compare one system with another, and testing in the future is required with people having different impairments.

In the examples below, the emerging guidelines from the simulator tests are classified under the appropriate TELSCAN headings from Parts 2, 3 and 4A of this Handbook.

4C. Guidelines for Adaptive Cruise Control Systems

Application of TELSCAN guidelines:

2A.2 Including elderly and disabled travellers in design

2A.4 Flexibility/Adaptability

It is important that headway is individually adjustable, by a qualified specialist, according to driver's characteristics and preferences to satisfy the needs and preferences of drivers with lower-limb disabilities. People with different types of impairments should be included when the adjustable range is determined. This need for adjustable headway becomes even more pronounced in poor weather conditions or night-time driving. Headway should not be altered by the driver, especially while driving.

As a starting point it is recommended that the ACC system uses a headway which is 0.7 seconds longer compared to that used for able-bodied drivers. For example, an often used headway value is 1.4 seconds in ACC systems. This value should be prolonged to 2.1 seconds.

(Tested by TELAID, Peters, 1995a)

TELSAN Comment:

An evaluation of one ACC system with drivers with lower limb impairments (Peters, 1995a) revealed that this group of drivers prefer a longer average headway, or distance to a leading vehicle, than that which the system used. Therefore, it is important that the headway parameter of the ACC system is individually adjustable according to these drivers' needs and preferences. Drivers with different types of impairments should be included when the adjustable range of the headway is determined.

The study found that mean headway was approximately 0.7 seconds shorter for the ACC condition. This means that on average the subjects were driving 17 m closer at a speed of 90 km/h to the leading vehicles. This shorter distance was accepted but it does not conform to the distances found under the unsupported condition. Some comments were also made by subjects that the ACC used a too short headway.

It is recommended, however, that testing in real traffic is undertaken to validate these guidelines.

4C. Guidelines for Adaptive Cruise Control Systems

Application of TELSCAN guideline:

2A.6 Familiarity/Conformance to expectations

The input and output of the ACC should be designed with respect to the function provided as viewed by the driver. Don't allow the driver to believe it is a Collision Avoidance System instead of an ACC by displaying irrelevant information
(Tested by TELAID, Peters, 1995a).

TELSCAN Comment:

The purpose of an ACC system is to assist the driver in controlling the speed of the vehicle. But the extended functionality of ACCs, compared to conventional cruise controls, might confuse the driver, who might expect to be able to use it as a Collision Avoidance System. It is very important, therefore, to make this distinction clear to all drivers, especially when the feedback or information presentation subsystem of the ACC is designed (Ross et al., 1996; Peters, 1995a).

Application of TELSCAN guidelines:

3A.5 and 4A.12 Location and grouping of controls

It should be possible to easily adapt the ACC controls so that they can be operated simultaneously with the primary driving task without interfering with it. For example, if the ACC controls are placed on an acceleration lever for drivers requiring hand controls (See Appendix 1) then the driver could activate the ACC at the same time as controlling the speed.
(Tested by TELAID, Peters, 1995a).

TELSCAN Comment:

In the TELAID evaluation of an ACC system with drivers with lower limb impairments, the controls were placed on the direction indicator stalk at the left hand side. The switches were obscured by the steering wheel which made it difficult visually to identify the controls. In order to operate the switches, the driver had to release his/her hand from the steering wheel. One switch had three different effects depending on the status of the ACC. The study found that it is important that the ACC controls are adaptable regardless of the type of hand controls used for accelerator and brakes.

4C. Guidelines for Adaptive Cruise Control Systems

Application of TELSCAN guideline:

3B.3 Feedback

The ACC feedback to the driver should be integrated into existing instruments as far as possible as long as relevant information can be accurately and quickly deduced.

(Tested by TELAID, Peters, 1995a).

Feedback from the ACC should also be adaptable so that the needs of individual drivers with special needs can be considered.

TELSCAN Comment:

In the TELAID evaluation of an ACC system with drivers with lower limb impairments, feedback from the tested system was considered to be well integrated into existing instruments. However, from this TELAID test, it is not possible to provide a specific guideline on appropriate feedback for an ACC system. In order to do this, it would be necessary to compare one system with another, and this needs testing in the future.

Application of TELSCAN guideline:

3B.8 Ability to distinguish signals and warnings

Audible tones, especially for alarms and urgent messages, should use frequencies of no higher than 2000 Hz, since the higher frequencies are the first to deteriorate due to age or exposure to industrial noise.

Audio or voice output in isolation may, however, make the task even more difficult for someone with even a slight hearing impairment. Therefore, a complementary or alternative mode of output should be made available to meet specific needs. It should also be adjustable to accommodate all levels of sensitivity.

TELSCAN Comment:

This modifies the HARDIE guideline:

“Imminent crash avoidance warnings should have a high fundamental frequency” (Ross et al., Chapter 4, 1996).

4D. Guidelines for Collision Avoidance Systems

Introduction

Appendix 5 applies the TELSCAN guidelines from Parts 2, 3 and 4A to the guidelines for collision avoidance systems (CAS) from the DRIVE II HARDIE Project V2008 (Ross et al., Chapter 3, 1996). The Appendix provides an example of how the TELSCAN guidelines can be more widely applied to specific systems or existing guidelines.

Appendix 5 is under review, as well as searching for other existing specific guidelines. The next version of the handbook will begin to capture specific guidelines on designing collision avoidance systems that will be more usable by elderly and disabled drivers.

4E. Guidelines for Reversing and Parking Aids

Introduction

The following section summarises the guidelines for reversing aids which have emerged from a limited number of field trials conducted in the TELAID project (Peters, 1995b) and the EDDIT project (Barham et al., July 1994 and Dec 1994). (See Appendix 3 for summary descriptions of the tests.)

In the examples below, the emerging guidelines from the field trials are classified under the appropriate TELSCAN headings from Parts 3 and 4A of this Handbook, with specific reference to the results of the field trials.

Please note that these guidelines are the result of a limited number of tests with disabled and elderly drivers, and more testing is recommended.

4E. Guidelines for Reversing and Parking Aids

Application of TELSCAN guideline:

3B.3 Feedback

Provide both auditory and visual feedback.

TELSCAN Comment:

The system that provides both auditory and visual feedback gives better support to and is preferred by the driver
(This is strongly suggested in limited testing by TELAID, Peters, 1995b, and by EDDIT, Barham et al., July 1994 and Dec 1994).

As is proven in other tests, auditory feedback is more omnidirectional than visual feedback and seems to interfere less with the primary reversing task. However, for people with hearing impairments both means of feedback are required. If you provide visual feedback both through the rear view mirror and through direct view, it will make visual feedback more omnidirectional (Tested by TELAID, Peters, 1995b).

Application of TELSCAN guideline:

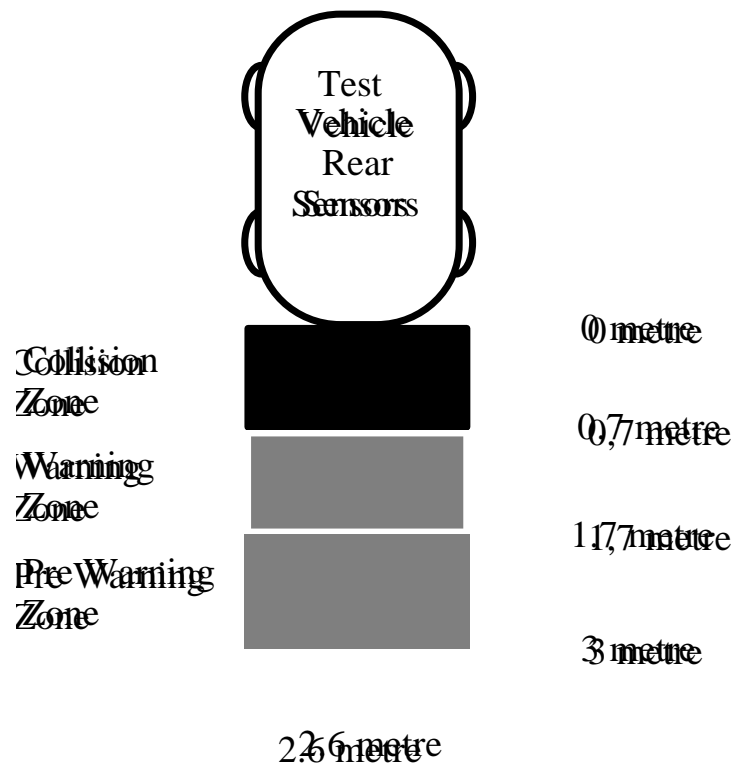
3B.8 Ability to distinguish signals and warnings

The warning zones, as defined by the existing standard ISO TR 12155, give better support to the driver for reversing tasks. Therefore, this standard also applies well to people with lower limb disabilities (Peters, 1995b).

TELSCAN Comment:

The three warning zones as specified in ISO TR 12155 are illustrated below:

4E. Guidelines for Reversing and Parking Aids






Application of TELSCAN guideline:

4A.18 Location of output

Positioning the display on the rear parcel shelf tends to have a less detrimental effect on drivers' visual and mental workload whilst manoeuvring.

In the EDDIT trials with two types of reversing aids, the systems differed in their positioning within the test car. Whilst the display of the infrared device occupied a position on the car's dashboard, the lights constellation of the ultrasound system was mounted on the rear parcel shelf (and so could be viewed using the car's rear view mirror). Subjects viewed the display almost exclusively through the rear-view mirror. In terms of the manoeuvring time spent glancing in each direction, the introduction of this system resulted in a substantial increase in the use of the rear-view mirror, and a marked decrease in glances over both shoulders and at both wing mirrors. The conclusion from the evaluations was that, whereas the dashboard-mounted display both increased the number of changes of glance made by subjects and increased manoeuvring time (indicating an increase in drivers' visual and mental workload whilst manoeuvring), volunteers were not affected in either way when using the display positioned to the rear.

(Barham et al., July and Dec 1994)



Future versions of the Handbook will see developments in more specific guidelines to ensure that travel and traffic information systems are usable by elderly and disabled drivers.

Guidelines for travel and traffic information systems for drivers are emerging from the literature review which is now in progress, including for example Ross, et al., Chapter 1 (1996) and Green et al. (1995). These guidelines are being reviewed by TELSCAN to ensure that they meet the needs of elderly and disabled people. Guidelines are also being produced by current Transport Telematics projects, many of which have already agreed that their guidelines could, and should, be reviewed by TELSCAN and compiled into this Handbook.

Many existing and prospective systems and guidelines need to be tested with elderly and disabled drivers, and TELSCAN is now in the process of arranging its own or collaborative testing to this effect.

This section represents a first draft of the guidelines for ATT systems for elderly and disabled travellers, using various modes of public transport.

Guidelines are emerging from an ongoing literature review covering, for example, the CEC TIDE (Telematics Integration for Disabled and Elderly People) programme. Some projects within Transport Telematics are also developing guidelines in the course of their work and have given us permission to include them in this Handbook. Guidelines will also be developed through TELSCAN's collaborative or complementary testing with other projects, which is now being arranged. It is interesting to note that many of these guidelines are being developed specifically for elderly and disabled people within the TIDE programme and need to be identified, adapted if necessary, and disseminated more widely amongst the transport telematics community. We intend that this Handbook and the efforts of TELSCAN will serve this purpose.

Examples of guidelines which have relevance to ATT systems for travellers are provided below, along with their sources and other relevant information about the projects concerned. Thus far, much of our literature review has focussed on user requirements (see Part 1 of this Handbook), from which certain guidelines are emerging. As we can see from a selection of projects below, the users' requirements will have implications for the design of the system hardware and software, as well as the kind of information available to the user. Guidelines are emerging under the following headings, and these will be further developed in future versions of the Handbook:

Specific technologies, such as smart cards

These technologies may be applied in the transport sector to increase the usability of different types of self-service systems, such as ticketing machines.


Specific applications or systems, such as travel aids, information systems, or hazard warning systems.

These applications or systems may be applied in the transport sector to increase the mobility of specific categories of disabled travellers.

5.1 Specific technologies

5.1.1 Smart Cards

SATURN (Gill, 1994) is a TIDE project studying the needs of elderly and disabled people in relation to smart card systems. Such technology may be applied in the transport sector to increase the usability of self-service systems, such as ticketing machines. Contactless smart cards (or those that can work at a distance and do not need to be inserted into a reader) hold the greatest potential for meeting the needs of elderly and disabled people. For



example, they will aid people in wheelchairs who cannot reach the slot for the card reader, or those with hand tremor, arthritis or visual impairments.

The project produced a number of guidelines for smart cards and self-service terminals, examples of which follow:

Information must only be stored on a card with the consent of the user.

Coding onto a smart card should allow for either specific user preferences or a general description of the impairment. Specific preferences would include:

- Input - more time to complete the action, using the keyboard only.
- Operation - reduced functionality, pre-set amount.
- Output - large characters on screen, audio, amplification for each frequency band, maximal use of icons, braille display.

5.2 Specific applications or systems

5.2.1 Travel Aids

MoBIC (Strothotte et al., 1995) is a travel aid for blind persons based on the technologies of geographical information systems (GIS) and the Global Positioning System (GPS). The system consists of two interrelated components: the MoBIC Pre-journey System (MoPS) to assist users in planning journeys and the MoBIC Outdoor System (MoODS) to execute these plans by providing users with orientation and navigation assistance during journeys.

Based on user requirements work, the MoPS system should include basic maps and routes, and the ability to dictate the level of detail required. Furthermore, up-to-date information concerning transient obstacles should be available, and the user should be able to edit the journey plan with his/her own comments and memos.

Information that the MoODS aid should provide includes:

- directions to required destination (number of streets),
- name of streets,
- travellers current location (direction currently facing),
- shops (especially with stands outside),
- information about current roadworks,
- pedestrian crossings (and whether it has an auditory signal),
- useful buildings and landmarks (eg banks and their ATMs),
- layout of environment (steps),
- street furniture (lamp posts),
- useful items in the street (public telephones).

Furthermore, the output of the MoODS system should be ideally synthetic speech - user requirements work found other sounds and vibratory information to be significantly less popular (Strothotte et al., 1995).

The **OPEN** system (Stephens and Longley, 1995) aims to help blind or partially sighted people find their way on the metropolitan underground systems of London and Paris. The system consists of a series of beacons mounted at key points in each station and a receiver worn or carried by the blind or partially sighted person. Messages will be sent from the beacons to the receivers using modulated infra-red beacons. The system will help users find specific features of the underground system such as ticket areas, barriers, stairs, escalators, platforms and other obstacles.

The OPEN system will be installed in the following underground stations during January/February 1997: South Kensington, London; Heathrow Terminal 4; Chatelet, Les Halles, Paris; Blaak, Rotterdam. It is anticipated that user trials will take place during March and April 1997. Permission has been given to use the guidelines developed within these evaluations in future versions of the TELSCAN handbook, providing they are fully referenced.

5.2.2 Information Systems

NEWT is a project part-funded by the European Commission Transport Directorate General. Its main objective is to investigate how to make local transport information more accessible to disabled and elderly people. Guidelines on information presentation were produced for use by transport providers to ensure that a better service is provided to the whole community.


The TIDE **TURTLE** project developed and trialed a real time public transport information system which has as its main focus the needs of elderly and disabled people. Guidelines from NEWT were implemented in this demonstrator. TELSCAN is collaborating with the project to include these guidelines in our Handbook, and they will be made available, with their permission, in the next version.

5.2.3 Self-Service Systems

In addition to those guidelines that have emerged from the projects outlined above, a comprehensive list of recommendations for self-service systems (e.g. ATMs, information kiosks) are given by the **National Swedish Board for Consumer Policies and the Swedish Handicap Institute** (1995).

The following is a brief selection of the recommendations contained within that document - they are relevant to all self-service systems for elderly and disabled travellers:

Position systems at different height levels to cater for users of wheelchairs and short people.



Do not position the system in a noisy and open environment where the user could feel stressed and insecure.

Enable a choice between text and picture communication.

With auditory information, enable volume control and inductive coupling.

Provide a sun shield to reduce on-screen glare.

Instructions should be short and easy to understand.


Precise movements and sensitivity for using the control panel should not be required. It should be possible to control the system with hand in bandages or gloves.

Supplement the system with personal service if required. Furthermore, those who depend on such personal service should not have to pay more for it. (National Swedish Board for Consumer Policies and the Swedish Handicap Institute ,1995)

5.3 Next Steps

The next draft of this section of the TELSCAN guidelines handbook will contain:

- further guidelines relevant to elderly and disabled travellers from our on-going literature and project review, within Europe in the Telematics Applications Programme, from ITS America, and worldwide as far as our resources will permit.
- an integration of guidelines available - as they emerge - from the above projects, into consistent format (in full consultation with the projects concerned).
- guidelines emerging from Transport Telematics projects through their deliverables and collaborative evaluations. As an example, TELSCAN has already conducted an expert evaluation of the INFOPOLIS system, and guidelines produced from this work will be integrated into the next draft of the Handbook.



Elderly and disabled travellers may wish or need to change from one mode of travel to another in order to arrive at their destination. Such travel may involve not only different modes of transport, but also different telematic systems. Such systems should be integrated in a seamless fashion so that the information flow is accurate and efficient, and the traveller need not be handicapped with the transition from one mode to another.

TELSCAN has conducted a survey of existing and prospective systems for drivers and travellers, concentrating on transport telematics and crossing the boundaries of various transport modes (Nicolle et al., March 1997). Systems have also been identified which are in use or currently being developed specifically for elderly and disabled people or which would have particular benefits for them (eg from the TIDE programme).

This inventory of systems was then matched with the inventory of user requirements (see Part 1). For each user need in the Inventory of Requirements, TELSCAN considered - to the best of our knowledge - if there is an ATT solution available to meet the user need. This matching process results in a clearer indication of areas where existing solutions are available to meet user needs, where gaps exist, and where there is perhaps not even a prospective solution under development.

Our next task is to define the functions more clearly according to their relevance for elderly and disabled travellers. It will then be possible to suggest where more integrated solutions are possible to enable elderly and disabled travellers to more effectively fulfil their travelling needs within and across more than one mode of transport.

From the literature and surveys thus far, we can begin this process: Our survey of user requirements identified particular problems which could be solved by integrated telematic solutions. As an example, we found that elderly travellers often experience problems in booking taxis in advance for when they return from a destination. They may leave a cold UK airport for a winter break in the sun, and ask the taxi to pick them up 3 months later. Needless to say, the taxi usually forgets! Solutions could be a longer-term taxi-booking system, integrated with an airport information system, or an easy-to-use, short-term booking system accessible from abroad.

Smart cards pose an exciting opportunity for elderly and disabled travellers. The same card could be used to obtain personalised detail from an information system, to book a taxi, to reserve a train seat which is wheelchair accessible, to pay the fare for different modes of transport, or to purchase a newspaper and coffee en route.

This section will see further developments and ideas as we work closely with the Transport Telematics projects to ensure more usable systems for all.

To be updated on a regular basis

CEC project deliverables listed below can be obtained at cost from
European Commission Host Organisation,
CORDIS Customer Service,
B.P. 2373, L-1023 Luxembourg.

Barham, P., Alexander, J., Ayala, B., and Oxley, P., (Dec. 1994), Evaluation of reversing aids. Part II : Rear parcelshelf-mounted system used by Rover. CEC DRIVE II EDDIT Project V2031, Deliverable No. 19A.

Barham, P., Alexander, J., Ayala, B., and Oxley, P., (Jul. 1994), Evaluation of reversing aids. Part I : Dashboard-mounted system produced by GEC-Marconi Avionics. CEC DRIVE II EDDIT Project V2031, Deliverable No. 19A.

Barham, P., Alexander, J., Ayala, B., Oxley, P., and Mitchell, K., (Sept. 1994), Evaluation of the feasibility and effectiveness of electronic assistance for gap acceptance at a junction. Part I : Turning across an on-coming stream of traffic. CEC DRIVE II EDDIT Project V2031, Deliverable No. 18.

Barham, P., Alexander, J., Mitchell, K., Oxley, P., Ayala, B., (December 00000001994), Evaluation of Route Guidance System part 2: Motorola, CEC DRIVE II EDDIT Project V2031, Deliverable No. 20A.

Barham, P., Alexander, J., Mitchell, K., Oxley, P., Ayala, B., (June 1994), Evaluation of Route Guidance System part 1: Bosch Travelpilot, CEC DRIVE II EDDIT Project V2031, Deliverable No. 20.

Bekiaris, E and Naniopoulos, A. (eds.), (1992) Existing Aid Systems for Categories of Needs of DSN, CEC DRIVE II Project V2032 TELAID Deliverable No. 2.

Bevan, N., 1996, User-centred design technical guide - version 1.2, TAP INUSE project 2016, July 1996.

Boff, K.R., Kaufman, L. and Thomas, J.P. (Eds.), (1986), Handbook of Perception and Human Performance, Vol. 2. New York: John Wiley & Sons, Inc.

Briggs, R., Martin, N., Benbough, R., (August 1992), Review of Information Telematics, CEC DRIVE II EDDIT Project V2031, Deliverable No. 3.

CEN TC293 Technical Aids, Ad hoc group on communication systems, including personal alarms.

CEN TC293 Technical Aids, Ad hoc group on wheelchair and occupant restraint systems.

Defence Standard 00-25, Human Factors for Designers of Equipment

Denno, S., Isle, B.A., Ju, G., Koch, C.G., Metz, S., Penner, R., Wang, L. and Ward, J., (1992), Human Factors Design Guidelines for the Elderly and People with Disabilities, MN65-2300, Minneapolis, Honeywell Inc.

EEC 77/649, Field of vision.

EEC 78/316, Identification of controls, tell-tales and indicators.

EEC 90/270, European Directive on Display Screen Equipment Work.

Eason, K.D., 1982, The process of introducing information technology. Behaviour and Information Technology, 1, pp197-213.

Eason, K. D., (1984), Towards the experimental study of usability', Behaviour and Information Technology, vol. 3, no 2, pp 133 - 143.

Galer, M. D. and Simmonds, G. R. W., (1984), Society of Automotive Engineers, Ergonomic aspects of Electronic Instrumentation: A Guide for Designers. Warrendale PA: Society of Automotive Engineers, SAE-576.

Galitz, W. O., (1980), Handbook of screen format design, QED Information Sciences (Third Edition), ISBN 0-89435-258-X.

Gill, J.M., (1994), Smart Cards, Meeting the Needs of Elderly and Disabled People, on the SATURN Project, London: RNIB, ISBN 1 86048 002 0.

Gould, J.D., and Lewis, C., 1983, Designing for usability - Key principles and what designers think. Proceedings of ACM CHI'83 Conference, pp 50-53.

Graham, R. and Mitchell, V.A., (in press 1996), An Evaluation of the Ability of Drivers to Assimilate and Retain In-Vehicle Traffic Messages, in Ergonomics of Intelligent Driver Interfaces, Y.I. Noy (Ed.). Lawrence Erlbaum Associates Inc.: New Jersey.

Grayson, G., (1993), Framework for MMI Safety Analysis, CEC DRIVE II HOPES Project V2002, Deliverable No. 5. TRL: Crowthorne, Berkshire.

Green, P., (1993), Design and evaluation of symbols of automobile controls and displays, in Automotive Ergonomics, Peacock B. and Karwowski W. (Eds). London: Taylor & Francis.

Green, P. & George, K. (1995) When should auditory guidance systems tell drivers to turn? Proceedings of Human Factors and Ergonomics Society 1995 Annual meeting, San Diego.

Green, P., Levison, W., Paelke, G., and Serafin, C., (1995), Preliminary Human Factors Design Guidelines for Driver Information Systems, Report No. FHWA-RD-94-087, University of Michigan, Transportation Research Institute, sponsored by Federal Highway Administration.

Hancock, P., Caird, J., Shekhar, S., and Vercruyssen, (1991), Factors influencing drivers' left turn decision, in Proceedings of the Human Factors Society, Vol. 35, pp. 1139-1143.

Haslegrave, C. M. (1988). Driving for handicapped people. In A. Mital and W Karowski (Eds.), *Ergonomics in Rehabilitation* (pp. 13-34). Philadelphia: Taylor & Francis.

ICE Ergonomics, Loughborough, UK., (January 1994), Driver Information Systems, Code of Practice and Design Guidelines (Revision D) . Prepared for the UK Department of Transport.

Imbeau, D., Wierwille, W.W. and Beauchamp, Y., (1993), Age, display design and driving performance, in *Automotive Ergonomics*, Peacock, B. and Karwowski, W. (Eds). London: Taylor & Francis.

ISO 2575, (1982) Road Vehicles - Symbols for controls, indicators and tell-tales (equivalent to BS AU 143c). 1984.

ISO 3208, Road Vehicles - Evaluations of protrusions inside passenger cars.

ISO 3958, Road Vehicles - Passenger cars. Driver hand control reach.

ISO 4040, (1983), BS AU 199 (1984). Location of hand controls, indicators and tell-tales in passenger cars.

ISO 4092, Road Vehicles - Diagnostic systems for motor vehicles.

ISO 4513, Road Vehicles - Methods for the establishment of eye ellipses for driver's eye location.

ISO 6385, Ergonomic principles in the design of work systems.

ISO 6549, Road Vehicles - Procedure for H-Point determination.

ISO 9241, Ergonomics requirements for office work with visual display terminals (VDTs), 17 parts.

ISO TC145 Graphical symbols, SC1 Public information symbols.

ISO TC159 Ergonomics, SC1 Ergonomic guiding principles - WG related to mental work.

ISO TC159 Ergonomics, SC4 Signals and controls -WG on visual display requirements.

ISO TC173 Technical Aids, SC4 Aids and adaptation for communication.

ISO TC176 Quality Management & QA, SC12 Quality systems.

ISO TCI Information Technology, SC18 Text and Office Systems - WG on user requirements and user/systems interfaces and symbols.

ISO TR 12155, 1994, Commercial vehicles - Obstacle detection device during reversing - Requirements and tests.

Nielsen, J., (1994), Behaviour and Information Technology, Special issue: usability laboratories, Vol. 13, Nosland 2, Taylor and Francis, London.

Jansen, W. and Nilsson L., (1991), An Experimental Evaluation of In-Vehicle Collision Avoidance Systems, 24th ISATA Conference, Florence.

Kanis H., (1993), Operation of controls on consumer products by physically impaired users. Human Factors 35(2).

Leiser, B. and Carr, D., (1991), Analysis of input and output devices for in-car use. CEC DRIVE I GIDS/DISI, Project V1041.

Maguire, M. and Kirakowski, J., (1997), TAP RESPECT project deliverable D5.1, User requirements specification framework, HUSAT Research Institute, The Elms, Elms Grove, Loughborough, Leics, LE1 1RG, UK.

Maguire, M., 1997, Usability Evaluation Methods within the design process, HUSAT Memo 1080, HUSAT Research Institute, The Elms, Elms Grove, Loughborough, Leics LE11 1RG, UK.

Marin-Lamellet, C., Dejeammes, M., And Chapon, A., (July 1994), Study of age-related interaction between the complexity and the size of symbolic guidance information. CEC DRIVE II EDDIT Project V2031, Deliverable No. 21.

Marin-Lamellet, C., Dejeammes, M., and Kerihuel, H., (Feb. 1994), Comparison of two methods of on-board information display (HUD and LCD screen) with respect to driver age. CEC DRIVE II EDDIT Project V2031, Deliverable No. 17.

Marin-Lamellet, C., Dejeammes, M., Mitchell, F., Harteman, F., Kerihuel, H., (July 1993), The driving Simulator Tests - Research Protocols for EDDIT, CEC DRIVE II EDDIT Project V2031, Deliverable No. 15.

- Marin-Lamellet, C., Dejeammes, M., with the collaboration of Berthelot, S. (1995), The processing of complex guidance symbols by elderly drivers : a simulator-based study and an evaluation of the CARMINAT guidance system by the European Community DRIVE - EDDIT project; Proceedings of the 6th International Conference on Vehicle Navigation and Information Systems, Seattle USA, pp. 110-117.
- Michon, J. (Ed), (1993), GIDS, London: Taylor and Francis.
- Miller, R. B., (1971), Human ease of use criteria and their trade-offs. IBM report TR 00.2185, 12 April. Ploughkeepsie, NY: IBM Corporation.
- Naniopoulos, A. and Bekiaris, E. (eds.) (1993) Prospective Aid Systems for Categories of Needs of DSN, CEC DRIVE II Project V2032 TELAID Deliverable No. 6A.
- Naniopoulos, A., Bekiaris, E. and Nicolle, C. (eds.), (January 1994), Design Guidelines for Aids for DSN, CEC DRIVE II Project V2132 TELAID Deliverable 7.
- Naniopoulos, A., Bekiaris, E. and Nicolle, C. (eds.), (January 1994), Draft Regulations for Aids for DSN, CEC DRIVE II Project V2032 TELAID Deliverable 8.
- National Swedish Board for Consumer Policies and the Swedish Handicap Institute (1995), Automatic Service Machines, Service for Everybody? Stockholm.
- Nicolle, C., (July 1995), Design Issues for Older Drivers, Ergonomics in Design. Santa Monica, CA: Human Factors and Ergonomics Society.
- Nicolle, C., Peters, B. and Vossen, P.H., (1994), Towards the Development of ATT Guidelines for Drivers with Special Needs, Proceedings of the First World Congress on Applications of Transport Telematics and Intelligent Vehicle-Highway Systems, Vol 4, ERTICO (ed), Artech House, Towards an Intelligent Transport System, Paris, France, 30 November-3 December 1994.
- Nicolle, C., Richardson, S.J. and Ross, T., Requirements Capture for Drivers with Special Needs, Proceedings of the 12th Triennial Congress of the International Ergonomics Association, McFadden, S., Innes, L. and Hill, M. (eds), Human Factors Association of Canada, IEA '94 Volume 3 Rehabilitation Ergonomics, Toronto, Canada, 15-19 August, 1994.
- Nicolle, C., Ross, T. and Richardson, S.J., (1993) Identification and Grouping of Requirements for Drivers with Special Needs. Proceedings of ECART 2 (European Conference on the Advancement of Rehabilitation Technology), Stockholm, 26-28 May 1993 .

Nicolle, C., Ross, T., Richardson, S.J., (eds.), (1992), Identification and Grouping of Requirements for Drivers with Special Needs, CEC DRIVE II Project V2032 TELAID Deliverable No. 3.

Nicolle, C., et al., (ed.), (March 1997), Inventory of ATT System Requirements for Elderly and Disabled Drivers and Travellers, TELSCAN Project TAP 1108, Deliverable 3.1.

Nilsson, L., Alm, H. & Janssen, W. Collision Avoidance Systems. Effects of different levels of task allocation on driver behaviour, CEC DRIVE I Project V1041, GIDS/MAN3.

Nordic Committee on Disability (Nordiska nämnden för handikappfrågor), (1993), Nordic Guidelines for Computer Accessibility, Thorén, C., (Ed.), Gotab Sthlm. ISBN: 91-86954-15-6.

Olson, P. L., (1993), Vision and Perception, in Automotive Ergonomics, Peacock, B. & Karwowski, W. (Eds). London: Taylor and Francis.

Oxley, P., Alexander, J., Ayala, B., and Barham, P., (Jan. 1995), Evaluation of electronic assistance for gap acceptance turns at a T-junction. CEC DRIVE II EDDIT Project V2031, Deliverable No. 23.

Oxley, P., Ayala, B., Alexander, J., and Barham, P., (Dec. 1994), Evaluation of route guidance systems. CEC DRIVE II EDDIT Project V2031, Deliverable No. 20.

Oxley, P., Ayala, B., and Barham, P., (May, 1994), The Jaguar night vision trials: A report on the use of an infra-red based vision system by a sample of elderly drivers. CEC DRIVE II EDDIT Project V2031, Deliverable No. 22A.

Oxley, P., Ayala, B., Barham, P. and Duddles, R., (Aug. 1994), Evaluation of an Emergency Alert System. CEC DRIVE II EDDIT Project V2031, Deliverable No. 19B.

Oxley, P., Mitchell, K. (February 1995), Elderly and disabled drivers information telematics. Final Report of the CEC DRIVE II EDDIT Project V2031.

Peters, B., (1995a), Evaluation of an Adaptive Cruise Control (ACC) system with drivers with special needs, Effects on workload, comfort, driving behaviour and attitudes of drivers with lower limb disorders, in Veenbaas, R., (ed.) (October 1995), Validation of ATT systems for DSN through driving simulator tests. Test Report, CEC DRIVE II Project V2032 TELAID Deliverable No. 9.

Peters, B., (1995b), Effects of Reversing Aids on parking behaviour and opinions of drivers with special needs, in Veenbaas, R., (ed.) (October 1995), Validation of ATT systems for DSN through driving simulator

tests. Test Report, CEC DRIVE II Project V2032 TELAID Deliverable No. 9.

Pheasant, S., (1986), Bodyspace. London: Taylor and Francis.

PROMETHEUS, (1991), MMI Checklist version 2.1, The PROMETHEUS Thematic Working Group 4: Man-Machine Interaction (WG4/MMI).

Richardson, S.J., Poulson, D.F., Waddell, F.N., Nicolle, C.A., Ashby, M.C., Heim, J., Endestad, T., Skjetne, J.H., Sdogati, C. and Cesaroni, F., *USERfit*. A Practical Handbook on User-Centred Design for Rehabilitation and Assistive Technology, December 1995, CEC TIDE Project T1062 USER Deliverable D6.

Ross, T. and Parkes, A., (1992), A framework for the development of European In-Vehicle MMI Standards, CEC DRIVE I STAMMI Project V1037, Deliverable No. 6.

Ross, T., Midtland, K., Fuchs, M., Pauzi•, A., Engert, A., Duncan, B., Vaughan, G., Vernet, M., Peters, H., Burnett, G. & May, A., 1996, *HARDIE Design Guidelines Handbook: Human Factors Guidelines for Information Presentation by ATT Systems*, CEC DRIVE II Project V2008 *HARDIE*, Deliverable 20, March 1996.

Chapter 1: Design Guidelines for Traffic and Road Information - including RDS-TMC

Chapter 2: Design Guidelines for Route Guidance and Navigation

Chapter 3: Design Guidelines for Collision Avoidance

Chapter 4: Design Guidelines for Autonomous Intelligent Cruise Control

Chapter 5: Design Guidelines for Variable Message Signs


Ross, T., Nicolle, C., Parkes, A.M., Peters, H., Pauzi•, A., (December 1991), *Experimental Approach to the Definition of Standards for the In-Vehicle Man-Machine Interface*. (Final Report). CEC DRIVE I STAMMI Project V1037.

Ross, T., Vaughan, G.M. and Nicolle, C., (1994), *Developing Human Factors Design Guidelines for Route Guidance and Navigation Systems*, Proceedings of the 12th Triennial Congress of the International Ergonomics Association, McFadden, S., Innes, L. and Hill, M. (eds), Human Factors Association of Canada, IEA '94 Volume 4 Ergonomics and Design, Toronto, Canada, 15-19 August, 1994.

Shackel, B., and Richardson, S., (1991), *Human Factors for Informatics Usability*, Cambridge University Press. ISBN 0-521-36570-8.

Shneiderman, B., (1987), *Designing the User Interface. Strategies for Effective Human-Computer Interaction*, Addison-Wesley Publishing Company.

- Sivak, M., (1981), Driving and perceptual/cognitive skills: Behavioural consequences of brain damage, Arch Phys Med Rehabil, Vol 62.
- Smith, D.B.D., Mashkati, N. and Robertson, M.M., (1993), The Older Driver and Passenger, in Automotive Ergonomics, Peacock, B. and Karwowski, W. (Eds). London: Taylor and Francis.
- Stahl, A., Berntman, M., and Lind, L., (1994), The Volvo ultra-violet light trials: A report on the use of an ultra-violet vision system by a sample of elderly drivers. CEC DRIVE II EDDIT Project V2031, Deliverable No. 22B.
- Stephens and Longley, (1995), An Orientation and Navigation System for Blind and partially Sighted People. Proceedings of ECART 3, 10-13 October 1995, Lisbon: National Secretariat of Rehabilitation. ISBN: 972-9301-18-2.
- Stokes, A., Wickens, C. and Kite, K., (1990), Display Technology - Human Factors Concepts, Warrendale, PA.: Society of Automotive Engineers, Inc.
- Strothotte, T., Petrie, H., Johnson, V. and Reichert, L., (1995), MoBIC: user needs and preliminary design for a mobility aid for blind and elderly travellers, in *The European Context for Assistive Technology*, I. Placencia-Porrero, and R. Puig de la Bellacasa (eds)., Proceedings of 2nd TIDE Congress, 26-28 April 1995, Paris, pp 348-351. Amsterdam: IOS Press. ISBN: 90 5199 220 3.
- Trace R & D Center, (1988), Considerations in the Design of Computers and Operating Systems to Increase their Accessibility to Persons with Disabilities, a Working Document of the Design Consideration Task Force of the Industry/Government Co-operative Initiative on Computer Accessibility, Version 4.2, University of Wisconsin, Madison, USA.
- Trace R & D Center, prepared by Vanderheiden, G.C., (1992), White Paper on the Design of Software Application Programs to Increase their Accessibility for People with Disabilities, Release 1.2, University of Wisconsin, Madison, USA.
- T•V Bayern, (1989), List of European Standards, CEC DRIVE I STAMMI Project V1037, Deliverable No. 2.1.
- Vaughan, G., Ross, T., Nicolle, C., Fuchs, M., Duncan, B., Eggerdinger, C., Pauzi, A. and Vernet, M., (1993), Review of Existing Guidelines for Information Presentation in Vehicles. CEC DRIVE II HARDIE Project V2008, Deliverable No. 9.
- Veenbaas, R., (1995), Inventory of controls used in ATT while driving. Proposal for DSN MMI evaluation of controls. Delft, NL, TNO Road Vehicles Research Institute, in Veenbaas, R., (ed.) (October 1995),



Validation of ATT systems for DSN through driving simulator tests. Test Report, CEC DRIVE II Project V2032 TELAID Deliverable No. 9.

Vernet, M., Ross, T., Collins, J., Eggerdinger, C., Midtland, K. and Pastor, L., (1992), Survey of Man-Machine Interface Standards and Legislation Requirements for Driver Information. CEC DRIVE II HARDIE Project V2008, Deliverable No. 1.

Verwey, W.B. & Veenbaas, R., (1993), Driving performance of paraplegic drivers using common hand controls for accelerating and braking, Report IZF 1993 C-31, Soesterberg, NL: TNO Human Factors Research Institute. Also Annex VI to Validation of the identification of special needs of DSN - test report, CEC DRIVE II TELAID project V2032, Deliverable No. 5.

Verwey, W.B., (1995), The control of input devices by people driving with and without adaptations, Report TNO-TM 1995 B-9, Soesterberg, NL: TNO Human Factors Research Institute, in Veenbaas, R., (ed.) (October 1995), Validation of ATT systems for DSN through driving simulator tests. Test Report, CEC DRIVE II Project V2032 TELAID Deliverable No. 9.

Vienna Convention, 1969, United Nations, Conference on Road Traffic, 7 Oct-8 Nov 1968, United Nations Publications.

Ward, J., (1989), Human Factors Guidelines for the Disabled. Perspectives, Proceedings of the Human Factors 33rd Annual Meeting, Denver, Colorado, 10, 16-20, Voll, The Human Factors Society.

Weintraub, D. J. and Ensing, M., (1992), Human Factors Issues in Head-Up Display Design: The Book of HUD. CSERIAC 92-2. Wright-Patterson AFB, OH: Crew Station Ergonomics Information Analysis Centre.

Whiteside, J., Bennett, J. and Hotsblatt, (1988), Usability Engineering: our experience and evolution. In: Helander, M (Ed) Handbook of Human Computer Interaction, pp 791 - 817, Elsevier, Amsterdam.

Wierwille, W.W. and McFarlane, J., (1993), Role of expectancy and supplementary cues for control operation, in Automotive Ergonomics, Peacock, B. and Karwowski, W. (Eds). London: Taylor and Francis.

Wierwille, W.W., (1993), Visual and manual demands of in-car controls and displays, in Automotive Ergonomics, Peacock, B. & Karwowski, W. (Eds). London: Taylor and Francis.

World Health Organisation, 1980 (reprinted 1993), "International classification of impairments, disabilities and handicaps: a manual of classification relating to the consequences of disease, published in accordance with resolution WHA29.35 of the 29th World Health Assembly, May 1976", Geneva World Health Organisation 1980, ISBN 92 41 54 12 61.

Zwalen, H.T., Adams, C.C. Jr. and Debald, D.P., (1988), Safety Aspects of CRT touch panel controls in automobiles, Vision in Vehicles II, A. G. Gale et al (Eds), Elsevier Science Publisher B.V.

Appendix 1

Car adaptations for Drivers with Disabilities

In the Guidelines for Systems for Drivers (Part 4) of the Handbook, some aids for drivers with disabilities are mentioned. These are explained briefly below. For further reference and information on all relevant systems in the market worldwide, one should refer to TELAID Deliverables 2A and 6 or seek access to the TELDAT database of driving aids for drivers with special needs (Deliverable 6B of TELAID).

The aids mentioned below are simply indicative of a wide range of possible adaptations, which would include over 100 different types and 500 particular aids.

1. Ring accelerator

The acceleration pedal is replaced by an acceleration ring of smaller radius, mounted on top of the steering wheel and operated by the thumbs or palms of the hands; thus enabling the driver to steer with both hands and safely operate switches on either sides of the steering column.

Such a system is displayed in the figure below.

Figure 1: Guidosimplex acceleration ring

2. Segment accelerator (and brake)

The acceleration pedal is mechanically connected to a semi-circle lever, which is up against the steering wheel, as shown in Figure 2. The brake

pedal can also be connected to the same or an additional lever, as shown in Figures 3 and 4.

Figure 2: Segmented grip hand-controlled accelerator function
(from Betjeningshjelpmidler i bil © RTF, OSLO).

Figure 3: Feeny & Johnson segmented hand grip lever brake-
acceleration aid.

Figure 4: Feeny & Johnson segmented hand grip double lever
brake acceleration aid.

3. Push-pull hand controls mounted on the floor

Both acceleration and brake pedals are connected to the same lever, which is mounted on the car floor, between the two seats. The driver brakes by pushing the lever forwards, and accelerates by pulling the lever. The following Figure 5 displays such a system.

Figure 5: Push-pull hand controls mounted on the floor from AMU/ Kavlinge.

Appendix 2

Summary Descriptions of Advanced Transport Telematic Systems

The following is a brief summary description of Advanced Transport Telematic systems for drivers referred to in the TELSCAN Handbook. As the Handbook further develops over the course of the project, this section will cover additional systems where new guidelines are proposed. It is also likely that the future will see the introduction of systems not yet envisaged. Such developments will require generic principles for their design and evaluation, and it is an aim of the present work to provide such a generic framework to incorporate developments as they arise.

Adaptive Cruise Control (ACC)

This system keeps the car at a steady speed ('speed control'), and keeps a constant time gap to the car ahead ('distance control'). It accelerates or decelerates the car to 'keep in touch' with the car ahead or maintains a fixed speed if the road ahead is clear. The system can be overridden by the driver or ignored at any time.

Collision Avoidance System (CAS)

This system helps the driver to avoid collisions by detecting other vehicles or obstacles (e.g., using radar). It can warn when approaching another vehicle/obstacle ahead too quickly, and judge the relative speeds of the lead and approaching vehicles. This allows the system to alert the driver to situations that could lead to potential collisions.

Reversing and Parking Aid

These systems detect obstacles behind a vehicle (e.g., using radar). They inform the driver of the distance to obstacles immediately behind and to the side of the car. They can depict the car and adjacent obstacles in a plan diagram, or sound a variable signal (e.g., a tone increasing in pitch) to indicate closing distance. Visual displays could be on the parcel shelf, the dash, or over the rear view mirror.

Route Guidance and Navigation System

This system helps planning a route and finding unfamiliar destinations. It knows the car's location and stores information about the road network. It can determine the most efficient route to take and give the driver directions to follow this route. The term Dual Mode Route Guidance usually refers to equipment combining the autonomous mode - finding the optimal route solely from the map - and the dynamic mode, which takes account of real-time traffic speeds, throughout the network.

Travel and Traffic Information System/Co-operative Driving

This system gives the driver information about traffic problems on the road ahead. It provides messages relating to bad weather, roadworks, accidents and congestion, and includes information on the location, potential duration, and severity of the problem.

Appendix 3

Summary Descriptions of earlier Simulator Testing and Field Trials in the TELAID and EDDIT projects

(to be regularly updated with the results of TELSCAN)

Certain guidelines are suggested based specifically on simulator testing and field trials with elderly or disabled drivers within the TELAID and EDDIT projects. This section will include the description of further tests as their results are integrated into the guidelines. Thus far, guidelines have been developed for:

Reversing Aids - EDDIT project (Barham, et al., July and Dec. 1994)

Two types of reversing aid were evaluated by EDDIT:

a dashboard-mounted prototype based on infrared technology that gave precise positional information on the locations of objects to the rear of the vehicle (but no audible signal), and

an ultrasound-based system which had its in-vehicle display positioned on the rear parcelshelf of the car and combined a light display and sound to convey information on the proximity of the nearest rearward object.

Both aids were evaluated using the off-road facilities of the Transport Research Laboratory, at Crowthorne. In both cases, a test-site was laid out, using poles, kerb stones and crowd control barriers, to simulate a number of common reversing scenarios, namely those of reversing in a straight line to an object (such as a lamp-post), reversing at a 90° angle into a simulated garage and reversing into a parking space between two parked cars parallel to a kerb. A comparison was made of subjects' performance in these driving exercises both with and without each of the reversing aids, in terms of the accuracy of their manoeuvres, the time taken for each manoeuvre and the number of collisions that subjects had with kerbs and posts etc.. A record was also made of subjects' scanning behaviour whilst carrying out manoeuvres, with and without electronic assistance, in terms of the duration and direction of each glance made (ie. whether it was made at the reversing aid's display, the off-side wing-mirror etc.). This enabled an assessment to be made of the extent to which the presence of such in-car technology might impact on the driving task. Finally, to evaluate subjects' ability to detect a moving object encroaching to the rear of the car whilst they were manoeuvring, a wheelchair was pushed, unannounced, into the path of the reversing test car - once when a reversing aid was in use, and once when no

electronic assistance was available. The requirement of a sensing distance of 3m behind the vehicle is still believed to be reasonable for elderly or disabled drivers. The reversing aids enabled elderly drivers to park more accurately within confined spaces. Subjects preferred the provision of audible, as well as visual warnings.

The system mounted on the rear parcel-shelf of the car could be viewed using the rear view mirror. Subjects viewed this display almost exclusively through the rear-view mirror. In terms of the manoeuvring time spent glancing in each direction, the introduction of this system resulted in a substantial increase in the use of the rear-view mirror, and a marked decrease in glances over both shoulders and at both wing mirrors. This positioning was also preferable from the point of view of minimising the level of complexity of the driving task. The conclusion from the evaluations was that, whereas the dashboard-mounted display both increased the number of changes of glance made by subjects and increased manoeuvring time (indicating an increase in drivers' visual and mental workload whilst manoeuvring), volunteers were not affected in either way when using the display positioned to the rear.
(Barham et al., July and Dec 1994)

Route Guidance Systems - EDDIT project (Oxley, et al., Dec. 1994)

Three Route Guidance Systems were evaluated on the open road in the vicinity of the Ford Design Centre at Laindon, Essex. These were a Bosch TravelPilot, a Phillips CARIN device and a similar system provided by Motorola. All were installed in a Ford Scorpio, and were used by subjects on the same pre-set test route. In line with the common methodology of EDDIT, subjects' performance and behaviour whilst executing a given driving task was measured and recorded both with and without electronic assistance. In the case of the Route Guidance Systems, the subjects' task was to key in a given destination using the in-vehicle device provided, and then to follow the instructions given by the system to this destination. Test subjects were monitored in two ways : (i) a continuous log was kept of the time during which subjects were looking at the system's screen and the time during which they were looking straight ahead (which provided data on the frequency of glances at this screen, glance duration and the proportion of driving time that was spent with the eyes off the road), and (ii) an (ex-Police) expert driving assessor sat in the front seat of the test car and evaluated subjects' driving performance in terms of ten key driving parameters, including positioning, separation, use of gears, brakes etc.. Problems and recommendations were made for each of the systems tested, including for example, timing of instructions; content and detail of map-based systems; operation of the systems while driving; and mode, quality, location, size and contrast of output.

Gap Acceptance / Collision Avoidance - EDDIT project (Oxley et al., Jan. 1995)

One of the most common types of accident to befall elderly drivers is a collision at a road junction, particularly at a junction where the driver is required to manoeuvre into or across a stream of on-coming traffic. A test was designed, therefore, to assess the feasibility of a device that could act as a decision support mechanism for drivers in such situations. For obvious safety reasons, and because no technology currently exists to accurately measure the gap between successive cars in a stream of traffic, these evaluations were carried out on the driving simulator of the Transport Research Laboratory at Crowthorne. Two driving scenarios were simulated: a right turn from a major road into a minor road across on-coming traffic, and both a left- and right-turn at a T-junction. A device designed by GEC-Marconi Avionics was installed on the dashboard of the simulator's car - this device consisted of a simple two-light display: a green light which was illuminated when the current gap in the stream of traffic was six seconds or longer, and a red light that was illuminated whenever a gap was less than six seconds. For the simulated T-junction scenario, there were two such displays installed; one to indicate when the gap in the traffic approaching from the left was "safe", and one to perform the same role for traffic approaching from the right. A further advantage of using a driving simulator for this part of the evaluation was that data on minute aspects of subjects' driving performance were able to be recorded in real time. Therefore, as well as being able to provide attitudinal information (i.e., subjects' reaction to having such a device to help them make decisions, and their level of compliance with the system's instructions), it was also possible to closely monitor subjects' manoeuvring speed, instances of hesitation and any collisions / near misses with other vehicles, both with and without electronic assistance. Using the electronic device significantly increased the number of near misses experienced by subjects, which implies that some on-going indication of the proximity of a possible collision with an on-coming vehicle might be useful. It was found that for this equipment to enter the marketplace, the threshold for advising the driver to initiate a manoeuvre would need to be tailored to the requirements and capabilities of the individual.

Adaptive Cruise Control (ACC) - TELAID project (Peters, 1995a)

A driving simulator study on ACC driving was performed with drivers with lower limb disabilities (Peters 1995a). The subjects were accustomed to driving with hand controls for the accelerator and brakes, and the simulator was equipped with an ACC system. The purpose of the study was to investigate how ACC driving would influence workload, comfort and driving behaviour of drivers with lower limb disabilities, and also to see if ACC driving had a different influence on the driver depending on the type of hand control system being used. It was found that workload was lower and performance better for the ACC driving condition. The subjects also thought that they

could control both speed and distance to leading vehicles better with the ACC system than when driving manually. Their variations in speed decreased when the ACC was available, but the system did not influence choice reaction time, speed level, lateral position or variation in lateral position. Mean time headway for the car following situations was shorter for the ACC condition compared to manual driving. The ACC system was well received, wanted and trusted by the subjects.

The study revealed that this group of drivers prefer a longer average headway than that which the system used. Therefore, it is important that the headway parameter of the ACC system is individually adjustable according to these drivers' needs and preferences. Drivers with different types of impairments should be included when the adjustable range of the headway is determined. As a starting point it is recommended that the ACC system uses a headway which is 0.7 seconds longer compared to that used for able-bodied drivers. For example, an often used headway value is 1.4 seconds in ACC systems. This value should be prolonged to 2.1 seconds.

It is recommended, however, that testing in real traffic is undertaken to validate these guidelines.

Reversing Aids - TELAID project (Peters, 1995b)

The purpose of this field study in TELAID was to test parking behaviour and attitudes to two reversing aid systems, compared to an unsupported condition. Reversing into parking spaces often requires a precise control of the car. Drivers with physical disabilities, especially restricted flexibility in the neck region, find parking difficult as their direct view of the rear is limited. Reversing aids based on various ATT technologies have been developed mainly for trucks and buses. These aids could be used to alleviate the identified problems for this group of drivers with special needs.

Nine drivers with various physical impairments participated in a field test of two different reversing aids. One system used a video camera placed in the rear window and provided only visual feedback on the dashboard mounted monitor. The other system consisted of ultrasonic sensors on the rear bumper and provided both auditory and visual feedback to the driver. It was found that the ultrasonic system gave better support to the drivers. A probable reason for this result is that this system provided redundant feedback and interfered less with the driving task. This system also informed the driver of the position of rear obstacles based on ISO defined warning zones (Peters, 1995b).

Even though most of the differences between the systems were not significant, it seems likely that both systems can improve parking behaviour for drivers with special needs and that the systems will be accepted by the drivers. More testing of reversing aids is needed with elderly and disabled

drivers in order to find out to what extent these systems will promote their independent mobility.

The control of input devices - TELAID project (Verwey, 1995)

The possibility of drivers with no functional use of the lower parts of the body (i.e., people with paraplegia) to use various types of input devices while driving with adaptations was examined. From the controls currently used in ATT devices, a sample of controls varying in type, size and position were selected as well as an adapted control (head support switch) (Veenbaas, 1995). Subjects with paraplegia drove in a driving simulator on straight road sections and negotiated roundabouts, left turns, and curves. In these situations they performed a response task, using the selected buttons and switches. Their performance was compared with that of able-bodied drivers. The results indicate that a segment accelerator reduces the ability to operate buttons and switches more than a ring accelerator, but that even with a ring accelerator a disadvantage will remain for people with paraplegia. The study also supports the notion for all drivers that expectations or intentions to perform a certain task may affect driving performance and that the extent that driving is affected depends on the type of input device. In Part 3 guidelines are suggested for the control of telematic applications (Verwey, 1995).

Appendix 4

Application of the TELSCAN Guidelines to HARDIE Guidelines for Route Guidance and Navigation Systems

Introduction

This Appendix applies the TELSCAN guidelines from Parts 2, 3 and 4A to the guidelines on information presentation for route guidance and navigation systems from the DRIVE II HARDIE Project V2008 (Ross et al., Chapter 2, 1996).

This exercise is an example of how the TELSCAN guidelines can be more widely applied to specific systems or existing guidelines. The HARDIE guidelines have been used to exemplify this point, with cross-referencing back to the guidelines in Parts 2, 3 and 4A of this Handbook. For ease of reference, the original HARDIE guideline numbering system has been retained.

Under each heading HARDIE has produced several guidelines, including the rationale (with references), examples and further reading. Not all headings have been included in this exercise in order to demonstrate a selection of guidelines that have particular relevance to elderly and disabled drivers. Even if a heading is included, not all the guidelines under that heading have been reproduced. Those that are repeated here, however, are repeated verbatim.

This Appendix is under review to capture specific guidelines on designing route guidance and navigation systems that will be more usable by elderly and disabled drivers, and these will be integrated into Part 4B of the Handbook.

HARDIE Guideline (Ross et al., 1996)

I. NAVIGATION VS. GUIDANCE

Guidance should be given in the form of simple, step-by-step instructions at each manoeuvre.

Whilst driving, drivers should not be expected to process complex information to obtain the desired route, i.e. the system should not display a map with a highlighted route.

If these two guidelines are followed, the system will be subjectively less demanding and will minimise visual and attentional distraction from the main driving task.

To accommodate driver preference the provision of an “overview” screen in map form should be available, on request, whilst the driver is stationary.

TELSKAN Guideline References:

- 2A.1 Workload on residual capabilities
- 2A.3 Ease of use for more people
- 2A.5 Ease of learning
- 2A.6 Familiarity/Conformance to expectations
- 2A.7 Comfort in operation
- 3B.3 Choice of output format

TELSKAN Comment:

This guideline is likely to be particularly important for people with cognitive impairments, such as a lack of spatial awareness or an inability to process complex sources of information. It is also important for people with hearing impairments, as their visual channel already has a higher workload and the situation must not be made more difficult through the introduction of ATT.

HARDIE Guideline (Ross et al., 1996)

II. INFORMATION CONTENT

1. General

Information about one (preferably) or two (if necessary) manoeuvres ahead should be the maximum presented to the driver at any one time.

Systems should be able to vary the amount of information depending on the driving time between manoeuvres.

A system should include information on the following, whilst using a careful design so as not to overload the driver:

Direction of next manoeuvre

Current position

Road layout

Distance to next manoeuvre

Landmarks

Street names (from and to) or directions related to road signs

Distance to destination

TELSCAN Guideline References:

2A.1 Workload on residual capabilities

2A.2 Including elderly and disabled travellers in design

2A.3 Ease of use for more people

2A.7 Ease of learning

3B.3 Comfort in operation

C.2 Choice of output format

4A.17 Timing of information/response times

TELSCAN Comment:

It is important that the upper limit of variable information presentation is tailored to the abilities and capacities of all drivers. This is particularly important for drivers with cognitive limitations (e.g. impaired short-term memory, reduced information processing ability), or skeletal/physical impairments. For the latter group, drivers may already be under high levels of mental workload operating specific hand/foot controls. Therefore, if all the suggested information were presented, such drivers may experience overload. The sequence and priority of the listed categories of information will also depend on the type of route guidance and navigation system. The guideline does state the need for careful design though, and this should be stressed even more for disabled and older drivers. Testing is advisable for most groups.

HARDIE Guideline (Ross et al., 1996)

II. INFORMATION CONTENT

2. Landmarks

Landmarks should be included in guidance information, provided that a clear representation (visually and/or auditory) is technically possible. Such information will give clarification of the manoeuvre to take and thus increase driver confidence in the system.

The following landmarks are proposed for use within a system. It is recommended that those landmarks towards the top of the table are used wherever possible.

- | | |
|-----------------------|-----------------------|
| 1. Traffic lights | 5. Petrol station |
| 2. Pelican crossing | 6. Monument |
| 3. Bridge over road | 7. Railway station |
| 4. Hump-backed bridge | 8. Road sign/signpost |

TELSCAN Guideline References:

- 2A.2 Including elderly and disabled travellers in design
- 2A.3 Ease of use for more people
- 3B.1 Choice of output mode
- 3B.6 Size or intensity of output
- 3B.10 Use of symbolic language

TELSCAN Comment:

It must be noted that the above landmarks can only be recommended for use in the UK. Terminology must also be used with care; for example, the 'pelican crossing' is particularly British and could instead be termed a 'signal-controlled pedestrian crossing'. Care should also be taken with road signs/signposts, because these can be changed and frequent up-dating is needed. However, the study from which the list was derived produced a tentative predictor model which should allow the generation of a similar list for use in other countries/environments.

The requirement for a clear visual representation of a landmark will be more important for drivers who experience hearing difficulties and hence place a greater reliance on the visual information source. For visually presented landmarks, it may also be appropriate to combine text with symbols. Such redundancy, whilst taking care not to produce a cluttered display, will be beneficial in reducing uncertainty for older drivers and people with cognitive impairments. Although the study from which this guideline was derived did not include disabled or older people, it is felt that the criteria used to prioritise the importance of the listed landmarks would not be affected in most cases.

A possible exception may exist for drivers with reduced visual acuity and/or field of vision and people with cognitive impairments. Testing is advisable for these groups.

HARDIE Guideline (Ross et al., 1996)

II. INFORMATION CONTENT

4. Road Layout

Road layout information should be provided to the driver. This should be in a schematic form.

If this is not possible, simple visual information . . . can be used, but only if:

Sufficient spatial cues are provided within the auditory instruction (taking care not to make the message too long as a result)

OR

Good landmarks are used as part of the display.

TELSKAN Guideline References:

- 2A.6 Familiarity/Conformance to expectations
- 3B.1 Choice of output mode
- 3B.6 Size or intensity of output

TELSKAN Comment:

This guideline could be a problem for people with hearing and cognitive impairments. Additional auditory information cannot be provided for people with hearing impairments, and we cannot assume that landmarks will help those with cognitive impairments. Therefore, it is suggested that the system must have schematic representation of the actual road layout for these groups. Further testing is also recommended to substantiate this recommendation.

Consideration must also be given to the degree of impairment for which provision should be made, given that progression must be associated with increasing accident risk.

HARDIE Guideline (Ross et al., 1996)

III. SCHEDULING OF INFORMATION

2. Timing of Instruction

For manoeuvres which meet the following criteria:

- leaving the current route
- not requiring a lane change
- not at the end of a road
- without a slip road (i.e. a sudden turn)
- for speeds between 18 and 101 kph

The distance at which the final auditory guidance instruction should be given can be based on the following equations (where 'speed' is vehicle speed when the instruction is given):

$$\text{Preferred Minimum Distance (m)} = [\text{Speed (kph)} \times 1.637] + 14.799$$

$$\text{Ideal Distance (m)} = [\text{Speed (kph)} \times 1.973] + 21.307$$

$$\text{Preferred Maximum Distance (m)} = [\text{Speed (kph)} \times 2.222] + 37.144$$

The following show example values for each of the equations above:

| SPEED (KPH): | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|------------|
| Min. Distance (m): | 48 | 64 | 80 | 97 | 113 | 129 | 146 | 162 | 178 |
| Ideal Distance (m): | 61 | 80 | 100 | 120 | 140 | 159 | 179 | 199 | 219 |
| Max. Distance (m): | 82 | 104 | 126 | 148 | 170 | 193 | 215 | 237 | 259 |

TELSKAN Guideline References:

3B.1 Choice of output mode

4A.17 Timing of information/response times

TELSKAN Comment:

This is a guideline for presenting an auditory message. It requires testing for visual information presented to drivers who experience hearing difficulties.

Furthermore, the guideline was derived from a study in which no disabled or elderly drivers took part. It is likely that drivers who have slower response times, either as a result of age or a particular cognitive impairment, require messages to be presented earlier, but not too far in advance so as to forget it before action is due. Testing is recommended for these drivers.

HARDIE Guideline (Ross et al., 1996)

III. SCHEDULING OF INFORMATION

3. Stacking of Instructions

For manoeuvres which meet the following criteria:

- leaving the current route
- not requiring a lane change
- not at the end of a road
- without a slip road (i.e. a sudden turn)
- for speeds between 18 and 101 kph

If the distance between two manoeuvres is less than the "Ideal Distance" recommended for that speed (see III. Scheduling of Information, 2. Timing of Instructions), then the verbal instructions for the two manoeuvres should both be given prior to the first manoeuvre, i.e. "Take the next left and then the second right".

If avoidable, no more than two instructions should be given together.

TELSCAN Guideline References:

- 2A.1 Workload on residual capabilities
- 2A.3 Ease of use for more people
- 3B.1 Choice of output mode
- 4A.17 Timing of information/response times

TELSCAN Comment:

This is a guideline for presenting an auditory message. It requires testing for visual information presented to drivers who experience hearing difficulties.

Stacking, i.e. presenting two instructions within the same message, might be a problem for drivers with particular cognitive limitations, e.g. impaired short-term memory, reduced information processing ability. However, NOT stacking instructions that are close together may be even worse. Testing is recommended.

HARDIE Guideline (Ross et al., 1996)

IV. VISUAL VS AUDITORY INFORMATION

The ideal output media for route guidance is a combination of auditory and visual information. This enables drivers to adapt their strategies for information uptake according to driving task conditions.

TELSCAN Guideline References:

3B.1 Choice of output mode

4A.17 Timing of information/response times

TELSCAN Comment:

This guideline may still be applicable for drivers with skeletal/physical impairments; however, it requires modification to cater for people with severe hearing difficulties and visual/reading impairments.

It is generally accepted that, for non-disabled drivers, the primary modality for presenting route guidance information should be the auditory channel. Visual information should be available for confirmation purposes. However, using only one mode (if unable to hear/see/read the other) is very likely to cause problems, as the system will be designed to use as a 'whole', and each mode will not work well on its own. It is foreseeable that a completely different design would be needed for these impairments.

HARDIE Guideline (Ross et al., 1996)

V. MAPS

1. Information Content/Complexity

Ideally, a map should not be displayed to the driver whilst in motion. If this is deemed to be necessary, then the map information should not be the main source of information at each manoeuvre, i.e., the map information should be supplemented or replaced by turn-by-turn information specific to that manoeuvre.

When a map is shown whilst in motion, the information content of the map should be as simple as possible. A suggested maximum amount of information is: current location, destination, highlighted route, name of current road, name of destination road.

Preferably a map should only be shown whilst stationary. Where this is the case, the map can contain more detailed information to allow the driver to plan a future route or review a completed route. Detailed information should not, however, result in a cluttered display.

TELSCAN Guideline References:

- 2A.3 Ease of use for more people
- 4A.4 Ease of adjustment while stationary
- 4A.5 Ease of adjustment while driving
- 3B.5 and
- 4A.19 Density of information

TELSCAN Comment:

This guideline is likely to be particularly important for people with specific cognitive impairments (e.g. limited spatial awareness/information processing ability), and drivers who have reduced visual acuity (as a result of age or a visual impairment).

HARDIE Guideline (Ross et al., 1996)

V. MAPS

3. Text Display

The provision of text on maps should be avoided as much as possible to prevent a cluttered display.

When text is necessary on a map display (e.g. street names) it should, wherever possible, be displayed horizontally. Rotation of text will cause reading difficulties.

The number of names presented on a display should be limited to 2 or 3.

TELSCAN Guideline References:

- 2A.3 Ease of use for more people
- 3B.5 and
- 4A.19 Density of information
- 3B.6 Size or intensity of output

TELSCAN Comment:

This guideline is likely to be particularly important for people with specific cognitive impairments (e.g. limited information processing ability), and drivers who have reduced visual acuity (as a result of age or a visual impairment). Furthermore, the guideline will be important for drivers who have difficulties in reading.

HARDIE Guideline (Ross et al., 1996)

V. MAPS

4. Scale

Whilst driving, the driver should not be required to manually zoom in and out to different scale levels. Instead, the system should automatically present the optimum amount of usable information.

TELSCAN Guideline References:

- 2A.3 Ease of use for more people
- 2A.4 Flexibility/Adaptability
- 4A.5 Ease of adjustment while driving
- 4A.10 Automatic operation of systems
- 4A.20 Size or intensity of output

TELSCAN Comment:

This guideline does not indicate what the optimum amount of usable information might be for different driving situations. This issue is of particular relevance for drivers who have reduced visual abilities (e.g. acuity), as a result of age or an impairment. Drivers will vary in the degree to which they experience difficulties, and hence may differ in the optimum amount of information that should be present within a map display. As a consequence, it is possible that specialist calibration of the system is required for such individuals.

HARDIE Guideline (Ross et al., 1996)

V. MAPS

5. North-Up vs. Heading-Up

If use of a map display is necessary whilst moving then, generally, the orientation should be 'heading-up' (i.e. where the direction of travel of the vehicle is always 'up' the display). In most cases, a 'north-up' orientation should not be displayed whilst driving - nor should any other world referenced frame (e.g. south-up). There may be some situations where a combined (heading-up and north-up) display may be more useful, however current knowledge is insufficient to provide concrete guidelines on the use of this type of display.

TELSCAN Guideline References:

- 2A.3 Ease of use for more people
- 2A.6 Familiarity/Conformance to expectations
- 3B.3 Choice of output format

TELSCAN Comment:

This guideline is likely to be particularly important for people with specific cognitive impairments (e.g. limited spatial awareness/information processing ability), and drivers who have reduced visual acuity (as a result of age or a visual impairment). However, these groups have never been included in empirical studies and may exhibit different behaviour/preferences (i.e., would north-up be better?) This is unlikely, but still should be tested.

HARDIE Guideline (Ross et al., 1996)

VI. TURN-BY-TURN INFORMATION

1. Information Content/Complexity

Turn-by-turn guidance systems should give the following information to the driver:

- Direction of next manoeuvre
- Current position (in relation to next manoeuvre)
- Road layout (geometry)
- Distance to next manoeuvre
- Landmarks
- Street names (from and to) or directions relating to relevant road signs
- Distance to destination

A priority order cannot easily be given for each item of information. However, as a general rule, the first four items are probably the most important, primary information required. The remainder are advisable as supplementary, secondary information to increase driver confidence.

The layout and format of the visual display should be such that the primary information can be quickly and easily seen. Secondary information should also be visible, but can be less prominent.

The overall aim should be to design a display which contains all relevant information whilst remaining uncluttered.

TELSKAN Guideline References:

- 2A.1 Workload on residual capabilities
- 2A.3 Ease of use for more people
- 3B.3 Choice of output format
- 4A.17 Timing of information/response times
- 3B.5 and
- 4A.19 Density of information
- 3B.10 Use of symbolic language

TELSKAN Comment:

It is important that the upper limit of variable information presentation is tailored to the abilities and capacities of all drivers. This is particularly important for drivers with cognitive limitations (e.g. impaired short-term memory, reduced information processing ability), or skeletal/physical impairments. For the latter group, drivers may already be under high levels of mental workload operating specific hand/foot controls. Therefore, if all the suggested information were presented, such drivers may experience overload. For example, street names are seldom visible to drivers (if present at all) but a junction name is acceptable if prominently displayed at advance signs. The guideline does state the need for careful design though, and this

should be stressed even more for disabled and older drivers. Testing is advisable for most groups.

HARDIE Guideline (Ross et al., 1996)

VI. TURN-BY-TURN INFORMATION

2. Symbols vs. Text

For direction information, visual information should be in the form of symbols not text (these should be supplemented by auditory instructions).

The symbols used should be well known, well accepted or self-explanatory.

TELSCAN Guideline References:

- 2A.1 Workload on residual capabilities
- 2A.3 Ease of use for more people
- 2A.5 Ease of learning
- 2A.6 Familiarity/Conformance to expectations
- 3B.3 Choice of output format
- 3B.10 Use of symbolic language

TELSCAN Comment:

This guideline is likely to be particularly important for people with specific cognitive impairments (e.g. limited information processing ability), and drivers who have reduced visual acuity (as a result of age or a visual impairment).

HARDIE Guideline (Ross et al., 1996)

VI. TURN-BY-TURN INFORMATION

3. North-Up vs. Heading-Up

Step-by step guidance instructions should be presented to the driver in a heading-up orientation.

TELSCAN Guideline References:

- 2A.3 Ease of use for more people
- 2A.6 Familiarity/Conformance to expectations
- 3B.3 Choice of output format

TELSCAN Comment:

This guideline is likely to be particularly important for people with specific cognitive impairments (e.g. limited spatial awareness/information processing ability), and drivers who have reduced visual acuity (as a result of age or a visual impairment). However, these groups have never been included in empirical studies and may exhibit different behaviour/preferences (i.e., would north-up be better?) This is unlikely, but still should be tested.

HARDIE Guideline (Ross et al., 1996)

VI. TURN-BY-TURN INFORMATION

4. Text

On a guidance display, use of text should be limited to street names (or directions relating to relevant road signs) and distance.

The amount of text presented on a display should be limited to 2 or 3 units.

TELSCAN Guideline References:

- 2A.1 Workload on residual capabilities
- 2A.3 Ease of use for more people
- 3B.5 and
- 4A.19 Density of information
- 3B.6 Size or intensity of output

TELSCAN Comment:

The ability of drivers to see/read/understand text units should be tested with drivers with reduced visual acuity (as a result of age or an impairment), those with reading difficulties, and people with cognitive impairments (e.g. reduced information processing ability). Such groups may require an emphasis on different information types and/or a limited set of units available as an option.

HARDIE Guideline (Ross et al., 1996)

VI. TURN-BY-TURN INFORMATION

5. Message Structure

Auditory messages should be kept as simple as possible. Ideally, only the direction of the manoeuvre should be given (and possibly some simple road layout information, e.g. 'sharp' right or 'left fork'). For situations where supporting information is necessary as confirmation, e.g., the name of the street to turn onto, this should be added to the end of the message, or presented visually.

If longer messages are required, the most important information should be presented at the beginning or at the end of the message.

All messages should contain a prompt to the driver that a new instruction is to be presented. This prompt can either be extrinsic (an alerting tone) or intrinsic (a word at the beginning of the message which does not contain guidance information, but gives sentence structure).

TELSCAN Guideline References:

- 2A.1 Workload on residual capabilities
- 2A.3 Ease of use for more people
- 3B.1 Choice of output mode
- 4A.17 Timing of information/response times
- 4A.21 Ability to distinguish signals and warnings -
Auditory signals/warnings

TELSCAN Comment:

Lengthy auditory messages would be especially problematic for drivers with short-term memory difficulties (as a result of age or a cognitive impairment). Street names are seldom visible to drivers (if present at all) but a junction name is acceptable if prominently displayed at advance signs. It will also be important to consider carefully the words used within an auditory message to ensure that voice instructions are usable by drivers with language difficulties (e.g. aphasia).

HARDIE Guideline (Ross et al., 1996)

VI. TURN-BY-TURN INFORMATION

6. Repeating Messages

The driver should be able to request a repeat of an auditory message.

The number of possible repeats should not be restricted.

The repeat function should be easily accessible to the driver (e.g. via a control on, or close to, the steering wheel).

TELSKAN Guideline References:

2A.3 Ease of use for more people

3A.1 Choice of input mode

4A.17 Timing of information/response times

TELSKAN Comment:

This guideline will be irrelevant for drivers with severe hearing impairments who are using a visual-only route guidance system. However, it will be important for people with slight hearing impairments or memory problems.

The repeat function control should be modifiable to accommodate drivers with skeletal/physical impairments, e.g. through a voice activated control option.

HARDIE Guideline (Ross et al., 1996)

VII. LINKING TO EXTERNAL INFORMATION

The information presented by a route guidance system should be consistent with any information presented on the road.

The roadside information to consider for compatibility includes: road numbers, road names, direction signs, number of lanes, give way/stop signs, and variable message signs (VMS) for direction, lane closures and diversions.

TELSKAN Guideline References:

- 2A.1 Workload on residual capabilities
- 2A.3 Ease of use for more people
- 2A.5 Ease of learning
- A.7 Familiarity/Conformance to expectations
- 3B.3 Choice of output format
- 3B.10 Use of symbolic language

TELSKAN Comment:

Particular drivers may already experience problems in viewing and interpreting external information, for example, people with visual or reading impairments using road signs. Route guidance systems should not exacerbate such difficulties by providing information within the vehicle which is inconsistent with that outside. Furthermore, systems should not present too much information, and hence become over-complex leading to increased workload levels.

HARDIE Guideline (Ross et al., 1996)

VIII. VISUAL INFORMATION

1. Physical Characteristics

Reflection

Reflection of light from the surface of the display should be minimised.

Glare

Glare from the surface of the display should be minimised.

Ambient Illumination

The illumination of the display should be adaptable to changes in ambient light (e.g. day or night) to ensure that the illumination of the display is suitable for all ambient light conditions.

It is recommended that the display is illuminated automatically according to the ambient light.

Luminance

The luminance of the display should be easily adjustable by the driver, to suit the conditions (ambient illumination).

An automatic adjustment of the display according to the ambient light is recommended.

Contrast

The contrast between text/graphics and background depends on the users' selection of positive or negative representation. It should amount to at least 1:3 to 1: 5.

Not more than two states of contrast should be used (as a code or signal).

TELSKAN Guideline References:

- 2A.3 Ease of use for more people
- 4A.4 Ease of adjustment while stationary
- 4A.5 Ease of adjustment while driving
- 3A.1 Choice of input mode
- 4A.10 Automatic operation of systems
- 3B.7 Clarity and contrast of output
- 3D.4 Reflections or glare from the equipment

TELSKAN Comment:

This set of guidelines is of particular importance to older eyes which are more susceptible to the effects of poor lighting conditions, particularly glare, poor ambient light levels and a lack of contrast. It also applies to a number of other visually impaired people. Automatic adjustment of the display according to the ambient light would be especially important and helpful.

HARDIE Guideline (Ross et al., 1996)

VIII. VISUAL INFORMATION

2. Information Design Aspects

Display Format

The displays should be well structured. Related information should be coded so that it can be perceived as such (e.g. by colour, form, grouping, location - a maximum of 9 locations). The driver should be able to distinguish between the different types of system output (e.g. feedback, questions, warnings, error messages, menus etc.).

TELSKAN Guideline References:

- 2A.3 Ease of use for more people
- 3B.3 Choice of output format
- 3B.5 and
- 4A.19 Density of information
- 3B.6 Size or intensity of output
- 3B.7 Clarity and intensity of output
- 3B.9 Use of colour

TELSKAN Comment:

Drivers with reduced visual acuity (as a result of age or an impairment) or people with cognitive impairments may require a limited set of locations. Testing is recommended.

Text Size

Letters used in a display should be large enough to read in the moving vehicle environment (e.g. if the distance between the driver and the display = 60 cm, then letter-height should = 6 mm).

TELSKAN Guideline References:

- 4A.4 Ease of adjustment while stationary
- 3B.6 Size or intensity of output

TELSKAN Comment:

Adjustable text size may be necessary for drivers with reduced visual acuity, although small displays (e.g. on a standard-size radio receiver) may limit what can be done.

Font

No more than two different fonts and two types of emphasis should be used.

TELSCAN Guideline References:

- 2A.3 Ease of use for more people
- 3B.3 Choice of output format

TELSCAN Comment:

Drivers with reduced visual acuity or people with cognitive impairments may find two fonts and two types of emphasis difficult to distinguish or confusing. Testing is recommended.

Symbols/Icons

The number of symbols should be restricted to a manageable amount for the driver.

The meaning of each symbol should be recognisable for the average driver.

A maximum of four symbol sizes should be used.

TELSCAN Guideline References:

- 2A.3 Ease of use for more people
- 2A.4 Flexibility/Adaptability
- 3B.3 Choice of output format
- 3B.10 Use of symbolic language

TELSCAN Comment:

Adjustable symbol size may be necessary for drivers with reduced visual acuity. Also, a maximum of four symbol sizes may be too great, particularly for people who find it difficult to understand abstracts, such as symbols.

Colour

Colour stereotypes should be followed (DIN 66234/5: Display work station; Coding of information): red = alarms; yellow = warnings; green = normal).

Not more than four different colours should be used (excluding black and white).

TELSCAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 3B.9 Use of colour

TELSCAN Comment:

These guidelines will not apply for people with particular types of colour-blindness or reduced colour sensitivity. It should be possible for the user or a competent specialist to select particular tones and intensities of colour to cater for individual difficulties.

Coding

The system syntax should be easy to learn and easy to remember.

Information of differing importance (normal - warning - danger) should be coded differently by the use of stereotypes (colour, frequency, etc.).

Related information should be coded so that it can be perceived as such (e.g. by colour, form, grouping, location - a maximum of 9 locations). The driver should be able to distinguish between the different types of system output (e.g. feedback, questions, warnings, error messages, menus etc.).

TELSCAN Guideline References:

- 2A.3 Ease of use for more people
- 2A.4 Flexibility/Adaptability
- 2A.5 Ease of learning
- 3B.1 Choice of output mode
- 3B.3 Choice of output format
- 3B.9 Use of colour
- 3B.10 Use of symbolic language

TELSCAN Comment:

This guideline will be particularly important to ensure that a system is usable by drivers with memory limitations and/or learning difficulties.

In addition, particular impairment groups, for example drivers with reduced visual acuity or people with cognitive impairments, may require simpler symbology sets, with for example fewer location options. People with reading/ hearing difficulties or people with cognitive impairments often have a different language structure. This point should also be considered for other guidelines relating to message structures.

Timing of Presentation

Information needed by the driver should be presented with respect to traffic within an appropriate temporal margin.

TELSCAN Guideline References:

- 2A.1 Workload on residual capabilities
- 2A.4 Flexibility/Adaptability
- 4A.17 Timing of information/response times

TELSCAN Comment:

This is particularly relevant to people with limited processing capacity due to cognitive impairment or high workload.

Information Density

The number of information units relevant for decisions (symbols, streets, street names) within an actual display should be controlled by the system once selected by the driver (DIN 66234/3].

TELSCAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 3B.3 Choice of output format
- 3B.5 and
- 4A.19 Density of information

TELSCAN Comment:

It is recommended that tutored selection be provided by a competent specialist for elderly people and people with cognitive impairments. In any case, testing with these user groups is recommended.

HARDIE Guideline (Ross et al., 1996)

VIII. VISUAL INFORMATION

3. System Interaction

Personalising Information

The structure of the menus should be logically organised and oriented to the driver's demands (e.g. the most frequent function should be the easiest to select).

It should be possible to select according to different levels of system experience (novice - expert).

TELSKAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 4A.4 Ease of adjustment while stationary
- 3B.3 Choice of output format

TELSKAN Comment:

It is recommended that set options are available within the system design which are manually selectable or selected via a smart card . In any case, testing of these set options is especially needed for elderly people and people with cognitive impairments to ensure the options meet special requirements. The aim should be to present to all drivers all the information which is genuinely useful and no more.

Personalising Information

The driver should be able to control the speed and frequency of information presentation.

TELSKAN Guideline References:

- 2A.1 Workload on residual capabilities
- 2A.4 Flexibility/Adaptability
- 4A.4 Ease of adjustment while stationary
- 4A.17 Timing of information/response times

TELSKAN Comment:

This is particularly relevant for elderly drivers with slower response times or for people with limited processing capacity due to cognitive impairment or high workload. It is recommended that set options are available within the system design which are manually selectable or selected via a smart card . In any case, testing of these set options is especially needed for elderly

people and people with cognitive impairments to ensure the options meet special requirements. In some cases, tutored calibration by a competent specialist may be needed.

Perception of System State

Presentation of new information or a new system state (e.g. task solved, new display) should be clearly announced (e.g. by an acoustic message or signal).

TELSCAN Guideline References:

3B.1 Choice of output mode

TELSCAN Comment:

For people with severe hearing impairments an alternative alerting signal needs to be provided. However, this could be difficult visually as acoustic signals are well suited to this task. Testing of alternative methods, for example, use of the tactile sense, is recommended.

HARDIE Guideline (Ross et al., 1996)

IX. AUDITORY INFORMATION

TELSCAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 3B.1 Choice of output mode

General TELSCAN Comment:

In general, this section is irrelevant for people with severe hearing impairments. This should be borne in mind for all guidelines in this section. Those with mild or moderate hearing impairments may be able to use some auditory output but such usage may be inadvisable if the output is likely to be degraded. It is recommended that appropriate system parameters (e.g. the types/amount of visual information, auditory message volume, tone, quality, etc.) be adaptable enough to accommodate an individual's level of impairment.

1. Physical Characteristics

Sound Quality

The signal - noise difference of acoustic signals to ambient noise should be high enough for easy discrimination.

Ambient Noise

The loudness of acoustic signals should be adjusted automatically to the ambient noise.

Loudness

The loudness of acoustic signals should be easily adjusted manually by the driver (a minimum, audible limit should be set for warning/alarm signals).

Absolute and relative tone intensities should become greater when ambient noise becomes greater at higher speeds. The system should provide an increasing speech volume when the level of the ambient noise increases.

TELSCAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 4A.4 Ease of adjustment while stationary
- 3A.1 Choice of input mode
- 4A.21 Ability to distinguish signals and warnings -
Audible signals/warnings

TELSKAN Comment:

Systems should either be adjustable or adaptable to meet the needs of elderly and disabled drivers. The system could also store adjustments set by the driver (with the assistance of a competent specialist, if necessary) to subsequently present signals at an appropriate level. Although a minimum, audible limit should be set for warning/alarm signals, sudden noise could cause muscle spasticity for some people with disabilities and could be hazardous. (See 4A.21, Auditory signals/warnings). Manual adjustment of loudness for people with physical impairments may be problematic, if not impossible. A voice controlled system should be considered as an alternative.

Frequency Range

The acoustic signals should lie in the range of 200 to 8000 Hertz.

Audible cues should lie in the range of 500 to 3000 Hertz (this is likely to be appropriate for the auditory threshold of the majority of the drivers).

Rationale:

UK Draft Code of Practice: Recommends that: for tones the range should be 500 to 3000 Hertz (2000 Hertz for elderly persons); for speech the pitch should remain above 500 Hertz if the frequency spectrum needs to be modified to overcome background noise.

TELSKAN Guideline References:

4A.21 Ability to distinguish signals and warnings -
Auditory signals/warnings

TELSKAN Comment:

Hearing loss from noise exposure and age tends to be in the frequency range from 3000 to 6000 Hz. It is recommended that the upper limit of 2000 Hz. be adopted to cater for people with mild/moderate hearing loss.

2. Information Design Aspects

Different Presentation Types

If speech or audible cues can be used, then different kinds of information (warning, status messages, user requests) should be represented by different types of auditory presentation.

TELSCAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 3B.3 Choice of output format
- 4A.21 Ability to distinguish signals and warnings -
Auditory signals/warnings

TELSCAN Comment:

The ability of drivers to distinguish between different signals should be tested for people with cognitive impairments (e.g. reduced information processing ability), and those with hearing difficulties. Such groups may require a limited set of signals available as an option.

Speech, Vocabulary

Drivers should be able to switch easily between any modality of information presentation. However, the system should define the information which cannot be influenced by the driver, e.g., alerting cues, alarm signals.

TELSCAN Guideline References:

- 4A.5 Ease of adjustment while driving
- 3A.1 Choice of input mode

TELSCAN Comment:

Manual switching may be problematic, if not impossible for drivers with particular physical impairments. Voice activation should be considered as an alternative mode.

Coding Stereotypes

Auditory displays with distinctive sounds should be employed to code items requiring special driver attention.

TELSCAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 3B.3 Choice of output format
- 4A.21 Ability to distinguish signals and warnings -
Auditory signals/warnings

TELSCAN Comment:

The ability of drivers to distinguish between different signals should be tested for people with cognitive impairments (e.g. reduced information processing ability), and those with hearing difficulties. Such groups may require a limited set of signals available as an option.

Timing of Information

Spoken messages should be understandable, relevant, timely and repeatable (if the message was not understood).

TELSCAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 4A.5 Ease of adjustment while driving
- 3A.1 Choice of input mode
- 3B.3 Choice of output format
- 4A.17 Timing of information/response times
- 4A.21 Ability to distinguish signals and warnings

TELSCAN Comment:

The number of spoken messages and the ability to distinguish between them should be tested for people with cognitive and hearing impairments. A limited set of messages may be required for these groups and should be an available option.

Manually eliciting a repeat function may be problematic, if not impossible for drivers with particular physical impairments. Voice activation should be considered as an alternative mode in these cases.

Information Density

When driving, the optimal perceptual and cognitive solution should be a maximum of 7 - 9 information units contained within an auditory message for road information. However, for safety reasons it is generally recommended that traffic information should not contain more than 3 - 4 units of important information.

TELSKAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 3B.3 Choice of output format
- 3B.5 and
- 4A.19 Density of information
- 4A.21 Ability to distinguish signals and warnings -
Auditory signals/warnings

TELSKAN Comment:

The ability of drivers to hear and understand different information units should be tested with people with cognitive impairments (e.g. reduced information processing ability), and those with hearing difficulties. People with cognitive impairments require a limited set of units available as an option.

Transience, Repetition

Spoken messages should be repeatable at the driver's request.

The driver should be able to switch (forwards and backwards) to the required information.

The driver should be able to switch off repetition of the speech output.

TELSKAN Guideline References:

- 4A.1 Safety in controlling the vehicle
- 4A.9 Choice of input mode
- 4A.5 Ease of adjustment while driving
- 4A.17 Timing of information/response times

TELSKAN Comment:

Manual eliciting of a repeat function may be problematic, if not impossible for drivers with particular physical impairments. Voice activation should be considered as an alternative option in these cases.

Appendix 5

Application of the TELSCAN Guidelines to HARDIE Guidelines for Collision Avoidance Systems

Introduction

This Appendix applies the TELSCAN guidelines from Parts 2, 3 and 4A to the guidelines on information presentation for collision avoidance systems (CAS) from the DRIVE II HARDIE Project V2008 (Ross et al., Chapter 3, 1996).

This exercise is an example of how the TELSCAN guidelines can be more widely applied to specific systems or existing guidelines. The HARDIE guidelines have been used to exemplify this point, with cross-referencing back to the guidelines in Parts 2, 3 and 4A of this Handbook. For ease of reference, the original HARDIE guideline numbering system has been retained.

Under each heading HARDIE has produced several guidelines, including the rationale (with references), examples and further reading. Not all headings have been included in this exercise in order to demonstrate a selection of guidelines that have particular relevance to elderly and disabled drivers. Even if a heading is included, not all the guidelines under that heading have been reproduced. Those that are repeated here, however, are repeated verbatim.

This Appendix is under review to capture specific guidelines on designing collision avoidance systems that will be more usable by elderly and disabled drivers, and these will be integrated into Part 4D of the Handbook.

HARDIE Guideline (Ross et al., 1996)

I. AUDITORY SIGNALS

3. General Characteristics

If an auditory signal is used for the collision warning then it should be designed to meet the following criteria

1. It should alert but not startle.
2. It should not be easily confused with other auditory sounds both inside and outside the vehicle.
3. It should be audible above any background sounds and noise.

TELSCAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 4A.4 Ease of adjustment while stationary
- 4A.10 Automatic operation of systems
- 4A.20 Size or intensity of output
- 3B.8 and
- 4A.21 Ability to distinguish signals and warnings -
Auditory signals/warnings

TELSCAN Comment:

Systems should either be adjustable or adaptable to meet the needs of elderly and disabled drivers. The system could also store adjustments set by the driver (with the assistance of a competent specialist) to subsequently present signals at an appropriate level. Although a minimum, audible limit should be set for warning/alarm signals, sudden noise could cause muscle spasticity for some people with disabilities and could be hazardous. (See 4A.21, Auditory signals/warnings). Manual adjustment of loudness for people with physical impairments may be problematic, if not impossible. A voice controlled system should be considered as an alternative.

HARDIE Guideline (Ross et al., 1996)

4. Non Speech: General Characteristics

Non verbal auditory signals are an appropriate means of conveying collision warnings.

If an auditory non verbal signal is used it should be between 15 -25 dB above background noise, but it should not exceed 120 dBA.

The number of non verbal signals available should be restricted. Ideally only one non-verbal auditory signal would be available.

Non-verbal auditory signals should be carefully implemented especially if there are several (e.g. 2-3), since there are many other non-verbal sounds in the vehicle.

TELSKAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 2A.4 Ease of adjustment while stationary
- 4A.10 Automatic operation of systems
- 4A.20 Size or intensity of output
- 3B.8 and
- 4A.21 Ability to distinguish signals and warnings -
Auditory signals/warnings

TELSKAN Comment:

Systems should either be adjustable or adaptable to meet the needs of elderly and disabled travellers. Appropriate calibration should be made by a competent specialist to adapt the system to accommodate the level of hearing impairment by the individual driver. Alternatively, the system should store adjustments input by the driver to subsequently present signals at an appropriate level.

Manual adjustment of loudness for people with physical impairments may be problematic. A voice controlled or adaptable system is recommended.

For people with hearing or cognitive impairments, the number of different warnings that can be processed without confusion should be tested and if necessary limited.

HARDIE Guideline (Ross et al., 1996)

5. Non Speech: Physical Characteristics

An acoustic warning should have the following physical characteristics:

- High signal repetition rate
- High intensity
- High fundamental frequency
- Large frequency oscillations within auditory patterns

TELSKAN Guideline References:

2A.4 Flexibility/Adaptability

4A.10 Automatic operation of systems

4A.20 Size or intensity of output

3B.8 and

4A.21 Ability to distinguish signals and warnings -
Auditory signals/warnings

TELSKAN Comment:

High intensity auditory warnings may startle, especially individuals with potential susceptibility (e.g., people with spasticity). Warning signals should be distinguishable from other auditory signals and ambient noise. It is recommended intensity levels are set by a competent specialist for individual users.

Hearing impairment (due to age, exposure to industrial noise, etc.) is typically in the higher frequencies. A recommended highest frequency is 2000 Hz.

HARDIE Guideline (Ross et al., 1996)

6. Non Speech: Fundamental frequencies

Frequencies between 500 and 3000 Hz are recommended.

TELSCAN Guideline Reference:

4A.20 Size or intensity of output

TELSCAN Comment:

Hearing impairment (due to age, exposure to industrial noise, etc.) is typically in the higher frequencies. A recommended highest frequency is 2000 Hz.

HARDIE Guideline (Ross et al., 1996)

II. VISUAL DISPLAYS

1. General Principles

If a visual display is used for collision avoidance system (CAS) signals then it should be simple, such as a flashing LED.

TELSCAN Guideline References:

2A.1 Workload on residual capabilities

2A.3 Ease of use for more people

2A.8 Compatibility with other aids and systems

TELSCAN Comment:

This guideline may be accepted in general, but for people with hearing impairment who are also receiving visual information from other ATT systems, care should be taken that their visual channel is not overloaded.

HARDIE Guideline (Ross et al., 1996)

III. TACTILE DISPLAYS

1. General

CAS warnings may be delivered via an 'active gas pedal'. However, it must be noted that the usefulness of tactile CAS displays is still to be demonstrated in a robust way.

Rationale:

An active gas pedal may prove to be a desirable interface device because it provides an unusual stimulation to the sole of the foot, which is particularly sensitive to vibration.

TELSCAN Guideline References:

- 2A.8 Compatibility with other aids and systems
- 3B.1 Choice of output mode

TELSCAN Comment:

This option may be inappropriate for people with physical impairments where, for example, limb sensitivity is absent or restricted. However, it may be very appropriate for those with hearing impairments where the visual channel could be overloaded.

HARDIE Guideline (Ross et al., 1996)

IV. GENERAL FEATURES

1. Activation criterion

A Time to Collision criterion of 4 seconds has been a well used criterion, though more research is required in this area.

TELSCAN Guideline References:

2A.1 Workload on residual capabilities

4A.17 Timing of information/response times

TELSCAN Comment:

This guideline needs needs further testing with other groups having reduced cognitive functions, due to their slower response times or reduced information processing ability. The guideline should also be tested with people having skeletal/physical impairments, as they may be under high levels of mental or physical workload.

HARDIE Guideline (Ross et al., 1996)

3. Levels of Warning

If the system is not used in a tutoring role then it is recommended that ONE imminent collision warning is implemented.

TELSKAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 3B.1 Choice of output mode

TELSKAN Comment:

For people with perceptual limitations in the primary modality in which the warning is presented, a warning in an alternative modality is recommended. That is, a back-up visual warning should be available for a person with hearing problems.

To avoid redundancy resulting in clutter for people without such limitations, specialist system set-up is recommended.

HARDIE Guideline (Ross et al., 1996)

5. Reaction time of the driver

The activation criterion for the CAS may need to be adjusted to accommodate changes in elderly drivers' reaction times.

TELSKAN Guideline References:

- 2A.4 Flexibility/Adaptability
- 4A.17 Timing of information/response times

TELSKAN Comment:

Adequate documentation should be provided to enable a competent specialist to adapt the system accordingly.

HARDIE Guideline (Ross et al., 1996)

8. Manual built-in-test

There should be the capability to manually test the functioning of the CAS, even when the vehicle is mobile.

TELSKAN Guideline References:

- 4A.4 Ease of adjustment while stationary
- 4A.5 Ease of adjustment while driving

TELSKAN Comment:

Manual initiation of testing most probably refers to 'user initiated' rather than 'by hand.' Nevertheless, for people with certain skeletal/physical impairments testing 'by hand' may be inappropriate. An alternative, such as voice activated testing, is recommended.

HARDIE Guideline (Ross et al., 1996)

9. Manual control of signal features

A driver should be able to manually control the intensity of either an auditory or visual signal.

TELSKAN Guideline References:

- 4A.4 Ease of adjustment while stationary
- 4A.10 Automatic operation of systems

TELSKAN Comment:

Acceptable intensities to alert a driver in an emergency situation may differ from those chosen by the driver in a non-critical, neutral situation. As a safety related system, it should be argued that intensities have a set minimum. Any further adjustments should be performed by a competent specialist and appropriate documentation be provided to guide the process.