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The Potential of Intelligent Transportation Systems to Increase Accessibility to Transport for Elderly and Disabled People

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**The Potential of Intelligent Transportation Systems
to Increase Accessibility to Transport
for Elderly and Disabled People**

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16. Abstract <p>By the year 2025 elderly people will form 23 percent of the adult Canadian population, people with disabilities 21 percent and people with specific transportation disabilities 12 percent. This report reviews the access problems of pedestrians, bus passengers, train passengers and car drivers. Much has been done to make public transport and urban infrastructure physically accessible without using advanced technology. However, even with improved physical accessibility, barriers will remain. Many could be overcome by better information and the application of intelligent transport systems and other advanced technology.</p> <p>Intelligent transport systems are well suited to the driving tasks that pose problems as people age. Advanced Traveller Information Systems and Emergency Management Systems can already partially compensate for some of the effects of aging. Advanced Vehicle Control and Safety Systems will soon extend this process, particularly for night vision. Progressive automation of the highway system could greatly increase accessibility in the long term.</p> <p>Guidelines are urgently needed for the ergonomic design of ITS equipment that is easy for elderly and disabled people to use. Canada's role in the international forum Enhanced Safety of Vehicles (ESV) provides an excellent opportunity to produce and disseminate such guidelines. This report lists research and development that would improve transport accessibility, and suggests a research program for Canada on ITS and accessibility.</p>					
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16. Résumé <p>D'ici l'an 2025, 23 p. 100 de la population du Canada aura 65 ans et plus, 21 p. 100 une déficience quelconque et 12 p. 100 un handicap de mobilité d'une nature particulière. Le présent rapport traite des difficultés éprouvées par les piétons, les usagers des transports en commun et les conducteurs de voitures privées. De grands progrès ont été réalisés pour améliorer l'accessibilité des transports en commun et des installations terminales, sans faire appel à des technologies de pointe. Cependant, des barrières subsistent encore, qui ne seront abolies que par une information de meilleure qualité et l'utilisation de systèmes intelligents de transport, SIT, et d'autres.</p> <p>Les SIT, notamment les systèmes d'information des usagers et les systèmes d'alerte-urgence routière, promettent d'atténuer quelques-uns des effets de l'âge sur l'aptitude à conduire des conducteurs âgés. Les systèmes avancés de commande des véhicules et d'aide à la sécurité viendront les compléter bientôt. On pense entre autres aux systèmes de vision nocturne assistée. À plus long terme, ce sera l'automatisation graduelle de l'autoroute électronique.</p> <p>Les lignes directrices concernant les critères de conception ergonomique des SIT se font cruellement attendre. Le Canada aura un rôle à jouer dans le cadre du groupement international appelé Enhanced Safety of Vehicles (ESV) pour promouvoir et diffuser ces lignes directrices. Le présent rapport dresse une liste des actions de recherche visant à améliorer l'accessibilité des transports, et propose un programme de R&D sur les SIT et l'accessibilité au Canada.</p>				
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EXECUTIVE SUMMARY

Introduction

This report has been produced through the author's participation in the Visiting Expert Program at the Transportation Development Centre, Transport Canada. Its objectives are:

- To identify opportunities for applying ITS-related technologies to increase the accessibility of transportation for elderly and less able people;
- To develop an effective strategy for Transport Canada to assist in this application; and
- To identify roles for the involvement of the transportation community and providers of facilities and services in Canada, the U.S. and Europe.

People with Disabilities

Most countries estimate that about 12 -14 percent of their population are disabled in some way and 5 - 10 percent have walking or mobility difficulties. Ten percent of the Canadian population are believed to have a transportation disability. Typically, 0.5 - 1 percent of the population use a wheelchair, though often only for part of the time or for particular activities. The population of elderly people is expected to increase considerably in almost every country, and the number of people with disabilities to increase as the elderly population grows.

By the year 2025, 23 percent of the Canadian adult population will be aged 65+, 21 percent will be disabled and 12 percent will have a specific transportation disability. Disabled drivers already account for about 11 percent of all drivers, and by 2025 the proportion of drivers who are elderly or disabled will be approaching 20 percent.

Accessibility

Access to transport is made possible by information, by money and by vehicles and infrastructure that do not place demands on the user that are beyond the user's abilities. Well trained staff and considerate operating practices can overcome many problems of unsuitable equipment. The development of accessible transport has been a long process of improving the physical design and the operation of transport systems to progressively remove barriers to particular sectors of the population. In recent years the emphasis has been on transport that caters for all users in a single integrated system rather than providing segregated accessible systems for particular groups of users, such as people in wheelchairs.

Ergonomic requirements

During the 1980s research established the capabilities of the disabled and elderly populations and the ergonomic requirements for the physical design of cars, buses, terminals and walking areas. Subsequent research has addressed the requirements of people with sensory impairments and provided guidance on the supply and display of information. Since the mid-1980s, particular attention has been given to overcoming the problems of people with impaired vision, hearing and cognitive processes. It is likely that further improvements in the accessibility of transport will involve the use of electronic technologies. Ergonomic guidelines that will make these technologies easy for elderly and disabled people to use have not yet been agreed, although a number of research reports suggest suitable guidelines.

Accessibility Problems and Developments

Pedestrians

Elderly and disabled pedestrians are limited by the distance they can walk and by low walking speed. About half of all wheelchair users and ambulant disabled people can only walk 150 m without a rest. Hills and crossing roads cause problems for 30 - 50 percent of ambulant disabled people. These features, plus steps and crowds, are problems for about half of all registered disabled people. Visually impaired independent travellers have a high accident rate when walking, crossing roads and using trains.

Urban buses

Several European countries have published recommendations on the design of urban buses to be easy for elderly and ambulant disabled people to use. This led to a generation of vehicles which did not appear in North America. These were not accessible to people in wheelchairs but were much easier than the conventional North American urban bus for elderly and ambulant disabled people. The critical features are a floor height of about 550 mm, steps that are low and wide, good handrails, plentiful stanchions and widespread use of colour contrast (particularly yellow on handrails) to help people with visual impairments.

Low-floor buses

Low-floor buses started to appear in Germany in the late 1980s, are now in widespread use in Europe and are coming into use in North America. These were not initially to provide wheelchair access, but made it possible and low-floor buses are now always wheelchair accessible. In Europe, wheelchair passengers travel unrestrained, facing backwards in a secure compartment. In the U.S., wheelchair passengers travel facing forwards with the wheelchair and, optionally, the passenger restrained. Boarding time for a passenger in a wheelchair in Europe is about 40 seconds, in the U.S. 2 - 4 minutes.

The European application of low-floor buses has given people in wheelchairs a bus service that is as available to them as to everybody, on which they are integrated with all other passengers.

Trains and metros

The problems for disabled people, particularly those in wheelchairs, of using trains are the vertical step from platform to train, narrow doors and passages in coaches, and access to station platforms. Subways are now being built to be fully accessible and some older systems converted. Guidelines on improved access to trains have been published.

Cars and driving

The number of elderly and disabled drivers is increasing. Aging causes physiological changes that make driving more difficult. These include increased reaction time, deteriorating vision, particularly at night, and a reduced ability to split attention between several tasks. Because of self-imposed restrictions on driving, in most countries elderly drivers have one of the lowest accident rates per driver per year. Their accident rate per mile increases as drivers age past about 65, and increases rapidly beyond about 75 years old.

Improving Accessibility by the Use of ITS

For all transport systems, there are many simple improvements to vehicles, infrastructure and operational practices that can increase accessibility at little cost. These improvements are well known and the problem is one of implementation. Once these improvements have been made, there will remain barriers to accessibility that could be overcome by the use of ITS. These include, for all modes, the provision of better trip-planning information and information during a journey.

Pedestrians

ITS also has considerable potential to help pedestrians. Infrared beacons which transmit messages (talking signposts) and hand-held location and guidance systems should help pedestrians with visual impairments. All pedestrians have benefited from the application in Britain of person detectors at crossings which extend the crossing time for elderly and disabled people if they need it and also reduced delays to drivers by shortening or omitting the pedestrian phase when no one is waiting to cross. Similarly, warning lights at pedestrian crossings that flash when a person is on the crossing are being tested in the U.S. and have been shown to make drivers more aware of the crossing.

Public Transport

Public transport users would benefit from better information during travel, as well as better trip-planning information. Real-time transit information available at home on television or a portable terminal could reduce the time people have to wait for a bus. Displays at bus stops of the service number and the time to arrival of the next few buses gives passengers confidence and reduces stress. Visual displays of information can be made to talk when activated by a proximity transponder. Displaying the name of the next stop inside a bus or subway coach provides warning of upcoming stops and reduces the pressure on people who need time to alight from a bus or train. An inductive loop inside a bus or subway coach allows a person with impaired hearing to hear public address announcements directly on a hearing aid, free from background noise.

Smart fare-payment cards can reduce the time pressure on elderly and disabled people boarding buses or entering subways. Cards can be made to apply to many services, including public telephones. There is potential for using a smart payment card to provide optional information on traveller requirements, to ensure that the operators of each stage of a multi-modal trip are equally aware of what services are needed, so that there are no breaks in the chain of accessible links that comprise the complete journey.

Cars and driving

The capabilities of ITS are a remarkable match to the tasks which become more difficult for elderly drivers as a result of the physiological effects of aging. ITS equipment for private cars that is already available can partially compensate for the effects of aging. At present this is limited to Advanced Transport Information Systems (ATIS) and Emergency Management Systems (EM). These can provide navigational guidance, traffic information, warning of obstacles near the vehicle while manoeuvring at low speed, Touring information and emergency alert ("Mayday") systems. Evaluation of these systems in Europe by elderly drivers has found a very positive response to them and a willingness to pay realistic prices for them.

In the next few years, further application of ITS should reduce the risk of elderly drivers encountering conditions that they find difficult, and make driving easier. These applications will mainly be aspects of Advanced Vehicle Control and Safety Systems (AVCSS) and include night vision enhancement, intelligent cruise control, assistance with lane following, collision warning, in-vehicle display of signs and driver condition monitoring. In the longer term, ITS will probably lead to the automation of driving on major roads and the use of electronics to prevent dangerous and inconsiderate driving on minor roads. This could introduce a form of road transport that is almost a new mode and which is usable by almost everybody.

The Market for ITS Equipment

The total market for ITS equipment in North America, Europe and Japan over the next twenty years is predicted to be of the order of \$200 billion. Of this, about \$100 billion is consumer expenditure on ATIS (Advanced Traveller Information Systems) and about \$50 billion consumer expenditure on AVCSS (Advanced Vehicle Control and Safety Systems). Elderly and disabled people form a significant part of the market for ITS equipment, probably about 25 percent of the total, and ITS equipment must be designed to take account of their requirements and abilities. At present there are no generally accepted ergonomic guidelines for the design of ITS equipment that is easy for elderly and disabled drivers to use.

Research on ITS and Accessibility

The report has identified a number of research and development tasks that are necessary if ITS is to achieve its potential of increasing the accessibility of transport to elderly and disabled people. These are:

Data bases and statistics

Digital maps

Many of the ITS technologies can only be applied in areas for which high quality digital maps of the road system and associated land uses and addresses exist. Natural Resources Canada has a structured digital data base for the Canadian road network which covers the whole country. Navigation Technologies Corporation will start building a digital road map data base for the major cities of Canada in 1997, starting with Toronto.

Statistics on elderly and disabled drivers

In Canada, statistics on the proportion of people of different ages holding driving licences and currently active as drivers are not available. This is partly a result of the federal structure of the country and partly because Canada does not conduct a regular national travel survey, as is done in Britain and the U.S. These surveys are the only reliable way to measure the proportion of the population in different age groups holding driving licences and continuing to drive. Information on the number of drivers with disabilities is also lacking, as is any information on accidents involving disabled drivers and converted vehicles.

General

- Make the ergonomic evaluation of any ITS equipment used by the public a routine part of the design process. Include elderly and disabled drivers and travellers in these evaluations.
- Develop ergonomic guidelines for the design of ITS equipment to be suitable for elderly and disabled people. These are needed sooner than can be produced by the various international committees working on this topic, but must not be seen as competing with the work of the international committees. The identification of Canada as lead country for research on ITS harmonized through the international forum Enhanced Safety of Vehicles (ESV) provides an ideal opportunity for this activity.
- Develop a family of hand-held information storage and display equipment. This could start with a personal organizer/electronic yellow pages carrying travel and touring information; more complicated versions could include some combination of telephone, receiver for real-time data, GPS and digital map. A specialized version could provide location and guidance to people with visual impairments.
- Introduce to North America the contactless transponder to activate various types of equipment, including opening powered doors and making video displays talk when required.

Car drivers

- Set up, in co-operation with the U.S., long-term trials of the use of ITS by elderly drivers. Note ergonomic problems and the effect of the equipment on where and when elderly people drive, and possible on safety. Validate the ergonomic guidelines (see second paragraph of “General” above).
- Confirm that the measures of driver fatigue that are being established for the general population also apply to the population of elderly and disabled drivers.
- Introduce a system to broadcast map corrections direct to a vehicle’s navigation system, at least at the beginning of a day’s driving and possibly on a continuous basis to reflect accidents and incidents.

Public transport users

- Extend smart payment cards to make a single card cover public transport operators in many towns plus railways and public telephones (as is done already by the German Association of Public Transport Operators VDV). Investigate the use of

smart cards to carry optional information on traveller requirements, to help operators provide service required.

- Develop equipment for a communication system between passenger and bus to help a passenger hail a Community Bus.
- Establish a system that provides information on the predicted arrival times for buses at specified local bus stops, and other transit, travel and Yellow Pages information, using cable to a home computer or television, the Internet or broadcasts to a portable receiver.
- Look for other low cost ways to use ITS to help disabled people. One possibility is the use of inductive loops in transit vehicles, to enable people with impaired hearing to hear announcements direct through their hearing aid, without interference from other conversations and background noise.

Taking account of the requirements of elderly and disabled people means, firstly, ensuring that equipment is easy and safe to use by this group of people. This will almost certainly make it easier and safer for the whole population to use. Secondly, it means seeking ways of extending standard equipment to cover the specialized requirements of elderly and disabled people. Thirdly, it means seeking ways to use existing technology to perform a service specifically for elderly or disabled people.

While specialized products are undoubtedly useful for elderly and disabled travellers, it is more important to ensure that mainstream ITS equipment helps these groups rather than creating new barriers for them. As automatic control systems for automobiles become available, they should be checked for ergonomic suitability for elderly and disabled drivers. The standards organisations ISO and CEN are working on the general human factors aspects of ITS, but this will take some time to come to fruition. In the interim, ergonomic guidelines specifically relating to elderly and disabled people, based on existing information, are needed to ensure that current ITS equipment is easy for elderly and disabled people to use.

Unless a continuing research program maintains expertise on ITS and accessibility, there is a risk that the changes to road transport, and particularly to driving, that ITS will bring over the next twenty to thirty years, could unintentionally introduce new barriers to travel rather than improve accessibility.

A Research Programme for Canada

The report develops a series of detailed research activities to improve the accessibility of transport through the use of ITS. These activities include digital maps of the road system, ergonomic guidelines for ITS equipment, long-term trials of ITS equipment for car drivers, hand-held ITS equipment, smart payment cards, development of specific ITS

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equipment, maintaining expertise and international liaison and the roles of ITS Canada. Specific roles for the Transportation Development Centre in these activities are suggested.

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1. INTRODUCTION

The numbers of elderly people and of people with disabilities are growing rapidly in Canada, as in almost all developed countries. By the year 2025 it is expected that elderly people will form 23 percent of the adult population of Canada. By that year, people with disabilities are likely to form 21 percent of the adult population and people with specific transportation disabilities 12 percent (Goss Gilroy, 1995).

There are several pieces of Canadian federal legislation which require the inclusion of people with disabilities and prohibit discrimination on the basis of disability (National Transportation Agency of Canada, 1995). These include:

- Canadian Human Rights Act, 1976
- Charter of Rights and Freedoms, 1982
- National Transportation Act, 1987
- Canadian Transportation Act, 1996

The National Transportation Act, 1987 asserts that:

... a safe, economic, efficient and adequate network of viable and effective transportation services accessible to persons with disabilities and making the best use of all available modes of transportation at the lowest total cost is essential to serve the transportation needs of shippers and travellers, including persons with disabilities ...

Access to transport may be prevented by lack of money, so that the potential user cannot afford to travel. It may be prevented by lack of information (on the existence of a service or on how to use it). Access can be prevented by lack of competence or qualification (a driving license is needed to drive a car). It may be prevented by the transport system requiring the potential user to have abilities that they do not possess (to climb steps or stand for long periods, to read and understand airport information). Lack of access may be overcome by increasing the abilities of the potential traveller or by changing the design or operation of the system to make it easier to use. Having well trained staff available to assist can overcome many problems of unsuitable equipment or infrastructure.

Safety and security are aspects of transport that may limit its accessibility. As people age they become more vulnerable to the effects of accidents. Fatal accident rates increase for elderly pedestrians and passengers on public transport and for car drivers aged over about 75 years. The fear of an accident as an important factor limiting the travel people are willing to attempt.

Almost without exception, people need to travel to achieve the way of life that they desire. Everybody has limitations to their physical abilities, sensory functions, intellectual ability, skills or financial resources. The development of accessible transport has been a

long process of improving the technical design and the operation of transport systems to progressively remove barriers to particular sectors of the population. The aim has been to make transport systems usable by as wide a range of the population as possible. This ensures that lack of access to transport is not the sole factor preventing a person reaching and participating in an activity.

During the past two decades the accessibility of transport systems for elderly and disabled people has improved greatly. In recent years, the emphasis has been on transport that caters for all users in a single, integrated system, rather than providing segregated systems for particular groups of users, such as people in wheelchairs. The development of accessible transport in Canada has been documented in "Access and Mobility for All" (Transportation Development Centre, 1997). To complement this document and to avoid duplication, this report has concentrated on research and the development of accessible transport in Europe and the U.S., setting these experiences in a Canadian context where appropriate.

During the literature survey for this report it became apparent that research on accessibility in Europe and the U.S. has gone through a number of phases. From the late 1960s to the late 1970s research tended to concentrate on the travel behavior and needs of disabled people, and to identify qualitatively the physical and social barriers to travel. From the mid 1970s to the late 1980s many ergonomic measurements were made of the abilities of disabled people to perform the physical tasks necessary for the use of the different transport modes. There was also engineering development of equipment and converted vehicles, and operational research into special services such as dial-a-ride, to improve the accessibility of transport systems.

Since the mid-1980s research on the safety of elderly car drivers and on monitoring the effectiveness of the early accessible transport services has increased, as has research on the barriers caused by sensory and cognitive impairments. By the mid 1990s there appears to be little research on ergonomic capabilities or physical travel barriers, though work is being done on the understanding of displays and information. Monitoring studies of systems such as low-floor urban buses and of policies like the Swedish legislation on accessible public transport are being undertaken. Some development continues on equipment such as wheelchair and occupant restraints, which are still a cause of problems. The development of information displays (real-time information at bus stops, for example) appears to be occurring mainly in industry, for the mainstream public transport systems, but offers potential benefits to elderly and disabled people.

Vespa (1995) has also identified three phases in the development of accessible transport, particularly in Canada, which were:

- 1972 - 1984, when the focus was on mobility, the objective was to be able to travel in any way possible and the human need addressed was to be independent;

- 1985 - 1995, when concern was for integration and the focus was on mobility, sensory and cognitive difficulties, the objective was travel on the same systems as everyone else and the human need addressed was to be an integral part of society; and,
- Since 1995, concern has been for choice, comfort and dignity, with the focus primarily on the elderly, the objective has become travel with the same level of choice, comfort and dignity as everyone else and the human need addressed is now the joy of living.

Vespa considered that the emerging technologies that will improve accessibility would be largely electronic.

The term “Intelligent Transportation Systems” (ITS) refers to the application of information systems, telecommunications, sensors and control systems to road transport (Catling, 1994). ITS has the potential to increase the capacity and productivity of the road transport system, to improve the reliability and safety of road transport and to reduce its environmental impact and the adverse consequences of incidents. This report examines the ways in which ITS could be used to increase the accessibility of transport systems to elderly and disabled people. It concludes that ITS has the potential to make travel easier for drivers, pedestrians and users of public transport (urban and long distance). In the case of car drivers, the capabilities of ITS match well the aspects of driving that become more difficult as people age. To achieve the potential benefits of ITS for the whole population, including elderly and disabled people, attention must be paid to the requirements and abilities of elderly and disabled people. This group of travellers already form a significant part of the market for ITS equipment, and in the future will form an even more substantial part of the market. On commercial grounds alone, manufacturers of ITS equipment need to ensure that their products are easy for elderly and disabled people to use.

This report has been produced through the author’s participation in the Visiting Expert Program at the Transportation Development Centre, Transport Canada. Section 2 outlines the objectives of the Project “Intelligent Transportation and Accessibility” in the Visiting Expert Program and summarizes the other outputs produced and activities undertaken during the Project. Section 3 provides international statistics on the population of people with disabilities and their capabilities. Section 4 identifies the accessibility problems of the users of various transport modes and the ways in which these problems have been overcome, based on an international review of access to transport systems and services, and Section 5 summarizes briefly standards relating to accessibility, particularly for public transport and for transport infrastructure. Section 6 summarizes research on the benefits of accessible transport. Section 7, a major part of the report, describes the scope for improving accessibility by the use of ITS equipment. Section 8 identifies the ITS developments required to improve accessibility and suggests a research program for Canada to encourage the developments that are needed.

2. PROJECT OBJECTIVES AND OUTPUTS

The objectives of the project were defined as:

Research and identify opportunities for applying ITS-related technologies to increase the accessibility of transportation for elderly and less able people. Develop an effective strategy for Transport Canada to assist in this application, with the involvement of the transportation community and providers of facilities and services in Canada, the U.S. and Europe.

The work plan for the project required the preparation of an overview of the main transport accessibility problems for drivers, public transport users and pedestrians and another report on ITS technologies relating to these groups of travellers. It specified the development of options for a Canadian accessible transport R & D program building on the ATAS framework (Suen and Parviainen, 1993), the European TIDE Program (European Commission, 1994) and the European DRIVE II Program (European Commission, 1993). These options should lead to recommendations for specific R & D activities for TDC and a program for implementation.

In the event, the publications produced during the project, excluding this final report, included:

- A paper, "The value of intelligent transportation systems to elderly drivers", which was presented at the Third World Congress on ITS, Orlando, Florida, October 1996 (Mitchell, 1996).
- A paper, jointly with Suen, "ITS impact on elderly drivers" for the XIIIth International Road Federation World Meeting, Toronto 1997 (Mitchell and Suen, 1997).
- A paper, jointly with Suen and Rutenberg, "Directions for ITS research and development on safety and security for elderly and disabled travellers in Canada". This was accepted for the 3rd International Conference of ITS Australia, to be held in Brisbane in March 1997, but could not be presented there and is likely to be presented at the Fourth World Congress on ITS, Berlin, October 1997 (Suen et al., 1997).
- A paper for Industry Canada, "Intelligent Transportation Systems (ITS) - Applications for improving transportation for elderly and disabled travellers" (published as a Transport Canada report, TP 12925E) (Mitchell, 1997a).
- The overview of accessibility problems, "Access to transport systems and services - an international review" (published as a Transport Canada report, TP 12927E) (Mitchell, 1997b).

3. PEOPLE WITH MOBILITY PROBLEMS

Sections 3 to 6 of this report are based on the overview "Access to transport systems and services - an international review" (Mitchell, 1997b). These sections concentrate on the problems of accessibility that have been identified in the international literature, particularly from Europe and the U.S. The report also examines the means of improving accessibility that have been used in Europe and the United States, and to a lesser extent in Canada, and how these have come to be introduced. The purpose of this section is to summarize, for Canadian readers, the situation in Europe and the U.S. The current state of accessible transport in Canada has recently been described in "Access and mobility for all" (Transportation Development Centre, 1997). To avoid duplication, the situation in Canada has not been reviewed in detail in this report.

In the 1960s it began to be appreciated that, at least in the developed world, people were living longer and the population of elderly people was going to increase (Olshansky et al. 1993). Many of these elderly people were expected to be frail, disabled or have impaired vision or hearing, and in the 1970s the problems caused to elderly and disabled people by lack of transport were being appreciated in Europe (Norman, 1977) and North America (Revis, 1978). By the late 1960s or early 1970s, the concept of equity in transportation was beginning to be articulated (Bell, 1978). Section 16(a) of the 1970 amendment to the U.S. Urban Mass Transportation Act of 1964 states:

it is hereby declared to be the national policy that elderly and handicapped persons have the same right as other persons to utilize mass transportation facilities and services; that special efforts shall be made in the planning and design of mass transportation facilities and services so that the availability to elderly and handicapped persons of mass transportation which they can effectively utilize will be assured.

In Canada the inclusion of people with disabilities and the prohibition of discrimination on the basis of disability are required by the Charter of Rights and Freedoms, 1982; the Canadian Human Rights Act, 1976 with later amendments; the National Transportation Act, 1987 and the Canadian Transportation Act, 1996 (National Transportation Agency of Canada, 1995).

The UN International Year of Disabled People (1981) focussed attention on the problems faced by disabled people. In the early 1980s the disabled population was usually perceived as being a distinct and separate group of people, characterized by being in a wheelchair or being completely blind. However, some ergonomic research had included elderly and ambulant disabled people (for example, Brooks et al., 1974). The concepts of a single population covering the whole spectrum of abilities and capabilities, and of limitations or handicaps being caused at least as much by the situation as by the physical capability of a person, only developed during the 1980s (Dejeammes et al., 1988). This changing perception of the population who have mobility impairments has been reflected in changes in the supply of transport services to suit the

widest possible population. It was realized that the improvements made to help disabled people also helped all travellers; indeed, the problems of people with disabilities were useful indicators of ways to improve service standards for everybody (Hultgren, 1995). Another change in perception has been the appreciation of the importance of the complete transport chain from origin to destination. Making one link of the chain accessible had little effect while other links remain inaccessible.

3.1 The Population with Reduced Mobility

Estimates of the numbers of people with chronic and acute disabilities were produced in the U.S. in the mid-1960s, while the first survey of disability in Britain was by Harris (1971). Canadian and U.S. surveys of transport and handicapped people (Systems Approach Consultants Ltd., 1979; U.S. Department of Transportation, 1978) estimated that about 5 percent of the population aged 65 years and older were transportation handicapped. This has subsequently been increased, for Canada, to about 10 percent of the total adult population (Goss Gilroy Inc., 1995).

A summary of the numbers of people with impairments in different countries was given by ECMT (1986). It was estimated that about 10 percent of the population of Europe were impaired, although subsequent surveys have increased this figure to around 12 - 14 percent. Table 1 lists the numbers and percentages of impaired or disabled people in a number of ECMT member states.

Very recently, Cohen (1996) has reported that the U.S. National Long Term Care Survey is showing that the impairments of middle and old age - arthritis, high blood pressure and circulation problems - are troubling a smaller proportion of people aged over 65 each year. Problems accepted as normal in a 65-year-old in 1982 are now often not appearing until 70 or 75. Cohen suggested that the greying of the world's population may prove less of a financial burden than had been expected. In 1994, almost 80 percent of the people over 65 in the U.S. could complete everyday activities, which represented a significant drop in the proportion of disabled old people in the population.

People aged 65 years and over formed 12.8 percent of the total population of the U.S. in 1995, and are forecast to be 18.4 percent of the total population in 2025. In Canada they formed 11.6 percent of the total population in 1991 (14.7 percent of the adult population). They are forecast to form about 19 percent of the total population (23 percent of the adult population) by 2025. The proportion of the elderly population who are very old, over 80 years, will increase even more, from 2.1 percent of the total population in 1991 to 4.1 percent in 2016.

Table 1
Numbers and percentages of disabled people in different countries (ECMT, 1986)

Country	Number of disabled people (thousands)	Percentage of disabled people in population
Denmark	550 - 660	10.0 - 12.0
Finland	250 - 400	5.2 - 8.3
France	3 282 - 5 500	6.5 - 10.0
Germany ⁽¹⁾	6 608 - 7 462	10.8 - 13.1
Ireland	100 - 150	3.3 - 5.0
Italy	960 - 9 750	1.7 - 17.1
Luxembourg	35 - 40	10.0 - 11.0
Netherlands	1 123	9.5
Norway	500	12.0
Portugal	727	7.4
Spain ⁽²⁾	9 500	25.0
Sweden	1 000	12.0
Great Britain: (England, Scotland, Wales)	4 000	7.3
Other sources		6.0 - 10.0
Northern Ireland	51	3.9
Canada	3 435	13.7
Europe	42 000	10.0

1) *The lower figures are official statistics; the higher ones are based on survey data.*

2) *Includes up to 1 851 000 (5.1 percent) handicapped by luggage, shopping and accompanying small children. There is also believed to be some double counting in the Spanish figures.*

(Source: ECMT, 1986)

3.2 Types of Disability

The wide variations in the figures in Table 1 reflect different definitions of disability in different countries and different sources of information. These differences are even more pronounced when the numbers of people with different types or severities of disability are considered. With the proviso that figures are not comparable between countries, because of differences of definitions, Table 2 gives an indication of the percentages of the total population with different types and degrees of disability.

The figures for Britain have been increased by a subsequent survey (Martin et al., 1988). In particular, the proportion of the population who are disabled is now estimated as 14.2 percent, and those who use a wheelchairs as 1.0 percent of the total population. Similarly, in Canada the 1991 Health and Activity Limitation Survey has amplified the figures given earlier by ECMT. In the TransAccess Data Base (Goss Gilroy Inc., 1995),

the number of persons with disabilities in Canada in 1995 is estimated to be 3.81 million, or 17.1 percent of the adult population. Persons with transportation disabilities in 1995 numbered 2.19 million, or 9.9 percent of adults.

Table 2
Percentage of the total population with different disabilities

Country	All disabled	Mobility handicapped	Walking difficulties	Use wheelchair	Housebound	Impaired vision	Impaired hearing
Finland	8.3			0.4			
France	9 - 10	6.0			1.0		
Germany	10.8	6.5 (+2.2) ⁽¹⁾			0.15		
Sweden		12.0 ⁽²⁾	4.8	0.4		0.8	4.8
Britain	7.3			0.2	1.0		
1988 survey	14.2		9.9	1.0			
Canada	13.7		8.8 ⁽³⁾			1.2	2.7
1991 survey	13.1	7.6	5.7 ⁽⁴⁾		0.8	1.9	4.0

1) *Mobility handicapped, but not disabled.*

2) *Cannot use existing public transport or encounter difficulties getting about or travelling.*

3) *Problems with mobility and/or agility.*

4) *People with a mobility disability.*

(Sources: ECMT, 1986 plus Martin et al., 1988 for Britain and Goss Gilroy Inc., 1995 for Canada)

3.3 Capabilities of the Population

A number of detailed studies of transport-related disabilities have been undertaken. In France, 504 people from the population of 527 of a village participated in tests of their physical capabilities. These measured, for example, the force they could exert on a handrail or the acceptability of surfaces for walking, and determined the proportion of the population unable to perform tasks such as descending steps 35 cm high or descending a ramp sloped at an angle of 20 percent (Flores and Minaire, 1985). This gives probably the most comprehensive information available on the capabilities of a typical population.

Two general surveys of disabled people in Britain quantified the population of people with disabilities, identified the numbers of people using different types of mobility aid and measured the percentages of people capable of performing a wide variety of tasks, some of which were transport related (Harris, 1971; Martin et al., 1988). These included walking certain distances, climbing different numbers of steps, grasping and balancing.

Research in Britain and France during the 1970s and early 1980s defined the capabilities of elderly and disabled people in the context of bus use. These studies provide a comprehensive data base on requirements for step heights, handrail design, seating, and many other aspects of bus design (Brooks et al., 1974; Flores et al., 1981;

Oxley and Benwell, 1985; Mitchell, 1988). The information is applicable to other forms of transport such as light or heavy rail, where many of the tasks of boarding, moving within the vehicle and sitting are similar to those for bus users.

The capabilities of people as pedestrians have been studied by Leake et al. (1991). This provides information on the distances people can walk or travel in a wheelchair in total and without a rest, speed of movement, acceptable steepness of ramps, and aspects of surface conditions that cause problems. Bails (1986) gave recommended movement distances for elderly people of increasing age and with different walking aids. Knoblauch et al. (1995) collected information on the motor and sensory abilities of older pedestrians, including walking speeds, in the course of developing guidelines for the design of pedestrian facilities.

4. ACCESSIBILITY PROBLEMS AND DEVELOPMENTS

Surveys of travel by people with reduced mobility, and their transport problems, date from the late 1960s, with a major survey in U.S. by Abt Associates Inc. (1969). This found that, in the Boston area, handicapped people made 1.13 intra-regional trips per day compared with 2.23 trips per day for the general population. The reasons included lower automobile ownership; fewer handicapped people were licensed to drive; fewer were employed and more were poor. The survey covered physical travel barriers for handicapped people and also factors such as employment and income. It identified barriers such as climbing steps, but did not quantify them or measure the ergonomic capabilities of the sample surveyed. Subsequent surveys of travel by elderly and disabled people have confirmed the general result that these groups travel less than do younger people.

In Britain, Harris's survey of handicapped and impaired people (1971) included estimates of the numbers of people whose transport-related capabilities were limited. The Institute of Public Administration in its State of the Art Report for the U.S. Administration on Aging (1975) identified four major transportation problems facing older and disabled Americans. These were:

- No automobile or could not drive because they were too poor and/or physically unable
- Lived in areas that were poorly served by public transport (or not served at all)
- Confronted by transportation networks or facilities that did not meet their needs
- The physical design and service features of public transportation systems created serious problems of orientation and manoeuvrability.

It is interesting that social and financial issues were listed before the issues of the physical design of transport systems.

By the late 1970s many more surveys were examining the problems of particular groups of people or the users of particular modes. In "Transport and the elderly", Norman (1977) reviewed walking, the use of cars and buses, concessions and possible actions to improve the situation that existed in Britain. A British survey of the mobility of elderly people in the city of Guildford found that walking was the most frequent means of travel, accounting for 53 percent of journey stages (Hopkin et al., 1978). Where practicable, buses were used for longer journeys by those without cars; bicycles, trains, taxis and transport provided by welfare organizations were little used.

Forty-four percent of the sample of people aged 65 or over in Guildford had difficulty walking. They travelled about 10 percent less often than those who did not have difficulty. Despite having difficulty walking, they walked more frequently than those without difficulty. The physical factors that made walking difficult made using buses even more difficult, so this group made less use of buses than those who had no difficulty walking. Car ownership increased the number of journeys per day to 1.27 for drivers and

0.94 for non-drivers in households with a car, compared with 0.76 for people in households without a car.

Surveys of travel by the Swedish population in 1978 and 1984/85 included information about disabilities, and showed that the proportion of people with disabilities increased with age. About 70 percent of those who report a disability were aged over 65 years. Disabled people travelled less frequently than others (Börjesson, 1989). The annual number of trips by active people was 883, for people with impaired locomotion 371 and for disabled people 198. Excluding work and business trips, the annual trip totals were 492, 301 and 186 respectively.

More recently, Rosenbloom (1992) used 1983 survey data to show that annual trip rates for urban dwellers decreased steadily with age beyond 60 years. For people with driver licences, the range was from 1 272 trips per year for those aged 16 - 60 to 850 for those aged 71 - 75 and 377 for those over 85. For people without driver's licences, the corresponding trip rates were 750, 510 and 270 trips per year.

Sweden has one of the most accessible public transport systems in the world, as a result of legislation passed in 1979. In 1992, Ståhl et al. (1993) evaluated public transport services to assess the effects of the improvements made since 1979. This study identified the problems that still remained and the improvements suggested by elderly and disabled travellers. Overall, Ståhl found that getting to and from the mode of transport is the phase that caused most difficulties for all modes except subways, service routes and air. The trip itself is the cause of many problems, mainly considered minor, for trains, airplanes and subways. The results of this study are summarized in sections 4.3 and 4.5 for bus and train passengers, respectively.

More detailed ergonomic studies of pedestrians, bus passengers and car users were carried out between the mid-1970s and the early 1990s. They are reviewed in sections 4.2 to 4.6.

4.1 Trip-Planning and En Route Information

As will be shown in sections 4.2 to 4.6, elderly and disabled travellers by all modes would be helped by better travel information. This applies to information for trip-planning and while the trip is in progress.

The trip-planning information needs to cover the existence of services for elderly and disabled people, routes and vehicles that are particularly easy to use and details of timetables, fares (including concessions for elderly and disabled people) and booking procedures. It should, if possible, include real time information on changes to scheduled services - replacement rolling stock, which may not be accessible; staff shortages or failures of equipment such as lifts or escalators at particular stations; delays and

cancellations. Many elderly and disabled people find it difficult to cope with the problems caused by such changes to scheduled services.

There is a growing trend in Europe to provide much better trip-planning information for elderly and disabled people, and their friends, families and caregivers. This includes the establishment of organizations which can help with journey planning, publicity by operators about the existence of services, easier contacts with operators for details of timetables and fares, and for booking specific trips and requesting assistance. This is in addition to the general provision of real time information at terminals, at bus stops and in vehicles to help select the correct vehicle and to monitor progress. Operators have begun to display information in formats that are easy to read and understand, though the quality of display is still very variable.

In Britain, since 1983 the Department of Transport has regularly published a guide to transport for people with disabilities. Called Door to Door, this covers benefits, allowances and concessions; walking and wheelchairs; individual personal transport; taxis; local and health authority transport; cars; buses; underground and subway; rail travel; changing stations; coaches; sea travel; air travel holidays; and specialist information and advisory services. The first three editions were issued free, but this is now a priced publication, which has much reduced its circulation. Since the introduction of Door to Door, many other organizations have started to provide guides to transport services for disabled people. Examples are British Rail, London Transport, the Automobile Association and many local authorities.

Another information service for disabled people is a charity called Tripscope. This provides detailed advice on how to make any particular journey avoiding any specified barriers to mobility (Howard, 1995). Advice is free and is usually requested by telephone. During 1995/96, 4 000 help line requests were received, enabling 12 700 individual journeys to take place. Tripscope advises clients on specific journeys to the point of providing details of timetable, fares, instructions for interchanges and how to purchase tickets. The clients must make their reservations and purchase tickets themselves, direct from the operators or via a travel agent.

The purpose of real-time information during travelling is to ensure that the traveller gets to the correct platform or bus stop for their service, that they know how long they have before the service leaves, they can confirm that they are boarding the correct bus or train and that they know when they are approaching their destination and, if relevant, on which side of the train the destination platform will be. Providing timely and consistent information much reduces the stress of travelling and allows the traveller to be ready for boarding or alighting in good time, without the time pressure they often experience at present. It also allows the transmission of instructions for emergency situations, if necessary. While such information is of particular value to elderly and disabled people, who are often deterred from using public transport by stress and the need to move and act quickly while boarding and alighting, there is no doubt that it would help all travellers.

Real-time information on the waiting time until the next train and its destination has been shown at stations of the London Underground for some years, and in Paris the Canadian Visual Communications Network has recently been introduced on platforms of line C of the RER express subway. Displays of real-time information at bus stops are beginning to appear in many European cities (Rivett, 1996). These systems help all travellers, but are likely to be particularly helpful for people who are uncertain of the system or require frequent reassurance. In Southampton, people with visual impairments can use a proximity transponder to make a display at a bus stop announce the information audibly (Wren and Jones, 1996).

Some bus operators already have equipment in vehicles to display the name of the next stop, or to announce it audibly. It would be straightforward to provide an inductive loop, at least in the priority seating area, so that audibly impaired people could hear announcements through their hearing aids without interference from background noise (the Swedish X2000 intercity train is fitted with induction loops for passengers with hearing impairments). In buses, it should be possible for passengers who need to be told by the driver that they are at a particular stop to enter their requirement into a small memory unit at the drivers position, to remind the driver when the stop is reached.

Long waits at bus stops can be a real problem for elderly and disabled people, who are more sensitive to fatigue and to extreme weather conditions. Systems to transmit information on the waiting time for a bus at a nearby stop to homes using cable TV, to allow an elderly person to wait indoors until the bus is due. The European TIDE Project TURTLE is demonstrating these services using Teletext (European Commission, 1994), and much travel information is already available in Europe using Teletext on domestic television receivers. Urban travel information systems should allow elderly and disabled people to make last-minute checks on travelling conditions before committing themselves to travel.

Smart payment cards are being introduced to allow easy booking of tickets on several modes. It would be possible to extend these to provide optional personal information about the special requirements of the individual concerned. This could be used to ensure that all operators for a multi-modal trip have the necessary information on passenger requirements, that staff assistance at interchanges can be arranged, that accessible taxis are booked for the ends of the trip (if required), perhaps even that the traveller be paged in the event of anticipated delays or alteration to the service. This is a small extension of the service provided today by airline frequent flyer clubs.

4.2 Pedestrians

4.2.1 Barriers to walking

There has been relatively little research on the capabilities of disabled people as pedestrians. Much more research has been done on the safety of pedestrians in general and elderly pedestrians in particular (OECD, 1985; TRB, 1988; Knoblauch et al., 1995).

A British survey of the mobility of elderly people (Hopkin et al., 1978) found that 44 percent of people aged 65 and over had difficulty walking. This proportion increased from 29 percent of men and 39 percent of women aged 65 - 69 to 43 percent of men and 66 percent of women aged 80+. Features of the walking environment that caused difficulty included hills, ramps and narrow and/or uneven pavements.

Another British survey (Hillman and Whalley, 1979) identified pensioners' problems when getting around on foot as uneven pavements (15 percent of pensioners), hills/ramps (17 percent) and traffic/crossing roads (12 percent). Hitchcock and Mitchell (1984) collected results from several surveys to tabulate the aspects of the walking environment that caused difficulties for people with different degrees of disability (see Table 3, in which disability is greatest in the left column, least in the right column). Some features, including hills/ramps, narrow/uneven pavements and crossing roads cause problems for everybody, though more for people with disabilities. Other features such as steps and crowds are problems specifically for registered disabled people.

Table 3
Percentage of people reporting difficulties in the pedestrian environment

Aspect of pedestrian environment	Registered disabled	Elderly, difficulties with walking	Non-elderly, difficulties with walking	Elderly, no difficulty with walking	Non-elderly, no difficulty with walking
Curbs	12	5	4	4	2
Steps	58				
Hills/ramps	59	45	30	19	12
Uneven/narrow pavements	21	19	13	14	8
Crowds	50	4	0	5	2
Traffic/crossing roads	35	31	22	16	17
No difficulties	2	23	43	54	67
Sample size	143	366	23	459	172

(Source: Hitchcock and Mitchell, 1984)

A later survey and study of the mobility of disabled pedestrians and wheelchair users (Leake et al., 1991) identified the reasons for disabled pedestrians to require assistance in city centres (see Table 4).

Table 4
Percentage of disabled people needing assistance in city centres

Reason for assistance	Wheelchair users	Visually impaired	Stick users	No mobility aids
Push wheelchair	76	-	-	-
Open doors	49	37	26	15
Help with steps	36	41	35	15
Give confidence	25	37	34	11
Prevent accidents	33	43	31	11
Prevent fatigue	28	22	16	24
Carry bags	30	22	35	4

(Source: Leake et al., 1991)

A survey of 1 130 disabled people by the (British) Automobile Association found that 72 percent of disabled people sometimes had difficulty walking from their car to their destination. The problems cited included distance (43 percent), cannot walk far (20 percent), steps (16 percent), curbs (13 percent), lifts inadequate, slopes/hills, uneven surfaces and cars parked badly (Automobile Association, 1992).

4.2.2 Distances people can walk

The distances some disabled people are able to travel without a rest are very limited. A survey of 400 transport handicapped people in London (GLAD, 1986) found that 34 percent of them said that they could not walk 1/4 mile alone without severe discomfort. A more recent survey, also of disabled residents of London, found that of those who could walk at all, 30 percent could walk less than 50 yards and only 38 percent could walk more than 1/4 mile (Oxley and Alexander, 1994). Leake et al. (1991) recorded the percentages of disabled people stating that they were unable to walk a given distance without a rest, listed in Table 5a and also observed the percentages who were unable to move more than a given distance without a rest (see Table 5b). While the disabled people somewhat under-estimated their abilities, less than half of the sample could travel 180 m (200 yards) without a rest, and only 5 percent of stick users could travel more than 360 m (400 yards). Stick users were the most limited in travel range without a rest.

Leake et al. also measured the movement time, or slowness, of the sample of disabled people. Over a distance of 180 m the average slowness was 1.2 - 2.0 seconds/m, with stick users being the slowest. For the slowest 10 percent of the sample, the slowness over 180 m was 2.1 to 4.6 seconds per metre, with stick users, ambulatory unaided and

wheelchair users all grouping at 3.5 - 4.6 seconds per metre. The walking range of disabled people is limited by the time it takes to move as well as the distance they can move without a rest. In 1978, Dahlstedt reported measuring a mean walking speed for elderly pedestrians of 0.9 m/s and a slowest 10 percent speed of 0.6 m/s.

Table 5a
Cumulative percentage of disabled people stating inability to move more than the stated distance without a rest

	18 m	68 m	137 m
With assistance			
Wheelchair users	35	45	55
Visually impaired	5	20	35
Stick users	15	35	70
Ambulatory unaided	10	30	50
Without assistance			
Wheelchair users	65	75	80
Visually impaired	35	40	45
Stick users	20	40	70
Ambulatory unaided	20	35	55

Table 5b
Cumulative percentage of disabled people observed to be unable to move more than the stated distance without a rest

	18 m	68 m	137 m	180 m	360 m
With assistance					
Wheelchair users	0	5	5	60	85
Visually impaired	0	0	5	50	75
Stick users	10	25	40	80	95
Ambulatory unaided	5	15	25	70	80

(Source: Leake et al., 1991)

Knoblauch et al. (1995) report a field study of the walking speed of pedestrians while crossing roads. The mean speed for pedestrians aged over 65 years was 4.1 ft/s (1.25 m/s); the speed of the slowest 15 percent was 3.2 ft/s (0.97 m/s). Women walked more slowly than men. The speed for the 15th percentile women was 3.1 ft/s (0.93 m/s) for all female pedestrians aged over 65 years, and 3.0 ft/s (0.90 m/s) for all those crossing in compliance with a traffic signal.

4.2.3 Accidents to elderly and visually impaired pedestrians

Older persons have the highest pedestrian fatality rate of any age group (see Figure 1) (TRB, 1988). In Britain in 1989, nearly half of all pedestrians killed on the roads were over 60 (Department of Transport, 1991); in Canada in 1992, 32 percent of all pedestrians killed in traffic accidents in 1992 were aged 65 or more. In general, this over-representation of older people in pedestrian fatalities appears to be largely a result of vulnerability rather than any particular aspect of their walking behaviour. Table 3 showed that about 30 - 35 percent of elderly and disabled pedestrians found traffic or crossing roads a significant difficulty when getting around on foot. In the U.S., two-thirds of older people in two U.S. metropolitan areas expressed fear for safety while walking (Knoblauch et al., 1995). They were afraid of being attacked, being hit by a car or falling.

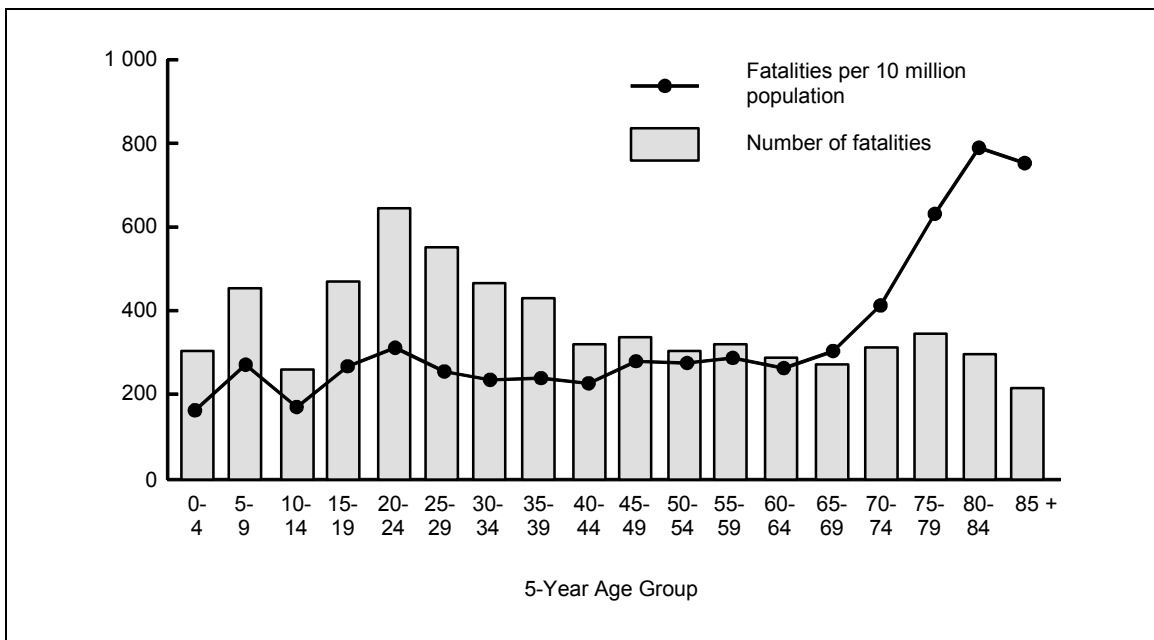


Figure 1 Pedestrian fatalities and fatality rates by age, 1986 (NHTSA data; TRB, 1988)

There are few statistics for the accidents to pedestrians that do not involve moving traffic. The British National Consumer Council estimated that more people were injured and more hospital resources utilised by accidents due to falls on sidewalks than by pedestrian accidents involving moving traffic (National Consumer Council, 1987). In the U.S., about 9 000 people aged 65+ die each year from accidental falls, compared with about 1 500 in pedestrian traffic accidents (Knoblauch et al., 1995). Not all of these falls are in the street, but clearly the risk from accidental falls is comparable with that from pedestrian traffic accidents.

A survey by Cranfield University (Gallon et al., 1995) of 302 visually impaired independent travellers has established the number of accidents they experienced while walking: this included accidents involving the footway, crossing roads, steps and plate glass windows. Virtually all respondents reported having had at least one accident whilst out walking, and over half had sustained injuries. Visually impaired people have higher frequencies of walking accidents than sighted people and are more likely to be injured. Visually impaired people also have more accidents than sighted people when crossing roads, and over a third of respondents had experienced accidents involving steps. Of the respondents who travelled by rail, 35 percent had experienced at least one accident. Twenty-three percent had had an accident during boarding or alighting and 5 percent had fallen off a station platform.

4.2.4 Improving accessibility for pedestrians

Ramped curbs began to be introduced in European countries in the early 1980s, to make it possible for people in wheelchairs to use sidewalks to reach accessible buildings. In the U.S. ramped curbs had been introduced a little earlier, when it was realized that inaccessible sidewalks were one of the barriers to the use of lift-equipped buses. In Britain, conflict between the requirements of people in wheelchairs for sidewalks without curbs, and of people with impaired vision for curbs to warn of the edge of the sidewalk, led to the development of textured paving to mark the edge of a sidewalk where there was no curb. Traffic signal controlled pedestrian crossings, and junctions with pedestrian phases, provide the pedestrian with an audible signal when the lights are in their favour. Tests have been under way since 1994 of pedestrian crossings with infrared people detectors to extend the time for pedestrians if people are still on the crossing at the end of the normal pedestrian phase. This helps elderly and ambulant disabled pedestrians, who often do not walk quickly enough to cross during the time allowed for pedestrians. The same equipment cancels the pedestrian phase if no one is waiting.

4.3 Bus Passengers

Some of the difficulties elderly and disabled people face when using buses depend on whether the potential passenger uses a wheelchair or is able to walk, albeit with difficulty and possibly using a mobility aid. Other difficulties are common to all groups of elderly and disabled people, and indeed to all bus users. The technical solutions to making bus services accessible to people in wheelchairs are different from the improvements needed by ambulant disabled people. In this section, where necessary, the problems and solutions for ambulant and wheelchair-bound people are considered separately.

For elderly and disabled people without cars, travel by bus should provide the best option for reaching destinations that are beyond a comfortable walking distance. In practice, since the late 1960s, many authors in Europe and North America have reported difficulties with bus services experienced by elderly and disabled people. Abt Associates

Inc. (1969) found that the primary reasons for avoiding public transit are barriers in the system, fear for personal safety, and the inconvenience of the routes. The barriers that were unique to the travel environment appeared to present more difficulty to handicapped passengers than the architectural barriers. In Britain, Norman (1977) analysed the problems for elderly people as:

The public transport on which these people depend has grown steadily more infrequent, unreliable, expensive and difficult to use, while centralization of services made it more essential for car-less people to use them.

Norman listed some of the difficulties as reductions in scheduled services, the administrative difficulties of obtaining licenses for rural self-help transport schemes, difficulties in obtaining information about services and getting on and off buses.

Revis (1978) made similar points for the U.S. situation. Many of the poor, elderly and disabled live in inner-city locations poorly served by public transit, especially off-peak and to the places they wish to go. Transit routes are designed to serve employment destinations and CBDs. Clinics, hospitals, special programs and facilities intended for the elderly and handicapped cannot be reached easily or at all by public transit. The elderly and the newly handicapped must learn to use public transit instead of their cars at the very time of their lives when their sensory and motor capabilities are reduced, their responses slowing and their strength and agility declining. On public transit modes the elderly and handicapped are under pressure to board and alight quickly, because of the need to keep to schedule.

4.3.1 Elderly and ambulant disabled bus passengers

From the early 1970s to the mid 1980s a series of scientific studies were carried out in Britain, France and Sweden to quantify the ergonomic capabilities of elderly and ambulant disabled bus passengers, and in the U.S. to assess the responses of wheelchair travellers to lift-equipped buses on fixed route services. Brooks et al., (1974) measured the factors affecting the use of buses by elderly and ambulant disabled people. A sample of 201 elderly and ambulant disabled people assessed, under laboratory conditions, the step heights they could negotiate with and without a handrail, the distance they could reach between stanchions and their strength to pull on a stanchion, and their preferred handrail diameter, seat height and seat spacing. This study produced information on the ergonomic requirements for the design of buses that has been regarded as definitive in Europe. The most generally applicable lessons from it were the decrease in the number of subjects who could negotiate steps with ease as the step height increased from 27 cm to 36 cm, and the importance of providing handrails that slope parallel to the slope of the steps (see Figure 2). Eighty-six percent of the subjects had problems with the height of bus steps and 50 percent had problems getting in and out of bus seats.

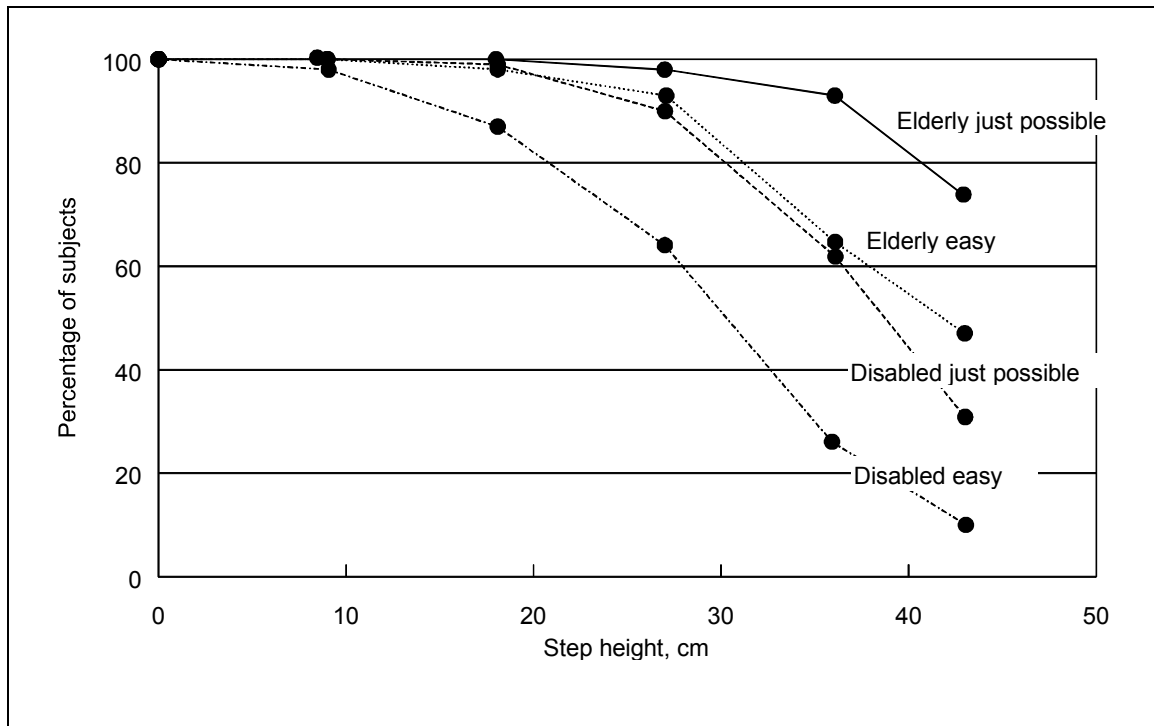


Figure 2 Percentage of elderly and ambulant disabled people able to negotiate bus entrance steps using handrails (Source: Brooks et al., 1974)

A study of the problems passengers had on moving buses showed that the majority of injury accidents to bus passengers were the result of falls while the bus was in normal operation (Leyland Vehicles Ltd., 1980). Elderly passengers were over-represented in this type of accident, and subsequently the (British) Department of Transport (1991) stated that almost half of all fatal and serious injury accidents to bus passengers involved people aged 60 or over. The comfort of passengers and the forces passengers needed to exert to retain balance were found to depend as much on jerk (rate of change of acceleration) as on acceleration. Flores et al. (1981) published a synthesis of ergonomic information of the comfort of bus passengers. This covered accessibility to the vehicles (steps, handrails, door dimensions); interior layout (gangways, standing space and seats); acoustic requirements; heating and ventilation; and comfort under dynamic conditions. This made use of the results from Brooks et al. (1974) as well as laboratory studies in France.

Oxley and Benwell (1983) observed the use of buses with different step heights in service, and surveyed passengers to check whether the results obtained by Brooks et al. were validated in practice. A survey of 783 passengers showed that only 34 percent of the passengers aged over 75 had no difficulty using buses, and that the most difficult activity was moving about inside the bus (Table 6); getting off was always more difficult than getting on. When asked the reasons for the difficulties experienced, the factors

listed were “jerking or bumpy ride” (29 percent of those experiencing difficulties), “step heights” (20 percent), “layout of vehicle” (15 percent), “getting up to leave the vehicle” (10 percent) and “driver started before I am seated” (10 percent).

Table 6
Age of bus users in relation to difficulties of using a bus
Most difficult act of using a bus

Age	Getting on the bus	Moving in the bus	Getting off the bus	No difficulty	Total (=100%)
Age under 65	21 (6%)	106 (31%)	54 (16%)	170 (49%)	347
Age 65 - 75	36 (11%)	114 (34%)	49 (15%)	135 (34%)	332
Age over 75	15 (14%)	34 (33%)	20 (19%)	35 (34%)	104

(Source: Oxley and Benwell, 1983)

Oxley and Benwell published a further study in 1985, in which disabled and elderly people used buses under laboratory conditions to quantify ergonomic requirements for many aspects of the interior design of buses, measured the stride length of passengers boarding and alighting from buses, and conducted a household survey to estimate how much bus travel would increase if buses were easier to use. A survey of bus services showed that allowing passengers time to be seated before the bus started and to remain seated until it stopped increased the route running time by 40 seconds/hour (1 percent) in the worst case.

Oxley and Benwell (1985) found that buses needed to stop within 40 cm of the curb to avoid elderly and disabled passengers stepping down into the road. For ambulant disabled people there appeared to be a critical step height of about 20 cm, above which some bus users complained. Steps should be at least 35 cm deep and risers should be vertical with no overhanging nosing or other protrusions. They confirmed the recommendations of Brooks et al. (1974) regarding handrail diameter and location, and identified the need for a horizontal rail to lead from the entrance to the priority seating. They found that ambulant disabled people were very sensitive to the slope of the floor, and that bell pushes should be located where they could be reached by seated passengers. These findings could be summarized in a sketch showing the desirable features on a bus for urban transit (see Figure 3). If buses were built to such a standard, Oxley and Benwell estimated that patronage would increase at least 2 percent. If, in addition, buses were operated in ways that enabled elderly and disabled passengers to be seated while the bus was moving, the increase in patronage could be substantially greater.

The difficulties elderly and disabled people were having when they used bus services was confirmed by the Greater London Association for Disabled People (GLAD, 1986), through a survey of 400 transport-handicapped residents of Greater London. Fifty-nine percent of the sample did use buses, but of this group only a quarter had no problems and a quarter needed help to use a bus. Of the 41 percent who did not use buses, half

could not use them at all. The problems experienced by all those who could use buses, but only with difficulty or with help, are listed in Table 7. The importance of the entrance and exit steps as sources of difficulty and situations where help is required is clear. Moving within the bus and waiting for the bus caused similar amounts of difficulty but was less likely to cause help to be required.

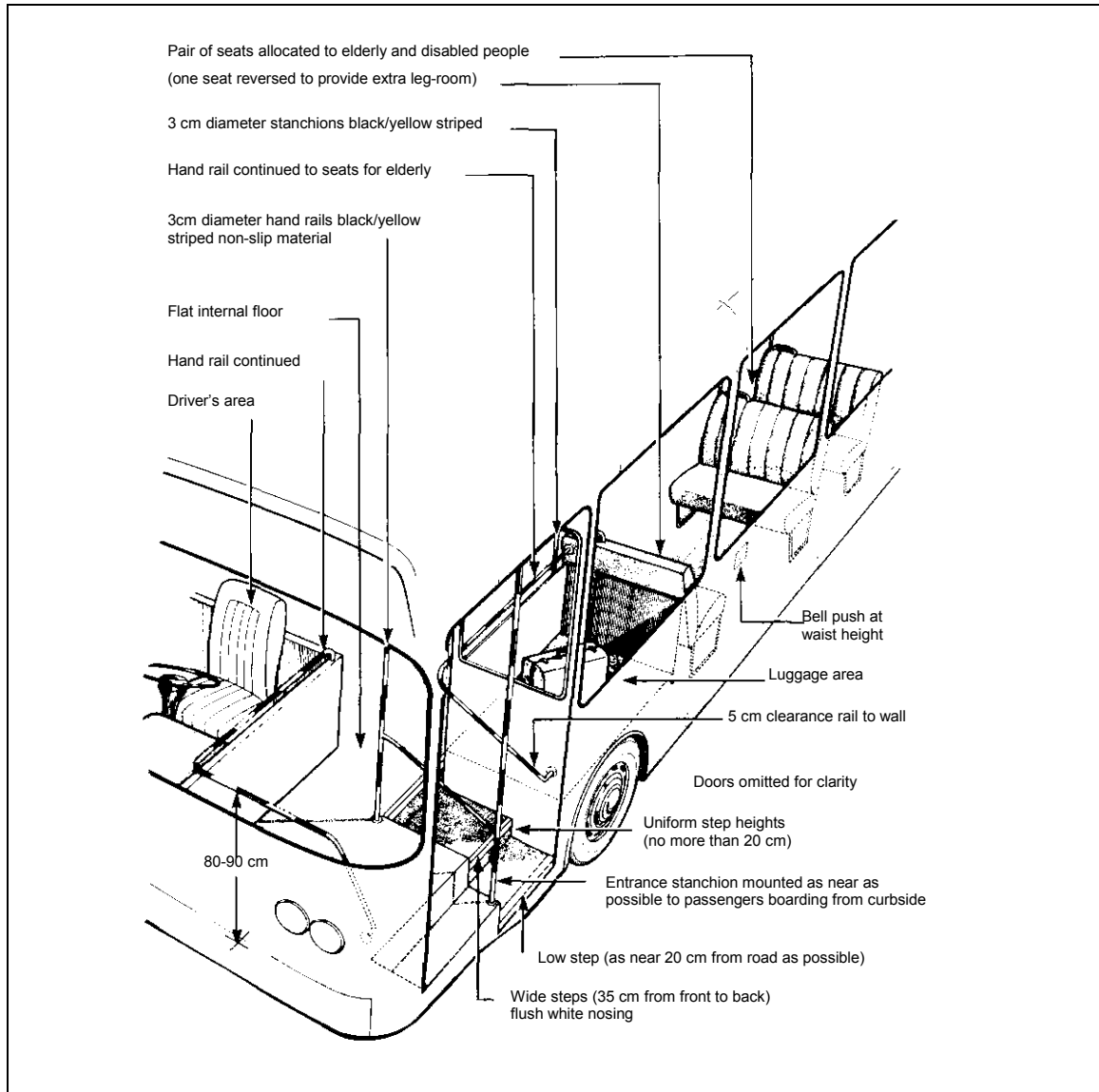


Figure 3 Bus design - desirable ergonomic features (doors omitted)
(Source: Oxley and Benwell, 1985)

Table 7
Difficulties in using buses

Aspect of bus use	Percentage finding this a problem	Percentage who cannot do this without help
Getting to or from the bus stop	54	20
Waiting for the bus to come	71	11
Knowing which bus to catch	18	9
Getting up on to the bus	64	31
Getting down off the bus	61	28
Getting to a seat	55	18
Getting up from the seat	44	12
Getting to the platform to get off the bus	58	20
Buying a ticket	9	6
Sitting on the bus	13	3
Knowing where to get off	15	9

*Sample: 248 transport handicapped people who can use buses, but only with difficulty or with help.
(Source: GLAD, 1986)*

Fowkes et al. (1987) carried out observations of minibus services for elderly and disabled passengers, including passengers in wheelchairs, and made laboratory studies of the ergonomic requirements of a sample of users of minibuses to day centres. This population was rather more severely disabled than the samples studied by Brooks et al. (1974) and Oxley and Benwell (1985); the maximum acceptable step height for this population was rather lower than that found by the other studies, but the results of the three studies were generally supportive of each other. Fowkes et al. took the opportunity to establish ergonomic requirements for some aspects of bus interior layout that the other studies had not included.

Mitchell (1988) collected the results from the various British studies, from Flores et al. (1981) and from good practice adopted by bus operators to synthesize a summary of ergonomic requirements and current good practice regarding features on buses to assist passengers with mobility handicaps. At the same time, the British Disabled Persons Transport Advisory Committee issued a recommended specification for buses used to operate local services (DPTAC, 1988), based on the work summarized by Mitchell (1988). In France, a rather similar "Proposition de spécifications pour l'accessibilité à tous de l'autobus urbain" was produced by COLITRAH (1991). The French and British specifications were only advisory, but in 1985 Sweden incorporated into legislation regulations for adapting public transport vehicles for use by disabled persons (Swedish Board of Transport, 1989).

A survey of 2 417 people living in the Greater London area who had a long-standing health problem or a disability that made travelling difficult was carried out by Cranfield

University in 1991/92 (Oxley and Alexander, 1994). This suggested that the proportion of mobility handicapped people using buses had probably fallen over the past decade, but that the ranking of difficulties in using buses was still much the same. Forty-four percent of the sample were currently using buses.

The reasons for not using buses were:

steps too high, difficult getting on or off	31%
too far to bus stop	20%
have own transport	16%
health reasons	15%
no need	12%
impossible with wheelchair/buggy	8%

The problems when using buses, for those who did use them, were:

steps too high, difficult getting on or off	31%
long waits/irregular service	8%
buses move off too quickly	6%
buses too full, no seats	6%
drive too fast	5%

The main improvements to buses and bus services suggested were:

lower steps/special entrance	43%
ability to take passengers in wheelchairs	24%
assistance getting on and off/more time	17%
more bus stops	11%
more reliable service/greater frequency	7%

The Automobile Association (1992) found that the main reasons for no longer using buses were: difficult to board (37 percent), steps awkward (22 percent), can't cope - wheelchair (14 percent), use own car (13 percent) and inconvenient (10 percent).

Ståhl et al. (1993) surveyed ways in which elderly and disabled passengers considered that bus services in Sweden needed to be improved, even after ten years of improving accessibility following legislation in 1979, implemented in 1985. Of all the public transport modes, buses were most in need of improvements. The large majority of the improvements concerned operational factors rather than design or information. The aspect of travel originally identified as the greatest problem, boarding and alighting, is still the aspect most frequently identified by the functionally impaired as in need of improvement.

Improvements to bus services recommended by Ståhl et al. (1993) included:

Design - At stops, pull in closer to curb, kneel bus, remove divider between entry streams at front entrance, identical handrails at both sides of all doors. Also, spaces for

wheelchairs and baby carriages, more leg room between seats, level flooring or colour contrast on changes of floor level, better ventilation.

Operational standards - Greater frequency, reduce distances to stops, reduce travel time by bus lanes, introduce Service Routes, reduce stress on drivers through more relaxed deadlines, rebates for pensioners.

Service and information - Smoother driving, escorts when changing at terminals, don't eliminate staff by automation, permit bicycles and scooters on buses. More legible timetables, information in Braille at certain stops, electronic displays at terminals, information boards at eye level, stop information in more buses.

4.3.2 Passengers in wheelchairs on buses

European countries, and in particular Britain, had watched the U.S. experience of fitting wheelchair lifts to buses under Section 504 of the U.S. Rehabilitation Act of 1973 (implemented in 1979). The European conclusion was that this was not an effective policy, because boarding and securing a wheelchair in a high floor bus was taking over so much time, and the buses were typically carrying one wheelchair passenger per bus per month. It was not attracting wheelchair users in sufficient numbers either to justify the extra cost of the lift and restraint equipment or to be considered an integrated form of public transport for all. If the lift-equipped buses did attract enough passengers in wheelchairs to justify the equipment costs, the boarding and alighting times were so long that the service would not be able to keep to schedule and all the bus passengers would be inconvenienced. In addition, the lift did nothing to help the large numbers of passengers with mobility impairments who were not in wheelchairs but did have difficulty with walking, climbing steps and balancing.

Led by Sweden, Europe adopted a policy of making urban buses as easy to use as possible for all disabled people except those in wheelchairs, and of providing separate demand responsive services (dial-a-ride) for those who could not use mainstream public transport. Initially in Sweden, and later in parts of Britain and elsewhere, subsidized taxis were offered as an intermediate mode for those who could not use public transport but did not need the dial-a-ride service that was fully accessible to a passenger in a wheelchair, often with an attendant to help during travel and with access from within the house to within the destination building.

Until the introduction of low-floor buses in the 1990s, carriage of passengers in wheelchairs in full size scheduled buses in Europe was limited to small numbers of specialized "Mobility" services. These used lift-equipped buses running very infrequently on routes designed to serve housing and destinations relevant to elderly and disabled people. Frequencies on a given route were typically one or two round trips each week, so that one lift-equipped bus could provide services for a whole town. The "Mobility Bus" was never more than a marginal contribution to the mobility of disabled people.

Passengers in wheelchairs travelled almost exclusively in separate demand responsive services, which required prior booking and were not available for spontaneous travel.

In the U.S. the approach to making buses accessible to elderly and disabled people was totally different from that in Europe. The basic vehicles were less suitable ergonomically, with a floor height of around 850 mm compared with 550 mm in Europe. Priorities have concentrated on disabled people in wheelchairs, who have had to board and alight using a lift. Boarding times have been long and usage in most areas rather low. Little has been done to improve the vehicles for the large numbers of elderly, disabled and encumbered passengers who have problems with the existing designs.

After the first installation of wheelchair lifts on mainstream bus services in the late 1970s, Falcocchio (1980) surveyed wheelchair users in Westchester County, New York, to identify the factors which prevented lift-equipped buses being used. Ninety-one percent of the sample knew of the lift-equipped bus services but only 37 percent viewed them as a transportation improvement. Sixty-five percent of the sample felt physically able to use the lift-equipped buses but 68 percent experienced difficulty getting to the bus stop and 59 percent had difficulty crossing streets. Less than half the sample could manage ramped curbs unaided, and only 37 percent had little or no difficulty crossing a street at pedestrian “walk/don’t walk” signs. The most frequent reason for not using the lift-equipped buses was preferring to travel some other way.

During the 1990s, many more urban buses are being equipped with lifts to carry passengers in wheelchairs, in the U.S. as a result of the Americans with Disabilities Act. There seem to be few recent research projects to measure the ease with which passengers are able to use these buses. One study of lift-equipped buses in Vancouver and low-floor buses in Victoria (Geehan, 1995) showed that the two aspects of the service with which passengers were least satisfied were the use of the wheelchair or scooter restraint system and the need to back onto the wheelchair lift for boarding, because of limited manoeuvring space within the bus. Securing and releasing the straps that secure wheelchairs and scooters were also perceived by bus drivers to be the least satisfactory aspects of their tasks related to disabled passengers.

4.3.3 Low-floor buses

A major change in attitudes to the carriage of wheelchairs on urban bus services occurred in Europe in the late 1980s, when Germany started to introduce low-floor urban buses. These have a level floor between the front and centre doors at a height above the ground of about 320 - 340 mm. A slight slope at the entrance reduces the floor height of 340 mm to a step height of 320 mm. The entry step could be further reduced to about 250 mm by kneeling the bus. These low-floor buses were initially introduced to reduce stopped time and to make urban public transport more attractive to everybody. It was quickly realized that they were much easier to use for passengers with children, people with walking difficulties and passengers encumbered with luggage or shopping.

Some people in manual wheelchairs could use the low-floor buses as they were. It only needed the addition of a ramp or small lift and a safe compartment for an unrestrained wheelchair to make them accessible to wheelchairs in general. The wheelchair passengers travel facing backwards, backed against a bulkhead at the front of a space opposite the second door but with no wheelchair or passenger restraint. The ramp is helpful for many people who have walking difficulties, and the boarding time for wheelchairs is only 30 - 40 seconds. The driver does not need to leave his or her seat to attend to passengers in wheelchairs.

In 1996, low-floor buses accounted for between 75 and 85 percent of all new urban buses in Germany, and were in service in at least France, the Netherlands, Denmark and Britain. The carriage of wheelchair passengers unrestrained has proved to be safe, even though laboratory tests with dummies in wheelchairs in Germany, France and Britain all showed unrestrained wheelchairs to be unstable during normal urban bus journeys. Ridership has increased generally, and particularly among ambulant disabled people, shoppers and mothers with children in buggies. Low-floor buses have increased the attractiveness of bus services to all passengers.

Low-floor buses are undoubtedly easier for ambulant disabled people to board than the standard North American transit bus with a floor height of about 850 mm. In Europe, the comparison is with buses with a floor height of 550 mm and which are generally easier to use for elderly and ambulant disabled passengers than are North American buses. Surveys in France (Dejeammes et al., 1993), Germany (Blennemann, 1992) and U.K. (Balcombe and York, 1995) all show consistently that low-floor buses are easier to board and alight from than conventional European buses. The benefits of low-floor buses are most strongly perceived by ambulant disabled people. Blennemann found that all passengers, as well as elderly and handicapped passengers, found the low-floor buses easier to use, but the difference in ranking of the two types of bus was greater as handicap increased. Dejeammes (1996) describes the European COST (Co-operation in Science and Technology) Action 322 on low-floor buses, and presents its recommendations.

Rutenberg (1995) has reviewed experience of low-floor bus operations in Canada, U.S. and Europe for the Canadian Urban Transit Association. He lists the key issues that transit operators need to decide in accommodating disabled persons. He recommends further research or investigation in the areas of passenger safety, technologies (particularly for wheelchair securement), operation and policy.

4.3.4 Community buses

Another change in the approach to urban bus services has resulted from the development, in Sweden, of "Service Routes". These are community bus services in which a wheelchair accessible small bus operates a scheduled service on a route that runs close to housing and destinations used by elderly and disabled people (Ståhl, 1991). The bus has a low-floor, a ramp for wheelchair access, and an entrance with an

initial step from the road of 200 - 230 mm. The buses are allowed ample time for their route and the driver is able to provide personal service for passengers if required. The first of these services were introduced in the town of Borås in 1983, and Service Routes have proved attractive to many disabled people who previously used special dial-a-ride services. Service Routes are more economical to provide than dial-a-ride services.

Service Route transit can be introduced both to complement other public transport services and to replace lightly-used routes so that more people use public transport. The accessible vehicles and mode of operation reduce the number of people who are unable to use public transport. By late 1991, more than 50 cities in Sweden had introduced Service Route transit. Service Routes have recently been introduced in Alberta and Ontario, where they are known as community bus services and in parts of the U.S.

Sweden has led the way in providing integrated systems of accessible transport for people with differing degrees of disability. The full range of options appears likely to consist of accessible fixed route public transport (low-floor buses and accessible subways) for those who can reach bus stops or subway stations; Service Routes for people who need a little more care than mass public transport can provide, and who do not need a very frequent service; subsidized taxis for people who need transport door to door, but do not need specialized care during the journey; dial-a-ride for the most severely disabled people who need considerable assistance or care; and subsidized private automobiles for those disabled people who are physically able to drive and who live far from public transport services or who are only able to work if they have an automobile available.

4.3.5 Smart fare cards

In Germany, Deutsche Telecom, Deutsch Bahn and the German Association of Public Transport Operators VDV are issuing a pre-paid "Paycard". This is a multi-function smart card which can be used to buy tickets for rail or local public transport journeys with any member of VDV and to make telephone calls. It can be recharged with cash at any card-telephone, using the dial buttons to debit the holder's bank account rather than requiring a cash payment.

4.4 Paratransit and Taxi Users

4.4.1 Paratransit

Paratransit is the general term used to cover a variety of transport services that complement mainstream public transport. This section will concentrate on demand responsive door-to-door services, often known as "dial-a-ride". This uses vans or minibuses to carry passengers door-to-door at the time they want to travel, similar to a taxi. Unlike a taxi, the journey can be shared with other passengers going in the same direction, and may not be direct as the route of the vehicle is chosen to serve the origins

and destinations of all the passengers using it. Dial-a-ride started as an element of public transport services in low density areas in the early 1970s. During the late 1970s the concept was applied to its present role of a specialized door-to-door service for disabled passengers who cannot use conventional public transport, often as a result of merging pre-existing voluntary and welfare transport services.

There was extensive research on paratransit services for elderly and disabled people from the late 1970s to the late 1980s. This was mainly of an operational nature and focussed on how to plan and operate services, how to co-ordinate dial-a-ride services with taxi and other paratransit services and how to select, operate and maintain vehicles to provide a reliable service at low cost. Many of the results of this work were incorporated into manuals on paratransit services, produced for the U.S. Federal Transit Administration in the early 1990s. Considerable work was done, mainly by industry, to develop satisfactory wheelchair and occupant restraint systems for the vans used for dial-a-ride services.

Another branch of research concerned the development of software for managing passenger demands and scheduling trips. Scheduling software is now well developed for dispatching taxis, and is providing quicker response to demands for service. Software for dispatching shared ride dial-a-ride services has come into routine use in the mid-1990s and is also demonstrating improvements to productivity.

There are relatively few studies of problems and barriers for users of paratransit services. Oxley and Alexander (1994) give, for residents of Greater London, the following reasons disabled people state for not using dial-a-ride services in London:

Have to plan well in advance/book in advance/at least 3 days in advance	22%
Not necessary/don't need to travel/have everything/(shops)close at hand/ have own vehicle/car/lift	17%
Difficult to get through on telephone/no answer, always engaged	13%
Always booked up when you get through/limited availability	11%
Can't use for hospital visits	8%

The problems quoted by those who did use dial-a-ride in London were:

Can't get to go out on it - always booked up/never available	9%
Always engaged/difficulty getting through	6%
The advanced booking/having to book so far in advance	6%
Limited journey lengths/types/won't travel over border/to hospital	4%

Changes suggested which could make dial-a-ride more likely to be used were:

Shorter notice/not have to book so far in advance	20%
Able to pick up on same day/book on day of travel/instant service	19%
Greater flexibility	18%
If able to get through on telephone	16%
More buses/more drivers	14%

The major problem of paratransit has been high costs which have limited supply and capacity. In some systems it has been necessary to telephone for a reservation as soon as the dispatch office opens for bookings, as the system capacity is quickly committed. Telephone use can be a barrier for hearing and speech impaired people, though this can be overcome by the use of a terminal for booking trips. In some European systems the driver and attendant have had difficult tasks bringing passengers to the van from inaccessible housing. But all other problems are secondary to the consequences of capacity not matching demand; which leads to limited availability of trips, need to book as far in advance as is permitted and often a high percentage of “no shows”, which are increased by a long booking lead time.

4.4.2 Taxis

Research on taxi services accessible to disabled people has fallen into three categories. These are studies of the co-ordination of taxi, paratransit and regular public transport services; studies of user-side subsidy schemes to make taxis affordable by elderly and disabled people; and development of accessible vehicles for use on taxi services. In Canada, the Transportation Development Centre has supported the development of technical equipment to help passengers communicate with the driver and monitor the meter.

Oxley and Alexander (1994) give, for residents of Greater London, the following reasons disabled people state for not using taxi services in London:

Too expensive	32%
Have own transport (car)	22%
No need	21%

Very few users reported any problems with taxis.

4.5 Train and Subway Users

There have been three primary issues of access to rail transport. These have been overcoming the vertical step from platform to coach floor, narrow doors and passages in coaches, and access to the station platforms. Other issues, such as accessibility within stations, spaces for wheelchairs in trains, information and ticketing processes, have been more similar to problems already being faced for public buildings and other forms of transport such as buses.

In Britain, railway platforms are much higher than in North America and in most other European countries. This means that for British Rail services the vertical step from platform to train floor is typically 20 - 30 cm, which can be bridged by a manually positioned ramp. Most other rail systems need to use lifts for access to the train. Subway systems provide almost flush access to trains in most countries.

4.5.1 Subways, suburban rail and light rail systems

More recent subways and light rail systems have been built from the start to be wheelchair accessible. In Canada and the U.S., in the late 1970s and early 1980s, there was considerable applied research on making suburban rail systems accessible. This concentrated on technologies for boarding wheelchairs from relatively low platforms. Rolling stock door widths tended to be taken as given, and were mainly suitable for most manual wheel chairs.

As early as 1975, an architectural study of the London underground (subway) was commissioned by London Transport on the use of the underground by ambulant disabled people (Penton, 1978). This found that as many as 20 percent of the population could benefit from a number of practical improvements to the underground system. These improvements often related to details such as handrails, lighting, consistency of stairs and risers, and the time available to board a train.

The Greater London Association for Disabled People study of public transport (GLAD, 1986) found that only 25 percent of disabled people used the underground at all, and only 10 percent without difficulty. Thirty-three percent said they could not use it at all, compared with 20 percent for buses. For those who could use the underground, but with difficulty or with help, the difficulties experienced are listed in Table 8.

Table 8
Difficulties using the underground (subway) in London

Aspect of underground use	Percentage thinking this a problem	Percentage who cannot do without help
Getting to or from station	66	31
Buying ticket	15	9
Using stairs at station	84	33
Using lifts at station	35	16
Using escalators at station	61	38
Finding the right platform	35	19
Getting on to the train	36	18
Getting to a seat on the train	29	15
Sitting on the train	15	6
Knowing when to get off	20	12
Getting off the train	41	19

Sample: 196 transport handicapped people who can use the underground, but only with difficulty or help (Source: GLAD, 1986)

In Europe, there was a wave of investment in the 1980s to provide light rail systems with level access, to make improvements to existing subway systems and to make suburban rail systems accessible. In Germany, at least two older subway systems (Munich and

Hamburg) are being modified to achieve wheelchair accessibility (Sack, 1989). Several suburban rail systems in Germany were also modified to achieve accessibility, though with some difficulties where long-distance and suburban trains shared the same platforms. The improvements to the suburban systems tended to concentrate on raising platform levels to provide level access to rolling stock and installing means of access to platforms (Blennemann, 1992).

This period of implementation was accompanied in Europe by research, mainly concentrating on ticketing machinery, ticket barriers, the provision of information, and colour contrasts and guidance for visually impaired people. Several papers in the 1992 and 1995 COMOTREDS reported the implementation of projects for various subways or light rail systems. The most frequently quoted problems were getting to or from the station, stairs at stations and using escalators.

Oxley and Alexander (1994) found that only 21 percent of their sample of disabled people in London were currently using the underground, compared with 44 percent currently using buses.

The reasons for not using the underground were:

No need/housebound/no need to go out/no need to go anywhere	27%
Access/can't manage stairs/can't climb stairs if escalator not working	19%
Too ill/not able to/impossible/epilepsy/too disabled	15%
Too far to walk to nearest station/can't get to station	12%
Fear of escalator/can't step off quickly enough/don't like escalator	7%
Have own car/transport	7%
Crowds/fear of crowds/affects my breathing	5%
Impossible with wheelchair	5%

The problems of using the underground, for those who did use it, were:

Can't cope with stairs/escalators - need help/slopes/ramps	17%
If escalator stops/have to cope with stairs	16%
Crowds/being pushed by other travellers	7%
Fear of falling/getting on/off train/gap	5%
Too crowded to get seat/inability to sit so have to battle the crowds	5%

The main improvements to the underground suggested to make it more likely to be used were:

Lifts to platforms in all stations	46%
Wheelchair accessible/put in ramps/make it suitable for disabled people	20%
Escalators to replace all stairs	13%
Too far from station/more stations/extended routes	9%
Help from staff	8%
Better design inside carriages for disabled	6%

Too crowded/claustrophobic	5%
Gap between platform and train too wide	5%

Ståhl et al. (1993) found that most problems with subways occurred during the trip, but these problems were mainly minor. Almost as many difficulties occurred getting to and from the station, and more of these were major problems. There were problems at stations and getting on and off, but these were mainly minor. The high standard of service that the subway theoretically offered was not worth much when equipment such as lifts and escalators was unreliable. Lack of staff at stations was also a problem.

4.5.2 Long-distance rail

By the late 1970s, many railways in Europe were starting to make provision for disabled passengers. Because of their low platform heights, most railways in continental Europe approached this by providing a small number of specially accessible trains (Presson, 1978; Sack, 1989). British Rail had the advantages of high platforms and rolling stock on intercity services that had external doors wide enough for wheelchairs, although there were problems with internal passage widths in rolling stock. British Rail therefore adopted a policy of making all mainline services between a limited number of principal stations accessible, although notice of travelling was required to ensure that staff were available to help disabled passengers. The principal stations themselves were also made accessible.

In 1992 ECMT and UIC (Union Chemin de Fer - International Union of Railways) produced a report on improved access to trains, to develop comparable standards for access to trains throughout Europe (ECMT and UIC, 1992). This included guidelines for wheelchair lifts and door and passage widths, and specifically stated anchoring of wheelchairs within trains was not considered necessary, but wheelchairs had to be capable of being immobilized by the use of brakes or a locked drive.

From the start, the railways took an integrated approach to making services accessible. In addition to developing ways to make the trains themselves accessible to people in wheelchairs, they arranged for staff to assist disabled passengers, improved stations, provided accessible toilets and catering, offered discount fares or free travel for helpers, and publicized the services they provided (Obrist, 1993). The rate of improvement was limited by the long life of rolling stock, the large number of stations and lack of funding. A good review of the integrated approach to service in Sweden, which is not unlike that in several other European railways, is given by Hultgren (1995). Hultgren makes the point that handicapped customers are the first to define service quality standards that turn out to be of great value to almost all other customers. Since the measures contribute to an overall service quality for the customers, the production-orientated way of calculation is of little use.

The Greater London Association for Disabled People study of public transport (GLAD, 1986) found that 29 percent of disabled people used British Rail services (compared with

25 percent for the underground), but only 10 percent without difficulty. Twenty-four percent said they could not use British Rail services at all, compared with 33 percent for the underground. For those who could use British Rail, but with difficulty or with help, the difficulties experienced are listed in Table 9.

Table 9
Difficulties in using trains

Aspect of train use	Percentage thinking this a problem	Percentage who cannot do without help
Getting to or from the station	74	39
Buying a ticket	14	11
Using stairs at the station	88	41
Finding the right platform	38	15
Getting up on to the train	63	33
Getting to a seat on the train	30	19
Sitting on the train	16	7
Knowing when to get off	19	11
Getting off the train	59	31

Sample: 209 transport handicapped people who can use trains, but only with difficulty or help (Source: GLAD, 1986)

The Automobile Association (1992) found that the main reasons for no longer using trains were: no need (29 percent), use own car (17 percent), difficult to board (14 percent), can't get to station (10 percent) and inconvenient (9 percent).

Oxley and Alexander (1994) found that 23 percent of their sample of disabled people were currently using British Railway trains, compared with 21 percent currently using the underground.

The reasons for not using trains were:

No need/housebound/nowhere to go	44%
Have own car/transport/taken everywhere I need	15%
Too ill/epilepsy/too disabled	13%
No lifts at stations/too many stairs	6%
Too far to station/can't get to station	6%
Getting on and off/step too high/gap	6%
Too expensive	5%

The problems when using trains, for those who did use them, were:

Steps at stations	12%
Need help to step up/off train/step too high	10%
Lack of staff/unhelpful staff	3%

Need a seat	3%
Trouble opening/closing doors	2%

The main improvements that would make it possible to use trains were:

Better accessibility for wheelchairs/disabled people	20%
Make it cheaper	18%
Lifts on all stations	18%
Low step up on to train/no gap from platform to train	16%
Staff available to help	12%
Ramps/slopes for wheelchairs	9%
Compartments/spaces for wheelchairs/disabled	9%
Better service/on time	5%
Sliding doors/easier to open	5%

Ståhl et al. (1993) found that train trips caused great problems for disabled travellers. Getting on and off the train caused the most major problems while travel on the train caused most minor problems. Getting to and from the station caused more difficulty than being at the station; both were more difficult than getting information before the trip. In group discussions, problems with baggage were mentioned. The boarding step and to a certain extent moving around in the train were difficult for large numbers of people with functional impairments. People in wheelchairs had many special problems. People with impaired hearing had particular difficulty obtaining information in stations and while travelling in the train. Swedish Railways has installed induction loops for people with hearing impairments in station buildings and in the new X2000 long distance train.

4.6 Car Drivers

4.6.1 Accidents and driving abilities

The numbers of elderly and disabled drivers are increasing. This is a result of several factors, which include:

- the number of elderly people is increasing
- previous generations of elderly people never learned to drive
- elderly people are getting richer
- the technology to help disabled people drive is improving.

In Britain in 1975, a survey in the city of Guildford collected information on driving and license holding by elderly people (Hopkin et al., 1978). The proportion of men driving regularly ranged from 57 percent for those aged 65 - 69 years to 11 percent for those aged 80 years and over. For women, the corresponding figures were 10 percent and 4 percent. Among people who had ever held a driving license, the proportion who had surrendered their licence grew from 20 percent of those aged 65 - 69 to 55 percent of those aged 80 years and over. More recent data from the British National Travel Survey

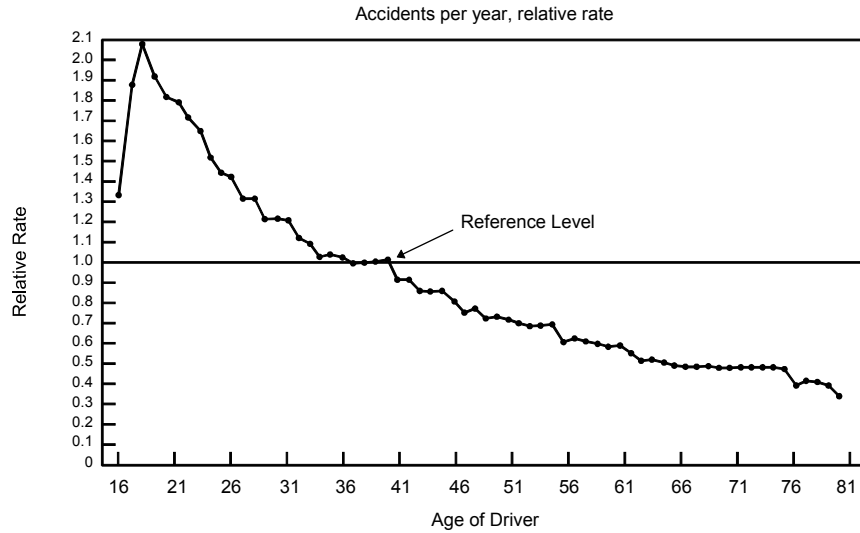
suggest that men, at least, are retaining licenses to older ages. In 1988-90, 41 percent of men aged 80-84 and 30 percent aged 85+ held current driving licenses. The survey does not contain information on people who had surrendered their driving license. License holding by older women in Britain is still very low - 7 percent for women aged 80 - 84 and 4 percent for those aged 85+ years. These low figures are a result of women, now in old age, having never learned to drive.

Data from the U.S. show much higher levels of license holding. In 1988, 85 percent of men and 49 percent of women aged 70 and over held current driving licenses (FHWA, 1995). By 1994, these proportions had increased to about 90 percent of men and 58 percent of women. Even for people aged 85 and over, 75 percent of men, but only 26 percent of women, held licenses. Similar figures are not available for Canada, which makes it impossible to accurately forecast the likely increase in the number of elderly drivers. This is partly a result of the federal structure of the country, which means that data on drivers, vehicles and road traffic are fragmented between the provinces and not necessarily collected on a consistent basis. In addition, Canada does not conduct a regular national travel survey, as is done in Britain and the U.S. These surveys are the only reliable way to measure the proportion of the population in different age groups holding driving licenses and continuing to drive.

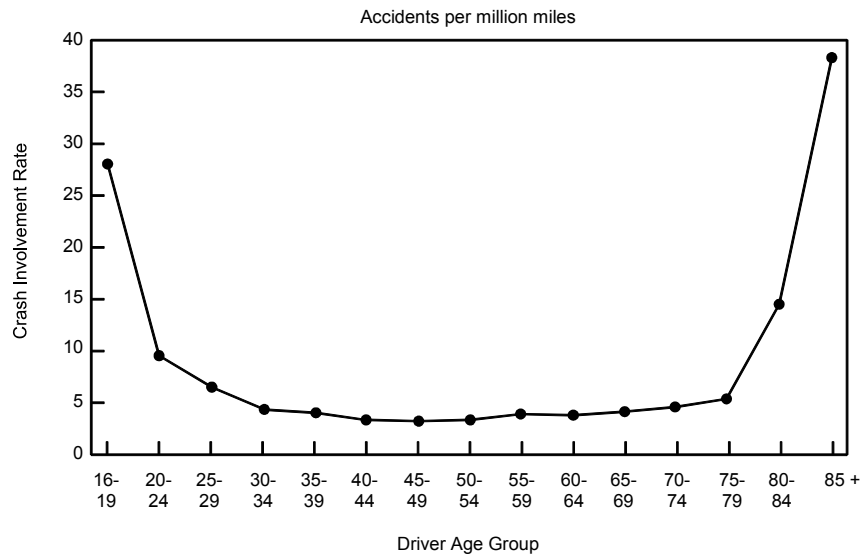
As people age, physiological changes occur that make driving more difficult. These are increased reaction time, a reduced ability to split attention between several tasks, and deteriorating vision, particularly at night. The lens of the eye yellows and hardens with age and the pupil tends to become smaller and loses some of its ability to dilate in dim light. Loss of the ability to focus increases with age, as does sensitivity to glare. All these effects reduce the ability of older people to read signs and to see well in poor light. In addition, impairments due to strokes, arthritis and rheumatism become more common as people age. There is great variation between different people of a given age, and age alone should certainly not be used as a criterion for ability to drive safely.

In most countries the risk of accident involvement per driver per year decreases steadily with increasing age (see Figure 4a and b) (TRB, 1988; Highway Users Federation, 1989; Oxley and Mitchell, 1995). In British Columbia in 1994, only 2.2 percent of drivers over 65 were involved in collisions, compared with 4.4 percent of all drivers.

Because the annual distance driven by elderly drivers reduces as they age, their accident rate per mile driven increases after the age of about 50, and sharply after the age of about 70 - 75. Older people are relatively frail, so the proportion of their accidents that result in their death or injury also rises with age (Evans, 1991). In Canada, in the past decade the percentage of all road users killed who were 65 or over has increased from 10 percent to about 14 percent. The number of senior road deaths has been increasing steadily since 1983, while deaths among other age groups have been decreasing (MacLennan, 1993). Despite this, traffic accidents are not a major cause of death for older persons, when compared to other causes (Highway Users Federation, 1989).



a) Crash involvement rate, per population (relative to 40-year-old drivers) (Laux and Brelsford, 1990)



b) Crash involvement per million vehicles miles (5 State files; TRB, 1988)

Figure 4 Elderly driver accident involvement, U.S.

The pattern of accidents in which elderly drivers are involved is different from that for younger drivers (TRB, 1988; FHWA, 1990; Hakamies-Blomqvist, 1996). Elderly drivers are more likely than average to have accidents at junctions, particularly where they have to turn across traffic. These tend to be due to failure to yield right of way; to involve other traffic signs or signals; to unsafe lane changes; and to angle collisions. They are less likely than average to be involved in accidents with speed too fast for conditions; loss of control; driving under the influence of alcohol; single vehicle accidents; rear-end collisions; pedestrian accidents; and non-intersection accidents. This pattern is based on studies in North America and Europe; the conclusions apply to both areas, despite the considerable differences in the highway systems.

Older drivers are over-represented in accidents at junctions, particularly unsignalised junctions on two lane roads. They are more likely than average to be involved in violations of rights of way. They are under-represented in single vehicle accidents, accidents at night, accidents involving speeding and drink/drive violations. Older drivers are more likely to be "at fault" for accidents than middle-aged drivers, but only after the age of 75 are they more likely to be at fault than teenage drivers. Older drivers make mistakes more frequently than younger drivers when turning across a lane of traffic or when merging into a lane. Older drivers recognize that they have problems with turns and merging, along with failing to respond to road signs and signals (Malfetti and Winter, 1987).

4.6.2 Driving problems

Older drivers attempt to compensate for the effects of aging by avoiding situations that they feel are dangerous, difficult or stressful. Several studies have established which driving situations elderly drivers try to avoid, but fewer have identified situations that are merely stressful or unpleasant. Drivers aged 55 and over report more problems than do those aged 35 - 44 with regard to reading traffic signs, seeing clearly at night, turning their heads while backing and when merging into high-speed traffic (Yee, 1985; Rothe, 1990). Benokohal et al. (1994a) surveyed drivers aged 65 and over in Illinois to determine what aspects of driving had become more difficult. The activities mentioned by most drivers were driving at night, driving in heavy traffic and driving at high speed on freeways (see Table 10).

4.6.3 Situations drivers avoid

Laux and Brelsford (1990) found that, as a group, older drivers tended to give up driving at night, drove less frequently, avoided driving in bad weather and avoided limited access highways. A smaller percentage of trips by older drivers included unfamiliar neighborhoods or major thoroughfares. Benokohal et al. (1994b) identified the conditions older drivers avoided, and how these changed with age (Figure 5). The most frequently avoided conditions were ice, rush hour and night. The proportion avoiding night driving increased with increasing age, from 28 percent for those aged 66 - 68 to 67 percent for those of 77 or over.

Table 10
Percentage of senior drivers who indicated
driving activity was more difficult now than ten years ago

Driving activities	Percentage
Driving at night	62.2
Driving in heavy traffic	52.2
Driving at high speeds on freeways	31.7
Driving in construction zones	28.5
Reading street signs in towns	26.8
Reading signs on freeways	23.5
Driving across intersections	21.2
Finding beginning of left turn lane at intersections	20.4
Making left turns at intersections	19.0
Following pavement markings	16.9
Driving in daytime	13.3
Responding to traffic signals	11.6

(Source: Benekohal et al., 1994a)

Rothe (1990) found that elderly drivers avoided bad weather, night driving and rush-hour traffic. Lerner et al. (1990) found no evidence of substantial avoidance of freeways by older drivers, except during rush-hour traffic. Simms (1993) surveyed 269 drivers aged 70 or more and found the percentage of drivers who avoided certain traffic situations on local journeys (see Table 11). Rabbitt et al. (1996) reported a more extensive list of situations avoided by older drivers and ex-drivers (Table 12).

There is considerable consistency between the situations avoided, given the variations in highway standards, traffic density and weather conditions in the different areas in which the studies were conducted. There is growing recognition of the fact that, by avoiding motorways and other limited access highways, elderly drivers are not making use of the roads that form the safest part of the highway system. This, their consequentially high use of local all-purpose roads and their very limited mileage per year are all likely contributors to their above average accident rate per mile.

Although Cohen (1996) has reported that the impairments of middle and old age are troubling a smaller proportion of people aged over 65 each year in the U.S., there is no evidence of any postponement in the physiological effects of aging that make driving more difficult for older people.

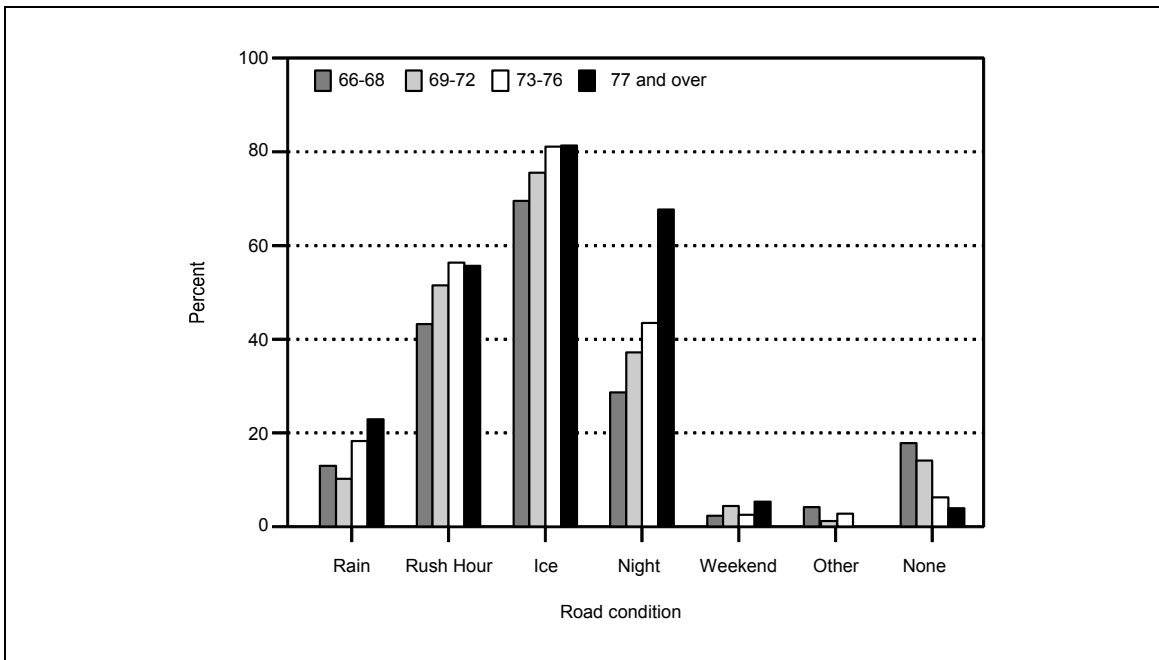


Figure 5 Road conditions older drivers purposely avoid, by age group
(Source: Benekohal et al., 1994b)

Table 11
Situations avoided by drivers aged 70 and older on local journeys

Situation or road feature	Percentage who try to avoid	Percentage who change their driving behaviour to avoid
Town centres	87	26
Complicated junctions	62	16
Roundabouts	37	38
Changing lanes	37	16
One-way systems	32	25
Merging into traffic	29	21
Right turns (across traffic)	24	33
Country lanes	20	10
Dual carriageways	13	23
Busy times	-	25
Multi-storey car parks	-	22

(Source: Simms, 1993)

The many studies of elderly drivers have established a good if fragmentary picture of their concerns and requirements. Elderly and disabled drivers are concerned over safety and try to avoid situations which cause stress or with which they feel they cannot cope. These include darkness, heavy traffic, high speed roads, road works, bad weather, unfamiliar areas, being lost, mechanical breakdown, illness, crime and being unable to summon assistance. Elderly and disabled drivers are well aware of their limitations and adjust their driving to match those limitations.

Table 12
Percentage of drivers and ex-drivers who reduced driving in particular situations

Driving situation	Percentage of all drivers reporting less driving	Percentage of all ex-drivers reporting less driving before giving up
Night driving	56	63
Dawn and dusk driving	43	54
Rush hour driving	58	58
Motorway driving	39	50
In bad weather	38	47
When tired	55	56
When in poor health	44	53
Unfamiliar vehicles	58	67
City centre	51	58
Unfamiliar areas	47	61
Country lanes	13	16
Driving long distances	42	37

(Source: Rabbitt et al., 1996)

4.6.4 Why drivers stop driving

Hopkin et al. (1978) reported the reasons given by elderly people for surrendering their driving licences (Table 13). The reason most frequently cited was no need to drive or no car. After that, old people who had difficulty walking cited disability as the next reason, while those with no difficulty walking cited lack of interest in driving.

Simms (1993) surveyed 269 drivers and 87 former drivers, all aged 70 or over. Eighty-two of the former drivers had voluntarily handed in their licences. The other 5 had been persuaded to give up driving, on the grounds of poor health or vision, by a doctor, optician, licensing authority or relative. The reasons stated by the 82 for giving up their licence were:

Financial reasons	39%
Health or disability	29%
Concerned about driving	17%
Poor vision	7%
No longer needed a car	7%

Oxley and Alexander (1994) reported reasons that disabled people in the Greater London area had given up their driving licence. Eighteen percent of those who did not hold a current driving licence had once done so. The principal reasons for having given up a licence were:

Ill health	40%
Eye trouble	11%
Too old/reactions slow	11%
No need	10%
Expense (of car)	7%
Lost interest in driving	7%
Had car accident	6%
Couldn't cope with traffic	4%

A more recent British report (Rabbitt et al., 1996) found that drivers who started driving young were more likely to continue driving into old age. A survey of 334 ex-drivers gave the following 440 reasons for giving up driving (percentages of 440 reasons):

Accident/safety	30%
Medical/ability	27%
Financial/economic	25%
Personal/social	14%
Other	4%

The general reasons were analyzed in greater detail, as follows:

Safety reasons (percentages of 334 ex-drivers):

Felt personally unsafe as a driver	30%
Felt that other drivers were unsafe	7%
Medical reasons for feeling unsafe	3%

Medical reasons:

Eye problems	17%
Movement problems	6%
Cardiac problems	6%
Other	7%

Social reasons:
 Prefer public transport 11%
 Another driver available 8%

These feelings of being personally unsafe as a driver, and of other drivers being unsafe, were in marked contrast to the feelings of the elderly people who continued to drive.

Table 13
Percentage of respondents reporting reasons for giving up driving licence, Guildford, England, 1975

Reason	No difficulty in walking	Difficulty in walking
No need/no car	42	43
Not interested	26	2
Can't drive/too old	16	12
Can't drive/disability/health	2	22
No money/expense	5	7
Can't drive/eyesight	2	7
Had an accident	5	2
Other	2	7
Number of respondents	57	58

(Source: Hopkin et al., 1978)

4.6.5 Making cars easier to drive

The first step to make cars usable by disabled people was the introduction of hand controls for those who could not use the normal foot/pedal controls. Information was then collected on what aspects of cars made them easier to get into and leave, and to sit in (Gazeley and Haslegrave, 1978; Institute of Consumer Ergonomics, 1985). The motor manufacturing industry has not taken significant steps to make its vehicles easier for older people to use in terms of access and seating, but advice on particular models has enabled elderly and disabled people to choose the best available. More advanced control adaptations were then developed to provide powered steering and brakes and zero force joystick controls (Haslegrave, 1986). These are now so effective that if a disabled driver has the cognitive skills to drive, and can afford the vehicle conversion, they can drive. These developments of controls made access and seating the limiting factors for disabled drivers. These difficulties have been partially overcome by the conversion of small vans that can be driven from a wheelchair.

5. EUROPEAN ACCESSIBILITY STANDARDS AND LEGISLATION

This section covers documents that range from advisory codes of good practice, through official standards, which may or may not be implemented, to legislation. All European countries have standards or legislation on the design of buildings, and all known to the author make some provision for access to public buildings. These will not be covered in this paper.

Many European countries have guidance on accessible infrastructure (sidewalks, stairs and ramps, pedestrian areas, car parks, bus stops, transport terminals). These can be issued by many different types of organizations, including government departments ((Netherlands) Ministry of Transport and Public Works, 1986), public bodies ((Irish) National Rehabilitation Board, 1988), standards organizations (Association Suisse de Normalisation, 1988), professional bodies (Institution of Highways and Transportation, 1991), transport operators (British Railways Board, 1989) and organizations for disabled people (COLITRAH, 1992). Inevitably, the different documents differ in the standards they set. Institution of Highways and Transportation (1991) compares the requirements of a number of different standards.

Fewer countries have standards or guidance on the design of buses. Sweden has mandatory legislation on the accessibility of all forms of public transport, but this is relatively general and only covers to the most important features that affect access (route number and/or destination sign, steps, doors, handrails and grabrails, seats, announcing bus stops, signalling device for alighting, ventilation, lighting and measures for allergic persons) (Swedish Board of Transport, 1989). In Germany the association of public transport operators VDV issues very detailed specifications for urban buses which enable manufacturers to build to standard designs for different cities, but these specifications have no legislative force (VDV, 1996). Britain and France have recommended specifications for urban buses which can define standards for contracts but have no legislative force (DPTAC, 1993; COLITRAH, 1991). The new Disability Discrimination Act (1995) in Britain will give legislative force to access standards, but the actual standards that will be required are not yet known. The European Union is drafting a directive on bus design, but as presently drafted, this will do nothing to improve access to buses. Improvements to vehicle design, such as the introduction of low-floor buses, have come about because they made economic and operational sense in relation to the carriage of all passengers, rather than as a result of legislation.

Access standards for railways are usually unpublished documents produced by individual railway operators for their own use when specifying new rolling stock or stations. The ECMT and UIC have produced an agreed report on improved access to trains which includes guidelines on making long distance trains accessible to passengers travelling in wheelchairs no bigger than the ISO standard for wheelchairs (ECMT and UIC, 1992).

There are no standards for access to private automobiles, though several countries have information for disabled drivers on features to check when selecting a car. The most extensive information available is in Scandinavia, where Senter for Industriforskning (Oslo) publish and update a register of details of most cars available for sale in Scandinavia. An English-language version of this is available. A number of countries have standards or guidance on conversions to control systems for disabled drivers. Some of these are over prescriptive; until recently, the Italian government defined which converted controls were permitted for drivers with particular impairments. Some are purely advisory and intended to raise the standard of design, installation and maintenance (Institution of Mechanical Engineers, 1990; National Mobility Equipment Dealers Association, 1990). In general, legislation for the safety of motor vehicles applies to vehicles for disabled drivers, exactly as it applies to all other vehicles.

The fundamental approach in Europe has been to legislate to prevent disabled people being excluded by barriers that could easily be avoided. In Sweden, an important goal of transport policy is that everyone, including disabled people, should be offered equitable and satisfactory transport facilities, and thus have access to employment opportunities and participation in social life. Once technical and economic feasibility had been demonstrated, legislation required new buses in Sweden to have at least one doorway with a step from the road of no more than 200 mm, and front door step height of no more than 230 mm.

In Europe, guidelines and legislation on access are tending to require access for passengers in wheelchairs no larger than the wheelchair defined by ISO standard 7 193 (issued 1985). This is to guarantee continuity of access through several modes and their interconnecting terminals, and to give the operators a definite standard to use when specifying vehicles and terminals. Access must also be provided for ambulant disabled people, frail elderly people, people with sight or hearing or cognitive impairments. Access is regarded as a human right, but the concept of a disabled person being able to claim access for whatever mobility aid they consider necessary has not developed. Some mobility aids are not allowed in buses or trains because of lack of stability or safety; others cannot get into buses or trains because of their size or weight. Access requirements set by law are applied to new vehicles and buildings only, except that when major refurbishing is undertaken, access must be provided wherever practicable.

6. BENEFITS OF ACCESSIBLE TRANSPORT

The benefits of accessible transport can be commercial, by attracting additional passengers and revenue or by avoiding the need for costly special services. Benefits can accrue to the whole community, by enabling people to participate in employment and social life. They can be so-called “cross-sector benefits”, which are savings to one part of the public sector caused by activities, such as providing accessible transport, in some other part of the public sector.

With regard to commercial benefits, studies of improvements to the design and operation of transit buses to make them easier for elderly and ambulant disabled people to use (Oxley and Benwell, 1985) suggest that low cost improvements to buses such as lower entrance steps, good handrails and adequate seat spacing could increase patronage about 2 per cent. Operating buses so that elderly and disabled passengers always had time to find a seat before the bus started could increase patronage by at least as much again.

Ståhl (1991) has shown that the establishment of a Service Route in an area reduces the dependence on Special Transport Services (STS - taxis and dial-a-ride) in that area by 25 - 40 percent. A trip by STS costs \$U.S. 14 on average, compared with \$U.S. 3 for Service Routes. Experience with low-floor transit buses is not yet sufficient to know whether a similar effect occurs when the main bus services become fully accessible, but it is likely that it will.

Cross-sector benefits have been studied in Britain by Cranfield University (Carr et al., 1993; Fowkes et al., 1994). Cross-sector benefits arose from elderly and disabled people being able to travel to obtain shopping or professional services such as medical care and chiropody (podiatry), and to attend day centres and social activities. By travelling to these activities, the elderly and disabled people did not require so many visits to their house by doctors, chiropodists, health visitors, home helps and the providers of meals-on-wheels. There was also some evidence that independent mobility could delay the need to move into a residential home, though there was also conflicting evidence that in some cases this move was not linked to transport independence. The mobility factors that correlated with the number of domiciliary visits required were the distance the person was able to walk and the ability to use a bus without help. The implied priority for accessibility was for mainstream public transport services.

By giving disabled people the opportunity to travel, they have the opportunity for social integration, and hence social benefits, that would otherwise be denied. It is difficult to quantify the notion of “quality of life”, let alone the effect that lack of transport has upon it (Fowkes et al., 1994). Organizations working in the field of disability are familiar with the psychological and physical problems associated with social isolation. GLAD (1986) reported that:

... social isolation can lead to increased handicaps as horizons shrink, knowledge of what is going on is hard to get, awareness of new possible activities and available pursuits is reduced, and dependency grows.

Deterioration of health due to isolation is known to occur. Gallon et al. (1992) showed that almost twice as many disabled people with limited access to transport described their quality of life as “not good” compared with public transport users. Conversely, almost twice as many disabled people who used public transport described their life as “good” compared with those with limited access to transport.

7. INTELLIGENT TRANSPORTATION SYSTEMS

One of the largest changes to the road system that will happen in the next few decades will be the progressive introduction of Intelligent Transportation Systems (ITS). These systems involve the application of telecommunications, information systems, sensors and controls to road transport. The U.S. National ITS Program Plan lists ITS applications as seven “User Service Bundles” (Euler and Robertson, 1995). These include AVCSS (Advanced Vehicle Control and Safety Systems), PTO (Public Transportation Operations), EM (Emergency Management), EP (Electronic Payment) and several services that can be classed as ATIS (Advanced Traveller Information Systems) and ATMS (Advanced Traffic Management Systems).

ITS has the potential to increase the capacity, productivity, safety and reliability of the road transport system. The U.S. National ITS Program Plan lists the goals of the U.S. National ITS program as:

- Improve the safety of the Nation’s surface transportation system;
- Increase the operational efficiency and capacity of the surface transportation system;
- Reduce energy and environmental costs associated with traffic congestion;
- Enhance present and future productivity;
- Enhance the personal mobility and the convenience and comfort of the surface transportation system; and
- Create an environment in which the development and deployment of ITS can flourish.

This section considers the ways in which ITS can increase the accessibility of transport to elderly and disabled people. One of the potentials of ITS is, at least in part, to compensate for some of the effects of aging that make driving increasingly difficult for elderly drivers. There is already evidence that well-designed ITS equipment has the potential to help older people continue to drive in safety.

The main areas where the requirements of elderly and disabled travelers should influence the design of ITS equipment, and indeed lead to the development of specialized items of equipment, are ATIS for driver information from in-vehicle and roadside displays, PTO/ATIS for passenger information and EM for emergency alert (Mayday) services. They also need to be involved in the introduction of smart payment cards (EP) for transit fares, parking charges and tolls. There may well, in the further future, be scope for ITS in rural transport, for example in transport brokerage, paratransit operations for rural areas and ride sharing.

Vehicle control and safety systems (AVCSS) will almost certainly be developed to serve the whole population of drivers. It is important that elderly and disabled drivers are involved in their development, to ensure that AVCSS does not introduce unnecessary barriers to the mobility of this group. Furthermore, some aspects of AVCSS such as intelligent cruise control (ICC), collision warning or avoidance and vision enhancement

have the potential for helping elderly drivers with aspects of driving that cause higher than average accident rates for them.

There is little general appreciation of the extent to which ITS is starting to be introduced in Europe and the U.S. It is a topic that has been talked about for years, with little for the average traveller to see on the ground. In the past one or two years significant applications have started to appear. In Europe the most obvious equipment is probably information displays for public transport passengers. In Britain a commercial ATIS service, Trafficmaster, has been providing drivers with real-time information on congestion on the motorway network since about 1993 (see Figure 6). Navigation systems are being built into some cars as original equipment; for example, BMW now offer the Philips Carin system in their series 5 and series 7 vehicles. Advanced urban traffic management systems are widespread in Europe, using linked networks of vehicle detectors and traffic signals, controlled by a central computer that optimizes the signal settings in real time.



Figure 6 The Trafficmaster traffic information system in Britain. *The system displays the speed of traffic on the motorway system, real time, at any points where the speed is less than 30 mph. This illustration shows the northwest quadrant of the M 25 London outer orbital motorway. The arrow with the number 20 in it indicates that at that point the traffic speed in the direction of the arrow has averaged 20 mph for the last three minutes. The display unit can be removed from the car; its battery provides about 8 hours of independent use as a hand-held unit.*

In the U.S. the main applications have been to commercial vehicle operations, which will not be considered further in this report, urban traffic management centres and ATIS that provides in-vehicle information to car drivers. Applications to public transport operations and information for passengers are increasing, but are not yet at the levels found in Europe. About 86 bus systems in the U.S. are expected to be using automatic vehicle location (AVL) equipment by the end of 1996. The GPS Global Positioning System plus the recent availability of digital maps of much of the U.S. has made possible navigation systems that will work in most areas. Hertz started to offer navigation systems in hire cars in July 1995. As a result of an overwhelmingly positive response from customers, in July 1996 Hertz increased their stock of NeverLost navigation systems to 8 000 units, offered as standard rental items in 16 U.S. cities (see Figure 7).



Figure 7 The Rockwell/Hertz "Neverlost" navigation system. *This on-board navigation system provides either a map display or junction by junction directs from the present position of the vehicle to a selected destination. Audio instructions are given on the approach to each junction. This illustration shows an instruction to bear right onto the SR 528 East toll road in 0.3 miles.*

7.1 Trip Planning for Elderly and Disabled Travellers

Intelligent Transportation Systems are making travel easier in Europe and North America by providing multi-modal information for selecting the best transport mode, time and route for a journey. Elderly drivers need information on how to avoid closed roads, roadworks and other sites that cause difficulties. A number of projects in Europe and North America are providing terminals in public places (airports, rail stations, shopping centres) for the provision of multi-modal trip planning information (see Figure 8). B.C. Transit has implemented an automated telephone system called BusLine to assist staff provide transit information to the public in Victoria, B.C. (Geehan, 1994).



Figure 8 A trip planning information terminal. *This example of a multi-modal trip planning terminal is at the main railway station in Southampton, England. It is operated through touch-screen controls and provides information on public transport services by bus, rail, air and ferry. For public transport or car journeys it gives details of the best route from a specified origin to destination. Once a route has been selected, detailed instructions can be printed for the traveller. The service is free to the public.*

More needs to be done to provide easy access to pre-trip information for all travellers in the home, workplace or hotel. In Europe, some travel and traffic information is available on television sets using Teletext. The European TIDE program includes one project,

TURTLE, to display real-time transit information on television sets at home using the existing Teletext system. A modem is being developed by Netscape to allow standard television sets to receive information from the Internet, using the remote controller as a keyboard (*Sunday Times*, 1 September 1996).

Equipment to provide electronic Yellow Pages is already available commercially, including hand-held portable data stores similar to personal organizers. These already include information on services along roads, accommodation, sites for recreational vehicles and details of tourist attractions. There may well be scope for the inclusion of more travel information in existing commercial services, for example a list of road numbers, intersections distances and turns for any journey selected. Provided the cost of data collection is not too great, it should be possible to include specialized information on accessible services for elderly and disabled travellers. The role of information in accessible transport was outlined by Suen and Rutenberg (1994). The existing hand-held units could become the first element of a family of portable ITS units incorporating some combination of yellow pages, a receiver for real-time traffic and transport information, a telephone, a location system, Mayday assistance, navigation and route guidance (see Figure 9).

There is also a great need for specialized information on what accessible services are available, and for specific advice for people with particular transportation disabilities on how to make particular journeys, using several modes if necessary. In Britain, an information service called TRIPSCOPE provides such advice to disabled travellers (Howard, 1995). This already uses a computerized data base, but it is clear that a greater use of information technology will be required for the two purposes of keeping information up to date and for increasing the speed with which questions can be answered.

The value of trip planning information applies at least as much to public transport as to private vehicles. Real-time information about bus services can reduce the time passengers need to wait at bus stops. This reduces one of the deterrents to bus use and can, in extreme weather, increase safety and security. The application of ITS to local transit services has been reviewed by the Schweiger et al. (1994). Canadian transit operators have chosen to use the telephone system to provide automated information on the times of the next few buses at specific bus stops. This is usually based on schedules, but in Hull and Halifax the operator provides real-time information from AVL systems.

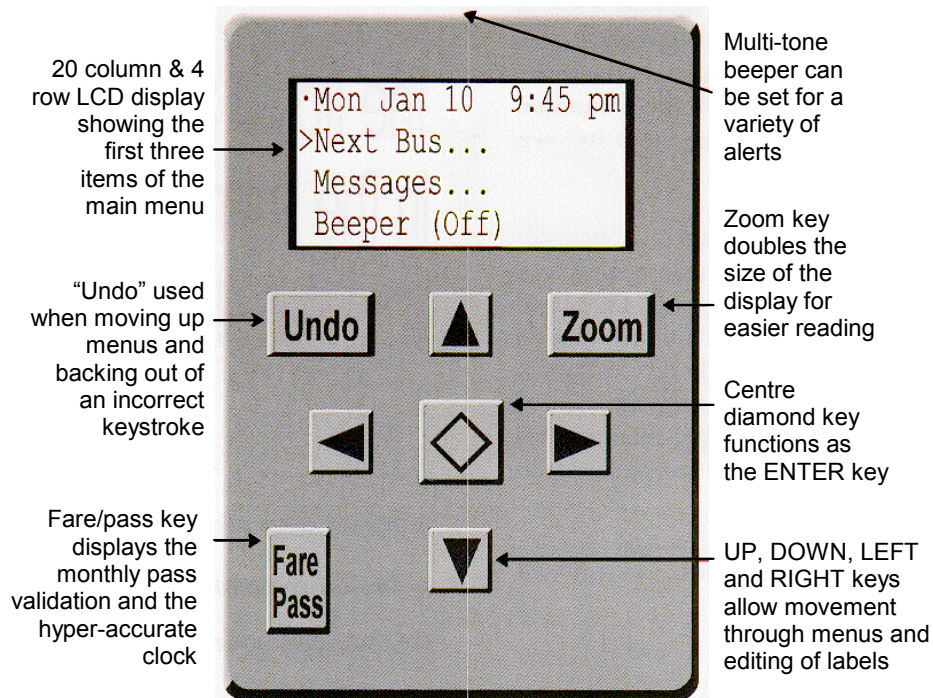


Figure 9 A hand-held transit information unit. *This unit provides real-time information on the time of the next bus at a specified stop. It also acts as a monthly transit pass and a personal pager. The unit measures 10 cm by 7 cm. (Photo: TRANSCOM International Ltd.)*

7.2 Pedestrians

Virtually all journeys involve two or more walk stages, if only from home to driveway. Many ambulant disabled people as well as people in wheelchairs are seriously limited in the distance they can walk or travel in a wheelchair. Access can be prevented by distance, slopes and road crossings as well as by the normally recognized curbs, steps and poor surfaces. Pedestrians in general are afraid of being attacked, being hit by a car or falling. ITS has considerable potential to help disabled pedestrians, particularly with road crossings and with orientation for visually impaired people. Table 14 lists the problems experienced by pedestrians and suggests roles for ITS in mitigating those problems.

Elderly and disabled pedestrians have problems with crossing roads because they walk more slowly than able-bodied people. Traffic signals often do not allow long enough for such pedestrians to cross the road safely. Fear of being caught in traffic while crossing roads limits mobility and represents a clear lack of safety. In Britain, people detectors are being used to extend the length of the pedestrian phase when a slow-

moving pedestrian is on the crossing. The same equipment omits the pedestrian phase if there is no pedestrian waiting to cross, even if the pedestrian button has been pushed. This avoids delaying traffic unnecessarily and increases the respect for light controlled crossings. In Britain, signal controlled crossings routinely provide an audio signal when it is safe to cross. Some signals also emit a continuous ticking noise to guide a visually impaired person to the button that demands the pedestrian phase.

Table 14
Pedestrian problems and ITS equipment

Impairment	Problems	ITS equipment
Mobility	Distance to walk	Hand-held route guidance system to advise routes with resting places
Mobility	Curbs, steps, ramps and hills	Hand-held route guidance system to advise routes avoiding particular barriers
Everybody	Crossing roads	Crossing signals that extend crossing time for slow pedestrians Crossings that warn drivers of pedestrians on crossing
Visual	Crossing roads	Audible signals at crossings Hand-held navigation system
Everybody	Falling on uneven pavements	Pavement condition monitoring Hand-held fall detector/Mayday system
Visual plus visitors	Getting lost	Hand-held navigation system Vision enhancement systems Audio sign posts
Visual	Finding correct bus stop	Audio announcement when triggered
Visual	Walking into traffic	Hand-held navigation system
Visual	Accidents: walking into plate glass, falling off platforms, steps	Hand-held navigation system
Everybody	Crime	Hand-held Mayday system

Francher et al. (1994) suggested fitting the signs at mid-block pedestrian crossings with lights that flash when a pedestrian is detected on or approaching the crossing. A similar idea has been tried experimentally in Santa Rosa, California, where the LightGuard crosswalk warning device uses flashing lights embedded in the road pavement to warn drivers when there is a pedestrian on the crosswalk (Urban Transportation Monitor, 1996).

Visually impaired travellers have a very high accident rate. Devices have been developed to warn blind pedestrians of nearby obstacles, but these have not proved to be useful. It is now appreciated that the greatest problem for visually impaired

pedestrians is location and wayfinding (Weetman and Baber, 1992). ITS makes possible a hand-held navigation system using differential GPS that could provide location to an accuracy of less than a metre, plus a digital plan of the area and, if required, audio announcements. This could provide warnings of hazards such as roads and edges of railway platforms, plus instructions for the route to a selected destination (Gowda and Meadors, 1995).

The European Technical Initiative for Disabled and Elderly People (TIDE) program includes two projects for pedestrian navigation systems (MOBIC and ASMONC) and one for a wheelchair navigation system (SENARIO) (European Commission, 1994). TIDE also includes a project, POVES, to develop a portable vision enhancement system to help people with night blindness, disturbed contrast, tunnel vision and other visual impairments. Finally, a British company is developing a hand-held unit that combines GPS, Mayday communications and a motion sensor. This can detect when an elderly person falls and automatically inform an emergency centre of the accident and its location (*Sunday Times*, 24 November 1996).

Another class of ITS equipment for visually impaired people is talking signs or infrared beacons at points such as bus stops, ticket dispensers, barriers and escalators. These are detected by hand-held receivers that speak messages which have been programmed into the beacon. They are being used in subway stations and transit terminals. The European TIDE Project OPEN is using beacons to help visually impaired people to find their way in the underground railway systems of London and Paris, and the Powell BART station in San Francisco has been used as a demonstration project (Smith-Kettlewell Eye Research Institute, 1995). Talking signs have the potential to be used generally in urban streets to provide location, guidance and warnings.

London Transport is using a different system in a large bus terminal. Speaking units on bus stop posts announce the route numbers of services from each bus stop when a contactless transponder carried by a person with impaired vision is held near the stop.

7.3 Bus Users

The Public Transportation Operations (PTO) bundle of ITS technologies are being used in North America and Europe to improve the efficiency, productivity and reliability of bus services. In Canada this technology is currently in use in Hull, P.Q. and Halifax, N.S. The technologies available include Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI) and communication between buses and a control centre (Rivett, 1996; Schweiger et al., 1994). These allow the control centre to monitor operation of the system and take action to minimize unreliability. Advanced Traffic Management Systems (ATMS) can improve operating conditions for bus services and give buses priority at traffic signals.

ITS technologies can help all passengers, by providing information or in other ways, and in many cases will be particularly helpful for elderly and disabled passengers. Table 15 lists the problems experienced by bus passengers with different impairments, and suggests ITS equipment that could help to overcome the problems.

Table 15
Impairments, problems and ITS equipment for older and less able bus passengers

Impairment	Problems	ITS equipment
Cannot stand for long, sensitive to cold	Unable to stand while waiting at bus stops	Display of waiting time at home, at bus stop on hand-held unit
Unfamiliar with area	Do not know bus service details	Telephone information service
Poor vision	Cannot read service number	Service display at bus stop Audio announcement by bus
Poor vision	Cannot see community bus in time to hail it	Hand-held device for communication between bus and passenger
Lack of manual dexterity, cannot do things quickly	Paying cash fare while boarding	Smart payment card
Poor vision, unfamiliar with area	Cannot identify destination stop	Display name of next stop in bus
Impaired hearing	Hearing announcements	Induction loop in bus
No vision	Finding bus stop, knowing which stop for which service	Talking signs, stops that announce services from them

Displaying the name of the next stop inside the bus gives passengers confidence and provides extra time to alight (see Figure 10). Another example of an application of ITS is the display at a bus stop of the next few services and the waiting times until they arrive (see Figure 11).

At least two Canadian ITS projects started to develop systems to broadcast real-time transit information to hand-held display units or home-based computers. At present both developments are blocked by lack of funding. The European DRIVE II Project PROMISE has developed portable and hand-held display and communication units for travel information (European Commission, 1993). It is also possible to use urban cable systems to transmit similar information to a home-based computer or television set. The European TIDE Project TURTLE is specifically developing such a system (European Commission, 1994). Finally, the computer system that disseminates real-time transit information could pass the information to the Internet, to be read on home computers or, using a special modem, on a television set.



Figure 10 Displaying the name of the next stop inside a bus in Malmö, Sweden. *The display is driven by the automatic vehicle location system (AVL) fitted to the bus. The red sign each side of the stop name is an indication that the next stop has been requested.*



Figure 11 Displaying the waiting time and destination for the next few services. *This display is in the London underground (subway). Similar displays are being introduced at bus stops in many European cities. In Southampton, a transponder carried by visually impaired people triggers audio announcements of the information displayed.*

In Canada, the Télécité Visual Communication Network (VCN) system is displaying information on board transit vehicles in the Montreal Subway. VCN allows more sophisticated displays than do the corresponding systems in Europe. Its extension to buses is being planned. It should be technically straightforward to install inductive loops in buses and subway cars so that people with hearing impairments can hear audio announcements directly through a hearing aid without interference from background noise (as is done already for some telephones). Swedish Railways has already installed induction loops to help people with hearing impairments in station buildings and in the X2000 long-distance train. The London and Paris underground rail systems are using infrared beacons to guide visually impaired passengers through stations as part of the European TIDE Project OPEN (European Commission, 1994).

European experience with “talking bus stops” that make continuous voice announcements of transit information has shown them to cause local nuisance. Peek Traffic Ltd. manufacture bus stop information displays that only make audio announcements when activated. This activation can be by a button or by a contactless device carried by a visually impaired person (Rivett, 1996). A similar device could change the visual display of information to large print. A contactless device to operate a variety of equipment has been developed by the British RNIB (Royal National Institute for the Blind) “React” project. London Transport are using React to trigger audio announcements of the bus services from particular stops at transit terminals. In Southampton, England, a contactless device carried by a visually impaired passenger triggers audio announcements from a bus stop visual display (Wren and Jones, 1996). In Canada the greatest use for such a device would be in transport terminals.

Security can be improved directly by the use of ITS equipment. With AVL and a communication system a bus driver can summon assistance quickly in response to any incident. If the bus is equipped with a video camera, as has been done in Paris, real-time pictures of the incident can be sent to the control centre. Passenger safety can be improved by systems to detect passengers close to the bus where the driver cannot see them, as is being tested on school buses in the U.S. There may be scope for people detectors to warn the driver if a passenger is trapped in the doors.

Elderly people find the time pressure of boarding, paying a fare and finding a seat before the bus starts a significant deterrent to transit use. Smart payment cards remove the need to pay a fare while boarding a bus and reduce this stress. Transit operators would like a contactless payment card to speed boarding; one Canadian company (Precursor Ltd.) is developing smart payment cards for transit systems, but lack of standards is delaying widespread application. The Precursor smart card is being used by transit systems in Ajax and Burlington, Ontario. Société de Transport de l’Outaouais is working on the introduction of a smart card fare payment system. The Ministry of Transport, Ontario, is conducting general studies to develop standards for a Universal Public Transport Card. The German Association of Public Transport Operators (VDV) already has in service a smart payment card for fares on all their members transit systems that

also allows the purchase of railway tickets and the use of public telephones (see Figure 12).

There is a more general role for a smart payment card that applies to all modes of transport (air, ferries, intercity bus, transit, taxis and car hire) and that carries optional personal information on a traveller's special requirements (as airline frequent flyer cards do today). This information could be read at the time of booking and would supply the operators of all stages of a trip with the requirements of the individual traveller. For a disabled traveller, the information could specify any need for assistance or storage space for a wheelchair. A common concern of disabled people making a multi-modal trip is that one of the later modes will not be accessible, or that help will not be available to transfer between modes or carry baggage, as necessary.



Figure 12 The German VDV smart payment card. *This card allows payment of transit fares in many cities, use of public telephones and the purchase of tickets for mainline train journeys. Money can be transferred to it from a bank account using the touch-tone dial of a public telephone.*

Community bus services, in which an accessible bus can be hailed at any point along its route, are already in service in Canada and are likely to become more widespread. A problem reported in Sweden, where these services originated, is that some passengers have difficulty recognizing the bus in time to hail it. This difficulty should be soluble by

the use of a hand-held unit that informs the passenger of the approach of the bus, or the bus of the waiting passenger. This could also apply to hailing intercity buses on roads where passengers are picked up wherever it is safe to stop the bus.

7.4 Paratransit and Taxis

ITS has the potential to improve the performance and efficiency of the paratransit and taxi systems that provide specialized transport services for elderly and disabled people. The aspects of paratransit systems that are most likely to be improved are:

- Telephone communications between passengers and the control centre. These are often overloaded and also present problems for people with hearing or speech impairments.
- Computer-aided dispatching. Dispatching software was first developed for taxi systems, and has only recently been developed for paratransit. Two Canadian companies, Trapeze Software Inc. and International Road Dynamics Inc., provide general paratransit dispatch systems (Trapeze and TransView). Trapeze has been found to give a 8 - 30 percent increase in productivity and can be regarded as a proven package, at least for medium and small paratransit systems (up to about 40 vehicles, say). It is also being used to increase productivity by allocating trips that are expensive by paratransit to backup taxis.
- AVL. There is service experience of AVL on the 153 vehicles of the Houston METROLift paratransit service. Measured service performance and efficiency improved significantly. TransView and Trapeze are being upgraded to accept AVL inputs.

Computer dispatching of conventional taxi systems is now in general service and is able to improve productivity and the accuracy of pickup times. The main improvements for taxi services used as part of the transport system for elderly and disabled people are likely to be telephone links that are easier for people with hearing impairments to use; systems to help passengers communicate with the driver; and data transmission links and smart card readers for taxis, to make it easy for elderly and disabled passengers to identify themselves and to pay their contribution to the fare. Data links and card readers are already in use in taxis in several Scandinavian cities, where they are used to validate credit card payments by able-bodied passengers as well as to operate the subsidized service for elderly and disabled people. A taxi meter with a display that is easy to read, and that also talks, has been developed by Record Electronics Inc. for TDC to enable people with visual impairments to monitor the fare (see Figure 13).



Figure 13 An easy-view “talking” taxi meter to assist visually and hearing impaired passengers

7.5 Trains and Subways

The benefits that ITS can bring to passengers on subways and suburban train services are similar to those for bus services. Real-time information can give confidence and provide a means of communication in emergency situations. Many urban rail systems already use visual displays on station platforms to indicate the routes of the next few trains and the waiting times until they arrive. Most of these use simple LED displays, but the Paris RER line C is using the more sophisticated Télécité Visual Communication System (VCN). The Montreal subway is using VCN in coaches to announce the name of the next station, and earning revenue from advertisements between announcements. There is scope for installing inductive loops in subway and suburban rail coaches to make public address announcements more audible to people using hearing aids.

Demonstration projects in Europe are establishing the value of infrared beacons to help people with impaired vision find their way in underground stations (see Project OPEN, European Commission, 1994). Another approach that is being tested in a railway station in San Francisco is talking signs - audible announcements that are activated by a transponder carried by a person with impaired vision. These can guide people to ticket dispensers, turnstiles and escalators and provide instructions on how to use ticket machines.

The role of ITS for long-distance rail transport should include all the features described above for subways and suburban rail systems. But in addition, people whose impairments make it difficult to use all transport services need to be able to find what accessible services exist and how to obtain the specific information on fares and schedules to enable them to book a trip. Because travelling is not a regular activity, it is stressful; infrequent travellers repeatedly ask for information on where to find their train, whether they are on the correct train, when it will arrive, and so on. This stress can be reduced by providing good information to give the traveller confidence. If a journey involves interchanges or several modes, the stress is increased by worries over whether assistance will be available at the interchanges and whether the later modes will be accessible.

The ways in which ITS can help long-distance travellers have been described already in section 7.1, trip planning for elderly and disabled travellers, and in 7.3 the value of carrying information on personal requirements on smart cards has been mentioned. Providing information on passenger requirements to all the operators of a multi-modal or multi-stage trip can only improve the probability that the whole journey will be a smooth and seamless progress.

7.6 Car Drivers

7.6.1 Ergonomic studies of ITS and elderly drivers

There have been relatively few studies of the ergonomic aspects of ITS with regard to elderly drivers. Walker et al. (1990) used a driving simulator to test the effects of seven navigation devices on the safe driving performances of samples of younger, middle-aged and older drivers. Results indicated that higher levels of task difficulty affected older drivers to a greater extent (a common finding). Audio devices appeared somewhat safer than visual devices, and moderate levels of complexity were preferable to higher levels.

In Canada, one small-scale study involving ten subjects was undertaken to explore what elderly and drivers with disabilities want from ITS technology (Barkow et al., 1993). The five primary requirements were: greater safety, ease of driving, foolproof to use, user friendliness and responsiveness to need. Only three drivers were aged over 65. They were cautious about ITS developments and the effects of increased sensory load on their driving tasks. Their preferences for ITS in order of priority were for AVCSS (driver monitoring, control aids and warnings of failures), ATIS including navigation systems, and onboard displays of touring information. As a communication output, drivers favoured speech, with text on a screen as a backup.

The European DRIVE II project EDDIT (Elderly and Disabled Drivers Information Telematics) tested whether Intelligent Transportation Systems (ITS) could partially compensate for the decline in driving abilities that comes with aging, and the ergonomic requirements for such systems (Oxley and Mitchell, 1995). The project evaluated 14

systems representing six different ITS applications and examined two generic issues. The applications tested were route guidance, traffic information, emergency alert, reversing aid, night vision enhancement and collision warning. The generic issues were head-up display (HUD) versus dashboard display and the size and complexity of guidance information.

The elderly drivers who took part in EDDIT were found, in general, to have a very positive attitude to ITS and to recognize its potential value. Route guidance systems were found to have little effect on driving safety; any changes were small and as likely to be improvements as reductions. One traffic information system was difficult to use and did interfere with driving. It is important to make the task of using an ITS system as simple as possible and to avoid displays that are small or complex. For route guidance systems, junction diagram displays were preferred to map displays. Touch-screen controls were disliked on the one system that used this feature. Drivers often mentioned the value of having audible instructions or warnings in addition to visual information. Mollenhauer et al. (1995) found a similar positive attitude by drivers aged over 65 to a navigation system, a rear-end collision warning system and to in-vehicle signing. These were tested in a driving simulator by a sample of 32 elderly drivers, who felt that these systems could well increase their mobility and who said they would be willing to pay about \$600 U.S. for each of the systems.

General guidelines on the understandability, usability and safety of information presented to drivers have been drafted by the European DRIVE II Project HARDIE (Ross et al., 1995). Nicolle and Stapleton (1995) have developed guidelines for the usability of in-vehicle systems by drivers with special needs. These guidelines, developed as part of the DRIVE II TELAID project, are intended to help manufacturers during the design and development of ITS systems and to provide criteria for the evaluation of ITS equipment. They cover general principles, control of the system, display of information, training and documentation. They also include specific guidelines for route guidance and navigation systems, adaptive cruise control, collision avoidance and reversing and parking aids. In the U.S., Green et al. (1995) have published preliminary human factors guidelines for driver information systems. These do not include particular guidelines for elderly and disabled drivers.

Based on the literature reviewed above, it does appear that ITS technologies can mitigate some of the difficulties encountered by elderly drivers. Indeed, there is a remarkable match between the capabilities of ITS systems for car drivers and the driving tasks which become more difficult as people age. Table 16 shows the links from impairments, through the resulting problems, to the ITS equipment that can alleviate the problems.

Table 16
Impairments, problems and ITS equipment for older car drivers

Impairment	Problems	ITS equipment
Increased reaction time. Difficulty dividing attention between tasks	Difficulty driving in unfamiliar or congested areas	Navigation/route guidance Traffic information, VMS
Deteriorating vision, particularly at night	Difficulty seeing pedestrians and other objects at night, and reading signs	Night vision enhancement. In-vehicle signs
Difficulty judging speed and distance	Failure to perceive conflicting vehicles. Accidents at junctions	Collision warning. Automated lane changing
Difficulty perceiving and analyzing situations	Failure to comply with yield signs, traffic signals and rail crossings. Slow to appreciate hazards on highway	In-vehicle signs and warnings. Intelligent cruise control
Difficulty turning head, reduced peripheral vision	Failure to notice obstacles while manoeuvring. Worries over merging and lane changes	Blind spot/obstacle detection. Automated lane changing and merging
More prone to fatigue	Get tired on long journeys	Intelligent cruise control. Automated lane following
General effects of aging	Worries over inability to cope with a breakdown. Worries about driving to unfamiliar places, at night, in heavy traffic.	Emergency callout (Mayday). Vehicle condition monitoring. ATIS
Some impairments vary in severity from day to day. Prone to tiredness	Concern over fitness to drive	Driver condition monitoring

(Source: Mitchell and Suen, 1997)

7.6.2 Advanced travel information systems (ATIS)

Advanced Travel Information Systems (ATIS) are the group of systems that provide pre-trip and en route information to travellers by any mode. ATIS has the potential to make driving easier by providing traffic and travel information to overcome uncertainty and unfamiliarity en route. These systems are designed for all drivers but have the potential to provide particular benefits for elderly and disabled drivers.

Navigation and route guidance systems - These in-vehicle systems advise the driver on the route from the vehicle's present position to a pre-programmed destination. Most automatically revise the recommended route if the driver departs from it, but some need to be reset to start a new journey if the driver leaves the pre-computed route. Some use diagrams of each junction of the route to indicate the direction to take, others use a map on which the preferred route is highlighted, and many offer the choice of map or junction diagram displays as alternatives. Figure 7 showed the Rockwell/Hertz "Neverlost" navigation system. Figures 14 a and b show two other systems that are in production.



Figure 14a The Philips “Carin” navigation system, available as original equipment in BMW 5- and 7-series automobiles



Figure 14b A Siemens TIS navigation system, showing a map display (compare with Figure 7, which shows a junction direction display)

Tests during the DRIVE II EDDIT Project showed that navigation systems assist elderly drivers and give many the confidence to drive to unfamiliar places and into congested town centres (Oxley and Mitchell, 1995). They did not distract drivers and had little effect on driving safety. Drivers appreciated having audio instructions to complement the visual display of the route to follow. When they worked well, drivers described them as “like having a good co-driver in the car”. But in one city the digital map was not sufficiently up-to-date. Drivers found themselves directed into minor roads that were not on the map or junction layouts had been changed so that the display did not match the road. Problems with the map were the largest cause of driver errors when using the system.

Navigation systems need to be as simple as possible to use. It seems desirable that the destination can only be set while the car is stationary. Once a destination has been selected, the driver should not need to operate any controls on the system. Drivers prefer symbolic guidance at junctions to a more complex map. Junction symbols should be at least 5 cm high, yellow on a blue background. Text should be at least 3 mm high, spaced at not more than 3 letters per cm.

Direct sunlight on the screen often makes it difficult to read the display. Drivers like audio instructions to complement visual guidance. This should provide an initial warning of an impending manoeuvre plus an action message when the manoeuvre is required. If a distance countdown to a junction is provided, it must reach zero at or before the junction, otherwise the driver tends to overshoot. In the EDDIT Project, drivers did not like touch-screen controls. Systems should allow older drivers to select routes to avoid heavy traffic or freeways. Drivers should not need to reset a destination if they leave the recommended route.

Navigation and route guidance systems only become possible when a detailed digital map of the road system of an area exists. Maps of Europe and North America are being developed by at least two commercial organisations, which is one reason for the rapid growth in the availability of ITS navigation systems. The task of preparing and updating the digital map of the area should not be underestimated. The map needs to contain details of prohibited turns, one-way streets and the lane required on the approach to a junction. To avoid confusing drivers at junctions or directing drivers into roads that have been closed, the map must be updated any time the road system is changed. It may be possible to transmit corrections to the map from a Traffic Control Centre when a navigation system is switched on.

On-board display of signs and warnings of hazards - Elderly drivers experience deteriorating visual acuity and increased reaction times. Both these physiological effects make it difficult to read road signs, particularly at night. The technology exists to transmit the content of a road sign from the roadside to a vehicle and to display a replica of the sign, either on a screen on the dashboard or via a head up display (see Figure 15). This enables the sign to be read more easily and to be retained until the driver cancels it. The same system could be used to transmit advance warnings of rail road crossings and hazards on highways. Widespread application requires national or international

standards for the transmission of roadside information, and considerable investment in roadside transmitters.



Figure 15 In-car signing in a driving simulator at Centro Recherche Fiat
(Photo: Centro Recherche Fiat in ITS: intelligent transportation systems)

Variable message signs - Many urban areas are using variable message signs to direct drivers around congested areas, to guide them to parking where space is available and to guide them towards park and ride facilities. These signs, which complement radio announcements of traffic conditions, require no equipment in the car. It would be a minor addition to use variable message signs to guide disabled drivers to available special parking. Since many disabled people have a walking limit of as little as 100 yards, parking close to a destination is required to make that destination accessible. The size of lettering and the colours and contrasts used on variable message signs need to be acceptable to elderly drivers.

Traffic information - Traffic information systems should enable elderly drivers to avoid congestion and the disrupted driving conditions that cause stress and difficulty. In Europe, systems are available commercially to warn drivers of congested traffic. In Britain, Trafficmaster provides real-time measurements of speeds on motorways and main roads for visual display in a vehicle (see Figure 6). The Volvo Dynaguide is in large-scale use in taxis in Gothenburg, where it displays congestion as different colours on a road map of the city.

Elderly and disabled drivers should be involved in the human factors tests of these systems. Some of the existing systems require drivers to select the information required while driving, and tests have found significant interference with the driving task. The EDDIT Project found that the Sagem Carminat C1 traffic information system, which required the driver to position a window on a screen using a 4-way switch, interfered with driving to such an extent that significant speed changes and lateral wander occurred when the system was used (Oxley and Mitchell, 1995).

Touring information - Hand-held information storage and display units already exist that can provide touring or recreational information. For the cost of developing the data, these could be extended to provide specialized touring information about accessible facilities for elderly and disabled travellers. These units could become the start of a family of equipment containing some combination of telephone, GPS, radio data receiver and digital maps that could provide a range of communication, emergency alert, traffic warning and navigation/guidance services.

7.6.3 Control and safety systems (AVCSS)

There are many technologies that can help drivers, and most of them will prove particularly helpful for elderly drivers, since the effects of aging make driving more difficult for elderly people. These technologies include automation of various control functions, night vision enhancement, collision warning, blind spot/obstacle detection, driver condition monitoring and emergency alert/callout systems. Although these systems are intended for the general population of drivers, the assistance they provide closely matches the impairments that are caused by aging, as was shown in Table 2.

Vision enhancement - Vision enhancement describes a number of systems that improve the ability of drivers to see in darkness and poor visibility. The system that is likely to be in service first uses ultraviolet headlights to illuminate the road with UVA radiation without dazzling other drivers (Catling, 1994). Many detergents, dyes or pigments absorb UVA and re-emit visible light. The coats of many animals, including elk, fluoresce naturally. Volvo have tested UV enhanced headlights called UV-Light on prototype cars. Trials showed that the distances at which pedestrians and roadside objects could be seen with UV-Light were increased by about 100 m relative to the distance with dipped headlights (Oxley and Mitchell, 1995). The benefits of UV enhanced headlights can be increased by including fluorescent dyes or pigments in road markings, signs and vehicle paints. Introduction of UV-Light on production cars has been delayed by questions over the risk posed by objects that do not fluoresce and the possible health hazards of UVA radiation.

The other technologies employ infrared to provide night vision. One, called near infrared (NIR), illuminates the driving scene so that reflected infrared can be detected using a device similar to a camcorder. The resultant image is projected onto a head-up display to coincide with the outside scene. Other information, such as range or collision warning, could be included in the display. The growing number of older drivers is helping propel

the market for enhanced vision systems in the U.S. GM consider NIR vision enhancement will be available within ten years.

The DRIVE II EDDIT Project concluded that vision enhancement was the ITS system that had the greatest potential for improving road safety for elderly drivers. An FHWA study (Francher et al., 1994) suggests that in the U.S., vision enhancement could reduce the number of fatal accidents by 23 percent and the cost of all accidents by 11 percent. However, the European Traffic Safety Council (ETSC, 1993) estimated a maximum accident reduction of 1 percent for UV-Lights and 7 percent for vision enhancement by image processing. The results of such studies depend greatly on the assumptions made in them, but it is difficult to believe that vision enhancement would not improve driving safety at night.

Collision warning - There is a clear move by the automotive industry from crash protection to crash avoidance, using ITS to reduce the number of mistakes made by drivers. Collision warning can, in principle, cover rear-end collisions, lane keeping, lane changing and merging, conflicts at junctions and head-on conflicts while overtaking.

Measurement of available gaps in oncoming traffic to determine the safety of turning across the traffic is conceptually straightforward. The EDDIT Project tested a collision warning system in a driving simulator, and found it effective in preventing elderly drivers from turning across traffic through gaps that were dangerously short (see Figure 16). In the driving simulator trials, the collision warning system was even more effective for a small sample of younger drivers than for the main sample of older drivers.

The most complex situation to analyze for collision detection is at a junction, where vehicles can approach from ahead or either side, and can continue straight through the junction or turn. Studies are in progress on possible collision warning or avoidance systems for this situation. Equipment to protect against junction collisions will take the longest time to develop, but it does offer great benefits for elderly drivers and should help to overcome a major cause of accidents.

Obstacle detection - The terms "blind spot" and "obstacle detection" are used for two rather different classes of system. One class, of which examples are already in production for cars, trucks and school buses, detects objects close to a slow-moving vehicle. This helps the driver avoid collisions with people or objects hidden by darkness or blind spots while manoeuvring at low speed (see Figure 17). The other, which is still experimental, detects vehicles in hazardous positions during merges onto highways or lane change manoeuvres.

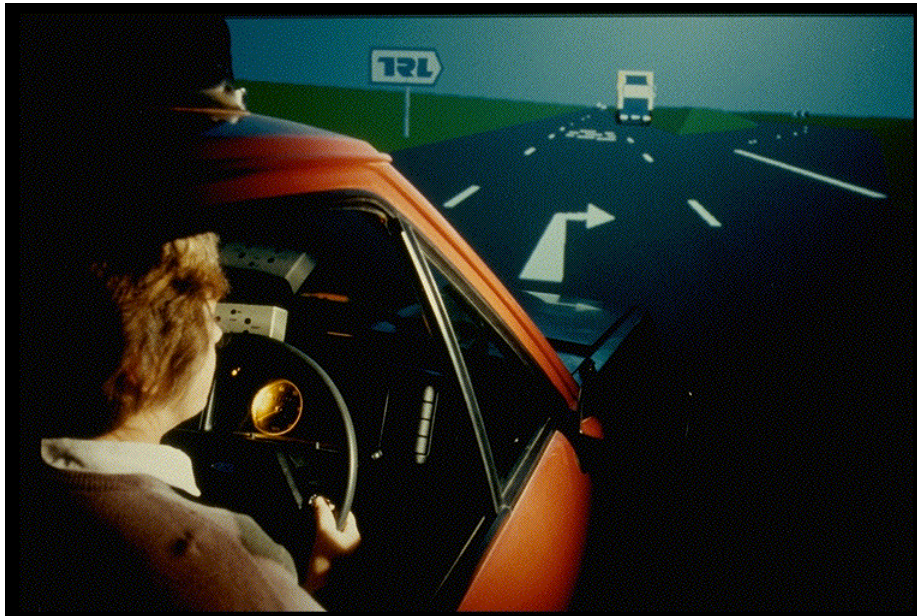


Figure 16 Simulator tests of a collision warning system. *The white box in front of the driver shows a green light if the gap to the nearest oncoming vehicle is more than 6 seconds, red if the gap is less. The tests were conducted in the driving simulator at Transport Research Laboratory. (Photograph: Transport Research Laboratory, Crowthorne).*



Figure 17 The Bosch ParkPilot obstacle warning system. *The light array on the rear parcel shelf shows green, yellow, red or red flashing, depending on the distance to the nearest obstacle behind the car.*

Both these classes of system are potentially of particular value to elderly drivers. One class of accident experienced frequently by elderly drivers is the low speed, damage only, collision while manoeuvring into a driveway or parking space. In addition, older drivers are deterred from using highways, which are objectively the safest roads, by fears of merging and lane changing. These manoeuvres are more difficult for older drivers because of reduced neck flexibility to look sideways, reduced peripheral vision, and the fact that both merging and lane changing require the driver to look forward to control the vehicle while monitoring traffic behind and to the side in other lanes. Tasks that require attention to be divided between two or more tasks are particularly difficult for older drivers.

Driver condition monitoring - It is believed that many single vehicle accidents are caused by drowsiness, and accidents of all kinds by incapacitation due to alcohol or drugs. Elderly drivers are much less likely than average to drive after drinking. However, elderly drivers are believed to be prone to tiredness, and do limit the length of their journeys because of this. Also, some impairments vary in severity from day to day. For elderly drivers, equipment to monitor driver state on an advisory basis could give confidence to continue driving. The European PROMETHEUS program has used two methods to monitor driver alertness (Catling, 1994). In Japan, Nissan has started field trials of a camera to monitor drowsiness in drivers (McCulloch, 1995). It is not yet known whether the measures of driver fatigue for the general population are also suitable measures for elderly and disabled drivers.

Intelligent cruise control (ICC) - Intelligent cruise control (ICC) adjusts the speed of a car in response to a speed set by the driver and measurements of the distance to the vehicle ahead. Most automobile manufacturers have prototypes of ICC systems running; in Sweden systems have been tested on public roads at the West Sweden test site. First systems of this type should be available as original equipment on production cars by 1998, and should reduce driver fatigue. In the further future, ICC systems may respond to the on-board navigation system or to roadside signals indicating the local speed limit, a yield sign, a traffic signal at red or a rail crossing, as well as to measurements of the distance to the vehicle ahead. Since elderly drivers have a higher than average number of accidents that involve failure to comply with rights of way such as yield or stop signs, or traffic signals, ICC should assist elderly drivers avoid this class of error. A Delphi survey by the University of Michigan (Underwood, 1992) predicts that ICC will achieve 5 percent market penetration by 2004 and 50 percent penetration by 2015, while GM suggest it will be in production within five years. BMW are planning to offer ICC on some 1998 models.

ICC systems should not involve the driver in any actions other than switching the system on or off and setting the desired cruise speed. Nevertheless, elderly drivers should be included in the samples of drivers who assess the human factors aspects of ICC systems. It is not yet known how elderly drivers will react to their vehicle changing speed without them having initiated the change.

Automated lane following, merging and lane changing - In the near future, equipment to assist with lane following will become available on production cars. The version proposed by BMW requires the driver's hand to be on the wheel, to make clear that the system is not intended for automatic driving. Used in conjunction with intelligent cruise control, lane following assistance should reduce the stress and fatigue of highway driving for elderly drivers. In the medium future, probably between 2010 and 2020, equipment for automatic lane following and automatic merging is expected to become available. This should make driving on highways even easier for elderly drivers, by making driving semi-automatic. Since highways are the safest roads, anything that encourages older drivers to continue to use highways instead of the less safe local roads should reduce the accident rate for older drivers.

7.6.4 Emergency management systems (EM)

Emergency alert (Mayday) - Systems that automatically report the location of a vehicle to an emergency centre in the event of a breakdown, accident or other emergency, and which allow communication with the centre, are now in production. The EDDIT Project found that all the elderly drivers who tested a prototype emergency alert system reported that it increased their confidence and feeling of security (Oxley and Mitchell, 1995). Eight out of 22 elderly drivers thought that they would be more willing to drive at night, on motorways and in unfamiliar areas if they had such a system.

Barkow et al. (1993) found that elderly drivers wanted to have the mechanical condition of their vehicle monitored, to give them advanced warning of a problem or breakdown. This was because they felt that they were not likely to be able to make roadside repairs such as changing a tire, and therefore it was important that they were able to avoid situations that required such actions.

7.6.5 Automated highways (AHS)

A major objective of the U.S. ITS program is to develop the technology for fully automated highways. Individual manufacturers in both Europe and North America have demonstrated automatic vehicles running individually and in platoons at close headway. The U.S. is due to demonstrate a test section of an automatic highway on I-15 north of San Diego in August 1997. The application of this technology to the normal use of highways and other major roads must be a long way in the future and depends on solving many problems concerning the system operation, reliability and institutional issues. Nevertheless, automated highways potentially offer a form of road transport that should be usable by elderly drivers, despite the effects of aging. To achieve this potential, it is necessary to take account of the requirements and limitations of elderly drivers throughout the development of automated highways.

8. THE MARKET FOR ITS EQUIPMENT FOR ELDERLY AND DISABLED PEOPLE

The IVHS America Strategic Plan (1992) estimated the expenditure on ITS deployment over a 20-year period as shown in Table 17.

Table 17
Distribution of 20-year ITS deployment expenditure, millions of dollars (U.S.)

ITS sub-system	Public sector costs	Consumer costs	Total
ATMS (traffic management)	24 941	0	24 941
ATIS (transport information)	1 996	102 362	104 358
AVCSS (control and safety)	4 320	46 250	50 570
CVO (commercial vehicles)	4 986	21 775	26 761
APTS (public transport)	2 855	0	2 855
Planning and engineering	340	0	340
Total	39 438	170 387	209 825

(Source: IVHS America, 1992)

Much of the equipment for supplying information to transit passengers in the U.S. is being installed to serve elderly and disabled people as a result of the Americans with Disabilities Act. This equipment is included in the total for APTS in Table 17. The readiness of consumers to purchase advanced travel information is currently being questioned (Orski, 1996). However, studies by SRI Consulting and reported in "Inside ITS" (November 18, 1996) consider that the markets for ITS infrastructure and fleet management equipment will be at least as large as those estimated in Table 17, as shown in Figure 18.

Hickling Corporation has developed market estimates of ITS for seniors and people with disabilities (Guthrie and Phillips, 1994). This identified the numbers of seniors and people with disabilities for whom particular types of ITS would be applicable. It showed that ATIS would be relevant to 59 million people with disabilities and to 18 million seniors in North America, as shown in Table 18.

The biggest market of ITS systems for elderly and disabled people is likely to be for equipment developed for the general population, that happens to be appropriate for elderly travellers and, particularly, for elderly drivers. Given that people with disabilities now account for some 2.1 million drivers of personal vehicles in Canada (about 11 percent of all drivers), it is likely that people with disabilities are likely to provide at least 10 percent of the market for ITS equipment for use in private vehicles. By the year 2020, the proportion of the population aged over 65 years is expected to 14 - 17 percent in Canada and about 18 percent in the U.S. Non-elderly people with disabilities will increase the total of elderly and disabled people to some 25 percent of the total

population and 20 percent of the population of car drivers. These percentages imply that by the year 2020, elderly travellers are likely to form between 20 and 25 percent of the market for ITS equipment purchased by individuals.

It may well prove to be difficult to make commercially viable products that are intended specifically for elderly and disabled people. It is relatively easy to ensure that equipment intended for the whole population is suitable for elderly and disabled people, and this group must be considered from the start of the development of a new product.

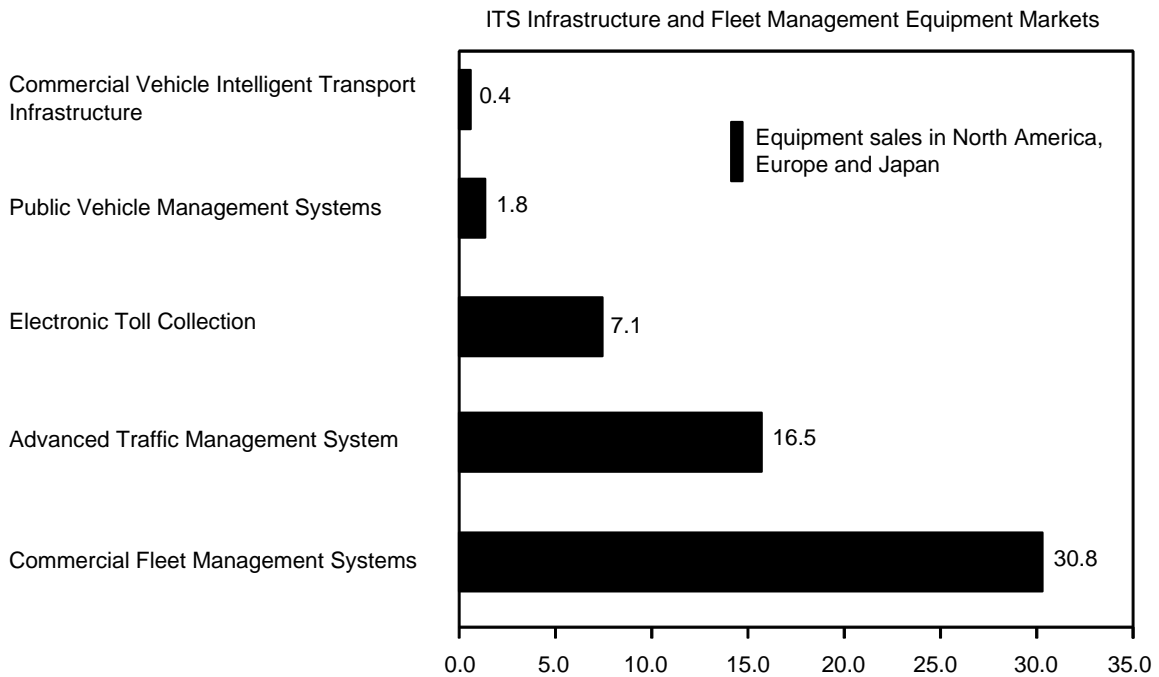


Figure 18 The projected market for ITS equipment in North America, Europe and Japan (Source: SRI Consulting, in Inside ITS, November 18, 1996)

Table 18
The potential beneficiaries of ITS with transportation disabilities
in North America in 1995

ITS application	Key beneficiaries	Potential number of beneficiaries with transportation disabilities
General systems		
Advanced traveller information systems (ATIS)	All people with transport disabilities.	59M with disabilities, 18M seniors.
Personal vehicle		
Collision avoidance systems	People with reduced perceptual, cognitive and mobility abilities.	40M with disabilities, 18M seniors.
Automated toll and parking payment	People with agility impairments, seniors and people with cognitive impairments.	24M with agility impairments, 18M seniors, 7M others.
Navigation/route guidance systems	Seniors and drivers with cognitive/learning disabilities.	23M seniors, 7M people with cognitive impairments.
Automatic comfort settings	People who have difficulty positioning seats, mirrors, etc. or forget to do so; those with agility and cognitive impairments and some seniors.	30M people with agility and/or cognitive impairments; 23M seniors who drive.
Emergency vehicle location and call	All users of personal vehicles; seniors and people with cognitive, mobility and communication impairments.	23M drivers who are senior, 40M others with disabilities.
Vision enhancement systems	People with reduced visual acuity at night; seniors, some people with poor vision.	23M drivers who are senior, 8M with poor vision.
Intersection assist and in-vehicle signs	Senior drivers and drivers with cognitive impairments, some drivers with hearing, mobility or agility impairments.	23M seniors, 40M drivers with cognitive, hearing, mobility or agility impairments.
Intelligent cruise control and lane keeping support	Comfort aid for all drivers; safety aid for some, including seniors and people with cognitive impairments.	66M overall, including 23M seniors and 7M with cognitive impairments.
Monitors of driver condition	All drivers, with special application to seniors and people with cognitive and agility/mobility impairments that become worse with fatigue.	23M seniors, 30M others.

(Source: Guthrie and Phillips, 1994)

9. RESEARCH ON ITS AND ACCESSIBILITY

The aspects of ITS that will make the greatest contributions to increasing the accessibility of transport are likely to be assistive technology for all drivers (which will be particularly useful to elderly drivers), the progressive automation of the highway-vehicle system, the provision of much better information to travellers on foot, by public transport and by car, and the development of special guidance equipment for visually impaired pedestrians. Most of these systems will be developed for all travellers, not specifically for elderly and disabled people. Research on ITS and accessibility should focus on two principal issues; ensuring that all ITS equipment is easy for everybody to use, including elderly and disabled people, and developing specialized equipment or modifications to existing equipment to satisfy the specialized requirements of elderly and disabled people.

The development of any ITS equipment must take account of the requirements of elderly and disabled people, since by the year 2025 they will comprise more than a quarter of the total population and perhaps twenty percent of all drivers in North America, and provide a corresponding percentage of the market for ITS equipment. The rapid rate of development of ITS means that it is important to get guidance on the ergonomic requirements of elderly and disabled people to industry more quickly than is possible through the formal channels of the international standardization organizations.

Section 9.1 lists the development activities and the ITS products that should contribute to improving accessibility. Section 9.2 suggests a research program for the Transportation Development Centre based on the list of activities and products.

9.1 Activities and ITS Products to Improve Accessibility

The following list of development activities and products covers the things that need to be done to ensure that ITS is useful for elderly and disabled people and to overcome problems experienced by many people. The products may provide niche markets for Canada to exploit. However, intelligent transportation systems are developing very quickly at present, and it is likely that equipment is being developed somewhere in the world to fill any gap that can be identified at present. ITS has the potential to help public transport users and pedestrians, as well as drivers of private vehicles. Developments need to consider its application to all modes of transport.

9.1.1 Data bases and statistics

Digital maps - Many of the ITS technologies described in sections 7 and 8 can only be applied in areas for which high quality digital maps of the road system and associated land uses and addresses exist. In Canada, the Centre for Topographical Information, Natural Resources Canada, has produced a structured digital data base for the Canadian road network which covers the whole country. Roads are represented by their

centre lines and are classified into highway, primary road, secondary road, street and access links. This data base is sufficient for many ITS applications, but not for in-vehicle navigation systems. Navigation Technologies Corporation will start building a digital road map data base for the major cities of Canada in 1997, starting with Toronto.

Statistics on elderly and disabled drivers - In Canada, statistics on the proportion of people of different ages holding driving licenses and currently active as drivers are not available. This is partly a result of the federal structure of the country, which means that data on drivers, vehicles and road traffic are fragmented between the provinces, and not necessarily collected on a consistent basis. In addition, Canada does not conduct a regular national travel survey, as is done in Britain and the U.S. These surveys are the only reliable way to measure the proportion of the population in different age groups holding driving licenses and continuing to drive. Lack of this information makes it impossible to accurately forecast the likely increase in the number of elderly drivers, as a basis for policy decisions. Information on the number of drivers with disabilities is also lacking, as is any information on accidents involving disabled drivers and converted vehicles. This information is needed for policy decisions on the control of vehicle conversions and the safety of disabled drivers.

9.1.2 General

- Make the ergonomic evaluation of any ITS equipment used by the public a routine part of the design process. Include elderly and disabled drivers and travellers in these assessments (by 2025 these groups will make up about 25 percent of the market for ITS equipment).
- Develop ergonomic guidelines for the design of ITS equipment to be suitable for elderly and disabled people. Work on general human factors aspects of ITS is in progress in CEN TC278/WG 10, ISO TC204 and ISO TC22/WG8. It seems likely that it will take some years for these bodies to produce guidance for industry. For this reason, quickly produced guidelines specifically relating to elderly and disabled users, which are needed now, would help to make ITS equipment easier to use.
- Develop a family of hand-held information storage and display equipment. This range could start with a personal organizer/electronic yellow pages carrying travel and touring information (special information on accessible facilities or services for elderly and disabled people); more complicated versions could include some combination of telephone, receiver for real-time data, GPS and digital map. These could provide real-time traffic and transit information, communications, emergency alert, location and guidance. A specialized version of this equipment could provide location and guidance assistance to people with visual impairments.

- Introduce to North America the British Royal National Institute for the Blind contactless “React” transponder to activate various types of equipment, including making video displays talk when required. An example could be a modification to information display systems in transport terminals and possibly at bus stops to trigger audio announcements from visual information displays or to change the size of the text displayed when required by a person with impaired vision. Another example is the operation of powered doors by a person in a wheelchair.

9.1.3 Car drivers

- Set up, in co-operation with the U.S., long-term trials of the use of ITS by elderly drivers. Fit out a number of cars with the ITS equipment now available and find out how elderly drivers use this over a period of several months to a year. Note ergonomic problems and the effect of the equipment on where and when elderly people drive (and possibly on safety - reports of near misses and perceived problems, for example). The equipment could include route guidance, traffic information, rear obstacle detection, emergency alert (Mayday) and, if available, night vision enhancement.
- Confirm that the measures of driver fatigue that are being established for the general population also apply to the population of elderly and disabled drivers.
- Introduce a system to broadcast map corrections direct to a vehicle’s navigation system, at least at the beginning of a day’s driving and possibly on a continuous basis to reflect accidents and incidents. One problem with navigation systems that has already been observed in Europe is the difficulty of keeping the system map updated with changes to the road network, let alone day-by-day changes when roads are closed for maintenance or other purposes. This problem would be eliminated by the introduction of dynamic route guidance systems which take account of traffic and delays in selecting routes.

9.1.4 Public transport users

- Extend smart payment cards to make a single card cover public transport operators in many towns plus railways and public telephones (as is done already by the German Association of Public Transport Operators VDV). This could be further extended to include air travel and major hotel chains. As a further extension, the card could carry, on an optional basis, information on passenger requirements (need wheelchair space, need staff assistance, prefer non-smoking room or seat, prefer to travel back to engine, etc.). The card would need to be able to operate as a proximity card for paying bus fares and an inserted card for use with telephones and, possibly, bank automatic machinery (ATMs).

- Develop equipment for a communication system between passenger and bus to help a passenger hail a community bus. This is targeted specifically at the elderly and disabled population and therefore would be expected to have a smaller market. However, it could well be applicable to hailing long-distance buses, which could increase the market. No such system is known to be under development.
- Establish system that provides information on the predicted arrival times for buses at specified local bus stops, and other transit, travel and Yellow Pages information, using cable to a home computer or television, the Internet or broadcasts to a portable receiver.
- Look for other low cost ways to use ITS to help disabled people. One possibility is the use of inductive loops in transit vehicles, to enable people with impaired hearing who use a hearing aid with a "T"-switch to hear announcements direct through their hearing aid, without interference from other conversations and background noise. Swedish Railways already provides inductive loops in the X2000 long-distance train, but the technology does not seem to have been applied to urban transit, where it would be more useful because background noise levels are higher.

Taking account of the requirements of elderly and disabled people means, firstly, ensuring that equipment is easy and safe to use by this group of people. This will almost certainly make it easier and safer for the whole population to use. Secondly, it means seeking ways of extending standard equipment to cover the specialized requirement of elderly and disabled people. An example would be adding an additional, optional, data base of accessible facilities to a standard hand-held data storage and display unit. Thirdly, it means seeking ways to use existing technology to perform a service specifically for elderly or disabled people. Using a contactless transducer to trigger audio announcements for a visually impaired person from a visual display of information would be a typical example.

9.2 A Research Program for Canada

This section develops suggestions for research that could usefully be conducted in Canada to improve accessibility through the use of ITS, based on the activities and products described in section 9.1. This research would be appropriate for the Transportation Development Centre to manage, though this is not the only way the program could be achieved. Some elements might be taken on by the National Research Council, others by industrial consortia or groups of municipalities or public transport operators. Some of the elements of the program could be purely Canadian activities, but many would involve international liaison or co-operation. Virtually all the elements require partnerships between the research managers and other organizations.

A promising development is the launch of an International Harmonized Research Agenda (IHRA) by the international forum Enhanced Safety of Vehicles (Noy, 1996). The

IHRA comprises six high-priority research areas, including Intelligent Transportation Systems. The goal of harmonized research on ITS is to develop test procedures to assess driver-vehicle interaction as a means for determining the safety potential of ITS crash avoidance. The three key elements of this research are government orientation, safety evaluation and driver-ITS interaction. Canada has been identified as the lead country for this activity. This provides an excellent opportunity for the production and dissemination of ergonomic guidelines for ITS, as described in points 1 and 2 of section 9.1.

If a research program similar to that suggested here is implemented, it will be necessary to ensure that liaison is maintained between the separate elements, and that where duplication of activities occurs it is limited and is known to all those involved. This task of co-ordination would fall naturally to the Transportation Development Centre if the whole program were to be managed by TDC. If the program management is split between several organizations, the co-ordination could still fall to TDC as a specific task, or could become a role for ITS Canada. This issue is explored in section 9.2.7.

9.2.1 Digital maps of the road system

Many aspects of ITS can only be implemented in areas where a digital map of the road system exists. This is self-evident for the in-vehicle navigation systems, for which the digital map has to be to a high standard. For other applications such as bus location systems, traffic control centres and the display of traffic information, a lower standard of digital map can be used. The maps for navigation systems must include one-way streets and turn restrictions, the detailed layout of complex junctions, minor roads which could be confused with intended routes, vehicle-type restrictions and entrances to any parking areas that are in the list of destinations (Navigation Technologies, 1996). To the map must be added a list of geographically coded addresses, either by name ("The Holiday Inn") or by number ("800 Blvd René Lévesque West"). At least four commercial organizations, Etak, Navigation Technologies Corporation, Tele Atlas and Zenrin, are between them building data bases for North America, Europe and Japan.

In September 1996 these four map producers, together with manufacturers of cars and consumer electronics and the software industry, agreed that one uniform standard for navigation data bases should be adopted on a worldwide basis as soon as possible. The only certified standard that already exists in this market is the GDF data standard that was drawn up in Europe and later discussed and modified by ISO. Japan and the U.S. have agreed in principle to accept as many European GDF definitions as possible to quickly reach agreement at a global level. The intention is that a CD of navigational data from any manufacturer should be usable in any navigation hardware in any vehicle (Traffic Technology International, Oct./Nov. 1996).

By the end of 1996, digital map coverage of the U.S. is complete for the inter-town road network; coverage in major metropolitan areas is complete for over 100 million population. By the end of 1998, all metropolitan areas of over one million population

should be complete. In Europe, inter-town coverage is complete for Austria, Belgium, southeastern England, France, Germany, northern Italy and Switzerland. Spain and the rest of Britain and Italy should be covered by the end of 1997, and most of the remainder of Western Europe by the end of 1998. Coverage of major metropolitan areas in Europe is already complete for about 80 million population.

In Canada, the Centre for Topographical Information, Natural Resources Canada, has produced a structured digital data base for the Canadian road network. This covers the whole country and is based on existing maps at 250 000 scale, with greater detail included where maps are available at 50 000 scale. Roads are represented by their centre lines and are classified into highway, primary road, secondary road, street and access links. The maps carry road numbers and exit numbers, but not street names. Junction geometry, one-way streets and turn limitations are not included. Updating the road networks for the 300 major Canadian cities is due to start in April 1997. This data base is sufficient for many ITS applications, but not for in-vehicle navigation systems. It is likely to form the basis for any future Geographical Information Systems (GIS) in Canada, as other organizations such as Statistics Canada and Canada Post link their own data bases to it.

Navigation Technologies are planning to build a digital map data base for Canada, starting with detailed networks for the major cities. Work on the data base for Toronto will start in 1997, with completion scheduled for 1998. The data bases for Vancouver and Montreal should follow shortly thereafter. It is likely, but not yet decided, that the whole of Southern Ontario will be included in the data base early in the process. Construction of the less detailed inter-town road network is being planned, and parts of the network may be available relatively soon.

The role for Transportation Development Centre - There is no need for the Transportation Development Centre to take an active role in the development of the digital road network for Canada, as this is happening already. It should maintain contact with Natural Resources Canada and with Navigation Technologies Corporation, as these are the foci of the digital mapping of the road system in Canada.

9.2.2 Ergonomic guidelines for ITS equipment

The first objective of this element of the research program is to get ergonomic guidelines for ITS equipment suitable for elderly and disabled people into the public domain. Information for these guidelines already exists in Europe (Ross et al., 1995; Nicolle and Stapleton, 1995; Oxley and Mitchell, 1995) and in Canada in the expertise of Transportation Development Centre and a number of consultants. In the U.S., Green et al. (1995) and Clarke et al. (1996) provide guidelines for the general population but not specifically for elderly and disabled people. Battelle will be submitting draft ergonomic guidelines to the Federal Highways Administration in January 1997 which include consideration of elderly drivers, but these will probably not become available until late 1997. In Britain, the British Standards Institute has published a guide to in-vehicle

systems (BSI, 1996), which offers the best current advice as to the design, installation and use of in-vehicle information systems. The British Department of Transport has produced a quantitative checklist to apply the requirements of this guide to individual in-vehicle information systems (Department of Transport, 1996).

Three factors are important in the publication of ergonomic guidelines.

- They need to be published very quickly, because equipment is being designed in 1996 and the information is required immediately. The current generation of equipment will set the design approach for some time to come (this can be seen already for navigation systems, where the case and controls are very similar for a number of different products).
- They must not be seen as competing with the formal standards being produced by bodies such as ISO and CEN.
- Their production should have the approval of the three co-ordinating organizations ITS America, Ertico and Vertis, and ideally they should be distributed by those organizations to manufacturers in the U.S., Europe and Japan.

These are difficult goals to achieve, because each organization will naturally want to develop its own guidelines, and the need to produce guidelines quickly conflicts with the need to obtain approval for their use outside Canada.

Canada is in a strong position to produce ergonomic guidelines for several reasons. The Transportation Development Centre, and several consultants who work with the Centre, have long expertise in the application of ergonomics to transportation systems that are accessible to elderly and disabled people. Because Canada does not have indigenous automobile design organizations, or the design organizations for any major consumer electronics manufacturers, it can produce guidelines without the risk of appearing to bias them to favour indigenous manufacturers.

One possible mechanism for the dissemination of ergonomic guidelines for ITS equipment is through the international forum for the Enhancement of Safety of Vehicles, ESV. This forum brings together government regulators involved in road vehicle safety. It has recently established a number of Internationally Harmonized Research Activities, IHRA. The identification of Canada as lead country for the IHRA on ITS provides a natural mechanism to disseminate ergonomic guidelines and evaluation procedures. Other possible routes are through direct contact with the international standardization organizations, with the appropriate government agencies in countries with industries that design and manufacture motor vehicles and ITS equipment, and with the organizations responsible for the promotion of ITS (ITS America, ITS Canada, Ertico and Vertis). It would also be worthwhile to present the guidelines repeatedly at conferences and professional meetings such as those named above.

The approach to the production of ergonomic guidelines that would have the best chance of success would be to allocate resources to drafting guidelines on the basis of existing research results as an element of the ESV research activity on ITS. Once these resources were committed, notification of the project and an invitation to a briefing on it should be sent to ITS America, Ertico, Vertis, ITS Canada, Industry Canada, ISO TC204, ISO TC22/WG8, CEN TC278/WG 10 and experts in the field such as Battelle Human Factors Transportation Center, U.S. Federal Highways Administration, HUSAT (University of Loughborough, England), INRETS (France) and to Canadian ergonomic consultants, as well as ESV partners. From this meeting, a consultative group should be established, to be informed of progress and invited to comment on drafts. This group should not have any veto over the guidelines, as it would be almost impossible to achieve consensus on all aspects of the publication.

The roles for the Transportation Development Centre - The technical task of reviewing the literature and drafting guidelines should not take more than about nine months for one person who is already experienced in the application of ergonomics to accessible transport. The task would be a very appropriate one for the Transportation Development Centre, either for one of its own staff or by using a consultant in close liaison with a TDC project officer. Specification of the research project and publication of the guidelines should be by Transport Canada.

The Transportation Development Centre should also encourage, as a consequence of the work of the consultative group, the widespread recognition of the need to conduct ergonomic evaluations of all new items of ITS equipment. Persuading industry to make such evaluations, and to always include elderly and disabled people in the evaluation panels, is a matter of continuing education. Some of the papers recently produced by TDC represent first steps in a process that will inevitably be an ongoing one (see, for example, Mitchell and Suen, 1997 and Suen, Mitchell and Rutenberg, 1997). Further effort is needed to repeat this message at international conferences, and to promote the guidelines as soon as they become available. Papers on this theme should be submitted to the Fourth World Congress on ITS in Berlin in October 1997, to the 8th Conference on Mobility and Transport for Elderly and Disabled People in 1998, to the U.S. TRB Annual Meetings and to other meetings that provide opportunities.

9.2.3 Long-term trials of ITS equipment for drivers

All the evaluations of ITS by elderly and disabled people to date have been short-term. Subjects have tested equipment in laboratories, driven simulators, driven on test tracks or driven cars on public roads, but only for a few hours. The subjects were evaluating the equipment at the same time as they were learning to use it, and any deductions on the effect the equipment would have on their safety and mobility are based on observations during this learning period and estimates by the subjects of how they might behave if they had the equipment long term. In some of the tests during the EDDIT Project, drivers made a number of mistakes while learning to use systems such as obstacle detection,

but the errors had decreased by the end of even a short evaluation trial (Oxley and Mitchell, 1995).

To obtain better information on the ergonomic suitability of equipment once older people have become familiar with it, and to better assess its effect on the safety and mobility of elderly and disabled drivers, trials are needed in which a group of subjects use cars equipped with ITS for periods of several months to a year. The ITS equipment must be well developed and reliable. Systems that would be suitable are navigation/route guidance, traffic information, tourist information/Yellow Pages, parking assistance/obstacle detection and Mayday. It would be very desirable to provide night vision enhancement using UV headlights, if it could be obtained, and possibly also intelligent cruise control. The long term trials should also provide an opportunity to validate the ergonomic guidelines on ITS equipment described in section 9.2.2.

The output from the long-term user trials of ITS by elderly and disabled drivers would be:

- Ergonomic evaluation of the ITS equipment by people who are familiar with it;
- Observations of the effect of ITS on elderly and disabled drivers' mobility, in terms of driving more, driving at night, going to new areas and using highways; and
- Estimation of the effect of ITS on safety by recording accidents, near misses and driver comments.
- Validation of the draft ergonomic guidelines on ITS equipment by using them to predict the suitability of the equipment used in the trials for comparison with user reactions.

This information, which is necessary for assessing the value of ITS to elderly and disabled drivers, can only be obtained from long-term trials.

The trials can only be conducted in an area for which a digital map is available for the navigation system and where traffic information is available for display in the vehicles. The first area in Canada that is likely to have the necessary facilities is Toronto, which could also include electronic toll payment on Highway 407. Possible areas in the U.S. for a co-operative trial include Oakland County, Michigan, north of Detroit, where the Fast-Trac demonstration has been running since 1993 and is now in its third phase; Houston, where traffic information is available on radio and the Internet, and some 700 hand-held computers are already in service in a Smart Commuter trial; Montgomery County, Maryland, where traffic information is available by radio, cable TV, broadcast TV, internet and via personal pagers; and Seattle, San Antonio or the New York/New Jersey/Connecticut area, which appear to have been selected as model deployment sites for the U.S. Operation Timesaver. Further afield, there could be scope for a joint Canadian-French co-operative trial in the Paris area.

The role for Transportation Development Centre - A co-operative trial would be the preferred approach. The Transportation Development Centre has much to offer in ergonomic expertise, experience with accessible transport and evaluation methodology.

A co-operative trial with the U.S. could well obtain equipment from the car and electronics industries and U.S. government funding or staff support. The Federal Highways Administration is requiring the inclusion of elderly drivers in ITS trials, and could well be a willing partner in a joint evaluation program as part of a model deployment of ITS or in the next round of ITS demonstrations. Similarly, a co-operative project with France could well obtain vehicles and electronic equipment from French manufacturers and French government funding or staff effort through INRETS. Disadvantages of co-operation with France are the higher travel costs and the similarity of the scientific experience that could be provided by TDC and INRETS.

9.2.4 Hand-held ITS equipment

It is clear that there will be a market for a family of hand-held ITS units, ranging from simple Yellow Pages directories of services for travellers to complex navigation and communication devices. Some elements of the family exist already as cellular telephones, GPS units, directories of sites and services for users of recreational vehicles, directories of services for travellers along highways in Canada and the U.S., and a hand-held Mayday system for old people that detects falls and automatically reports the occurrence and location of the fall. Two Canadian companies are seeking funding to develop hand-held receivers for travel and traffic information, and another is seeking funding to produce a data base of accessible services for elderly and disabled travellers, to mount on an existing hand-held unit for users of recreational vehicles.

In the U.S., Personal Digital Assistant (PDA) hand-held computers are in service for access to traveller information in several demonstrations and trials. These include the Atlanta showcase, Houston TranStar operational test, and the TransCal and TravInfo operational tests in Northern California (Wollenberg, 1996). In Minneapolis/St. Paul, PDAs and alpha-numeric pagers were used by about 500 individuals in a six-month operational trial (Starr and Wetherby, 1996).

The roles for the Transportation Development Centre - Hand-held units already exist and more refined versions will soon be produced commercially, with no intervention by TDC. The two roles for TDC are, firstly, to ensure that ergonomic guidelines for these devices are available soon and are distributed to manufacturers. Ergonomic guidelines for the use of these devices by elderly and disabled people are particularly important. Because of the small size of the units, these devices are more likely than most ITS equipment to have buttons that are small and close together, screens that are difficult to read and message in print that is too small. The elderly population are the perfect sample against which to check the suitability of these units, because they experience greater problems with the aspects of the devices that all people find difficult.

The second role for TDC would be to support the development of specialized data bases to make the hand-held units relevant to elderly and disabled people. This would have the effect of demonstrating the market for specialized information for elderly and disabled travellers, so that further data bases could be developed commercially. It could also be

used to provide a demonstration of an electronic Yellow Pages service for elderly and disabled travellers, which TDC could assess to ensure that the correct information was being included. The potential of a hand-held location and guidance unit for people with visual impairments has been recognized, but this would be very specialized and the market for such equipment must be limited.

9.2.5 Smart payment cards

Smart payment cards for urban transit services are being introduced commercially in Canada, but in a fragmented way. Each operator requires a passenger to use a card that is unique to that operator. This is partly because there are no standards for smart payment cards and partly because there is no clearinghouse that could distribute revenues from smart cards to the operators on whose services they were used. In Germany, the existence of a strong Association of Public Transit Operators (VDV) and agreements between VDV, German Railways and German Telecom allows a single smart card to be used on any transit system that is a member of VDV, on German Railways and for calls from payphones. A further agreement with the main banks has allowed the smart card to be charged with money from a passenger's bank account, using a payphone as a terminal and card reader.

The roles for the Transportation Development Centre - TDC could act as a focus, probably in partnership with the Canadian Urban Transit Association (CUTA) to develop standards for smart payment cards for use in urban transit. Ideally, this should be done in co-operation with the U.S., to achieve a standard that would be usable throughout North America. This would enable manufacturers of smart cards and their readers to economize on their production, through economies of scale.

A more difficult task would be to achieve agreements between transit operators to accept each others' cards, so that passengers need purchase only one card. If this proves too difficult to do nationally, it might well be possible to achieve locally in areas where there are several transit operators. In the Montreal area, for example, it might be possible to reach agreement between STCUM (Montreal), STL (Laval) and STRSM (South Shore).

An even more difficult task would be to extend the cards to be usable in payphones, and to be chargeable with money through payphones or bank machines (ATMs). Transportation Development Centre, as part of Transport Canada, should have the governmental status to attempt this task, although it is far from certain that it could be achieved, despite the example set by Germany. Achievement of a Canadian equivalent of the German transit smart payment card would be a real benefit to the people of Canada and a potential boost for the manufacture of smart card systems in Canada.

A final role for the Transportation Development Centre is the search for the agreement of disabled people of the value of a traveller card to provide, on an optional basis, transport operators with a statement of any special transport requirements that would make the service they receive more reliable and better tailored to their needs. This could be started through the Canadian Advisory Committee on Accessible Transportation and, if the value of such a card was agreed, through organizations for elderly and disabled people. The European Commission is interested in the concept, and might wish to seek a card that could be used with European as well as Canadian or North American transport operators.

9.2.6 Development of specific ITS equipment

In the past, the Transportation Development Centre has worked in partnership with industry to develop equipment or software to make transport more accessible. Examples are the Visual Communication Network (with Télécité), the talking taxi meter (with Record Electronics Inc.) and the TransView paratransit scheduling and dispatching software (with International Road Dynamics Inc.).

There may well be items of ITS equipment that could provide niche markets for Canadian manufacturers and which need TDC support at the stage of demonstrating technical feasibility. Examples are the application of inductive loops for public address announcements to buses and subway coaches, and a communication system between a passenger and a bus to help a passenger hail a hail-stop community bus or an intercity coach on a rural road.

Such projects need to be treated with great caution. One of the difficulties of developments of this type is the large investment needed to take a product into production after its feasibility and usefulness have been demonstrated. Another, which applies particularly to ITS at the present time, is that the pace of development is such that almost certainly someone is developing equipment to fill any market niche that it is possible to identify.

One application of ITS for which research and development work could well contribute to the safety of elderly drivers is driver condition monitoring. Commercial development of driver monitoring systems is in progress in the car manufacturing companies, as described in section 7.6.3. Research to identify parameters that can be measured and that are good predictors of driver fatigue is in progress at the University of Montreal. To date, none of the research and development for driver condition monitoring has studied elderly or disabled people, and it is far from certain that measurements and criteria developed for a younger and more able population will be relevant to older or disabled people. There is a need to study the characteristics of older and disabled drivers to identify indicators of fatigue for these particular populations.

The role for the Transportation Development Centre - TDC should consider carefully, in liaison with Industry Canada, whether there are items of ITS equipment that it would be

in the interests of the Canadian manufacturing industry to develop. If it is agreed that it would be worthwhile to support development to demonstrate technical feasibility and value to the traveller, then TDC should negotiate a partnership agreement with an appropriate manufacturer. It may well be necessary to fund market research to establish the likely market for particular products.

Notwithstanding this qualification, TDC should arrange for basic research to be conducted to identify suitable measures of fatigue for a population of older and disabled drivers. This should be done by a research group that is familiar with the subject, as one objective is to determine whether the measures that apply to the general population also apply to elderly and/or disabled people.

9.2.7 Maintaining expertise and international liaison

The introduction of ITS is potentially one of the largest changes that road transport has experienced. It should make the system more accessible, but it could inadvertently introduce barriers to elderly and disabled travellers. Governments need to maintain an expert oversight of the introduction of ITS to ensure that unintended adverse consequences do not occur. This is an issue that affects all countries and the Canadian government experts overseeing ITS would do a better job if they were able to develop good liaison links with corresponding groups in the U.S. and Europe.

The best way to maintain the oversight of ITS in Canada is through a group of experts in Transport Canada with experience of accessibility and of ITS. This group should conduct a research program on ITS and accessibility, as outlined in this report, in addition to assisting the policy divisions in Transport Canada and Industry Canada which are concerned with ITS. The research program would improve the quality of ITS equipment and ensure that any regulation of ITS in road transport is based on established scientific facts. It would also maintain the expertise of the research group and would keep them in contact with colleagues in the U.S. and Europe. There would be benefits for Canada, U.S. and Europe if research could be co-ordinated to limit, but not exclude completely, duplication between these areas. This co-ordination could be done through ITS Canada, ITS America and Ertico, or at a government level between Transport Canada, U.S. Department of Transportation and the European Commission.

One task that could very usefully be done by the Transportation Development Centre, as a service to Transport Canada and as a way to maintain expertise, is the production of regular reports giving statistics on licence holding by elderly people, disabled drivers, and the effect of age and disability on driving safety. This would involve collecting information from the provinces where it is held and consolidating it to provide a national picture. Professional judgment would be needed to overcome problems of inconsistent definitions. In addition, questions should be purchased in commercial "omnibus" surveys to check on elderly people's licence holding, age and reasons for surrendering a licence, current driving and possibly experience of accidents. Using a commercial survey should

allow this to be done relatively inexpensively, but would not allow the quality control that could be achieved for a dedicated survey.

9.2.8 The roles for ITS Canada

The introduction of ITS in Canada and its regulation by Transport Canada generate several roles for ITS Canada. One is to act as a forum in which manufacturers and corporate users of ITS can develop their views and interact with government policy divisions and researchers. A second could be to co-ordinate a Canadian research program on ITS and to help to disseminate the results of government research to manufacturers and users. This second role would need significantly more resources than ITS Canada has available at the present time. This would be particularly the case if ITS Canada were to take on the management of a research program on ITS and accessibility that involved a number of separate research organizations.

Experience in several countries has shown that there are valuable roles for organizations like ITS Canada. These can range from education, forums for discussion, focusses for negotiation with government or industry, organization of research, development of architecture and setting of standards. The role of ITS Canada will undoubtedly change as the implementation of ITS develops. It is important that the organization has the flexibility to evolve into roles which cannot yet be foreseen.

10. CONCLUSIONS

This report has been produced through the author's participation in the Visiting Expert Program at the Transportation Development Centre, Transport Canada. Its objectives are:

- To identify opportunities for applying ITS-related technologies to increase the accessibility of transportation for elderly and less able people;
- To develop an effective strategy for Transport Canada to assist in this application; and
- To identify roles for the involvement of the transportation community and providers of facilities and services in Canada, the U.S. and Europe.

10.1 People with Disabilities

Most countries estimate that about 12 -14 percent of their population are disabled in some way and 5 - 10 percent have walking or mobility difficulties. Ten percent of the Canadian population are believed to have a transportation disability. Typically, 0.5 - 1 percent of the population use a wheelchair, though often only for part of the time or for particular activities. The population of elderly people is expected to increase considerably in almost every country, and the number of people with disabilities to increase as the elderly population grows.

By the year 2025, 23 percent of the Canadian adult population will be aged 65+, 21 percent will be disabled and 12 percent will have a specific transportation disability. Disabled drivers already account for about 11 percent of all drivers, and by 2025 the proportion of drivers who are elderly or disabled will be approaching 20 percent.

Accessibility - Access to transport is made possible by information, by money and by vehicles and infrastructure that do not place demands on the user that are beyond the user's abilities. Well trained staff and considerate operating practices can overcome many problems of unsuitable equipment. The development of accessible transport has been a long process of improving the physical design and the operation of transport systems to progressively remove barriers to particular sectors of the population. In recent years the emphasis has been on transport that caters for all users in a single integrated system rather than providing segregated accessible systems for particular groups of users, such as people in wheelchairs.

Ergonomic requirements - During the 1980s research established the capabilities of the disabled and elderly populations and the ergonomic requirements for the physical design of cars, buses, terminals and walking areas. Subsequent research has addressed the requirements of people with sensory impairments and provided guidance on the supply

and display of information. Since the mid-1980s, particular attention has been given to overcoming the problems of people with impaired vision, hearing and cognitive processes. It is likely that further improvements in the accessibility of transport will involve the use of electronic technologies. Ergonomic guidelines that will make these technologies easy for elderly and disabled people to use have not yet been agreed upon, although a number of research reports suggest suitable guidelines.

10.2 Accessibility Problems and Developments

Pedestrians - Elderly and disabled pedestrians are limited by the distance they can walk and by low walking speed. About half of all wheelchair users and ambulant disabled people can only walk 150 m without a rest. Hills and crossing roads cause problems for 30 - 50 percent of ambulant disabled people. These features, plus steps and crowds, are problems for about half of all registered disabled people. Visually impaired independent travellers have a high accident rate when walking, crossing roads and using trains.

Urban buses - Several European countries have published recommendations on the design of urban buses to be easy for elderly and ambulant disabled people to use. This led to a generation of vehicles which did not appear in North America. These were not accessible to people in wheelchairs but were much easier than the conventional North American urban bus for elderly and ambulant disabled people. The critical features are a floor height of about 550 mm, steps that are low and wide, good handrails, plentiful stanchions and widespread use of colour contrast (particularly yellow on handrails) to help people with visual impairments.

Low-floor buses - Low-floor buses started to appear in Germany in the late 1980s, are now in widespread use in Europe and are coming into use in North America. These were not initially to provide wheelchair access, but made it possible and low-floor buses are now always wheelchair accessible. In Europe, wheelchair passengers travel unrestrained, facing backwards in a secure compartment. In the U.S., wheelchair passengers travel facing forwards with the wheelchair and, optionally, the passenger restrained. Boarding time for a passenger in a wheelchair in Europe is about 40 seconds, in the U.S. 2 - 4 minutes. The European application of low-floor buses has given people in wheelchairs a bus service that is as available to them as to everybody, on which they are integrated with all other passengers.

Trains and subways - The problems for disabled people, particularly those in wheelchairs, of using trains are the vertical step from platform to train, narrow doors and passages in coaches, and access to station platforms. Subways are now being built to be fully accessible and some older systems converted. Guidelines on improved access to trains have been published.

Cars and driving - The number of elderly and disabled drivers is increasing. Aging causes physiological changes that make driving more difficult. These include increased reaction time, deteriorating vision, particularly at night, and a reduced ability to split attention between several tasks. Because of self-imposed restrictions on driving, in most countries elderly drivers have one of the lowest accident rates per driver per year. Their accident rate per mile increases as drivers age past about 65, and increases rapidly beyond about 75 years old.

10.3 Improving Accessibility by the Use of ITS

For all transport systems, there are many simple improvements to vehicles, infrastructure and operational practices that can increase accessibility at little cost. These improvements are well known and the problem is one of implementation. Once these improvements have been made, there will remain barriers to accessibility that could be overcome by the use of ITS. These include, for all modes, the provision of better trip-planning information and information during a journey.

Pedestrians - ITS also has considerable potential to help pedestrians. Infrared beacons which transmit messages (talking signposts) and hand-held location and guidance systems should help pedestrians with visual impairments. All pedestrians have benefitted from the application in Britain of person detectors at crossings which extend the crossing time for elderly and disabled people if they need it and also reduced delays to drivers by shortening or omitting the pedestrian phase when no one is waiting to cross. Similarly, warning lights at pedestrian crossings that flash when a person is on the crossing are being tested in the U.S. and have been shown to make drivers more aware of the crossing.

Public Transport - Public transport users would benefit from better information during travel, as well as better trip-planning information. Real-time transit information available at home on television or a portable terminal could reduce the time people have to wait for a bus. Displays at bus stops of the service number and the time to arrival of the next few buses gives passengers confidence and reduces stress. Visual displays of information can be made to talk when activated by a proximity transponder. Displaying the name of the next stop inside a bus or subway coach provides warning of upcoming stops and reduces the pressure on people who need time to alight from a bus or train. An inductive loop inside a bus or subway coach allows a person with impaired hearing to hear public address announcements directly on a hearing aid, free from background noise.

Smart fare-payment cards can reduce the time pressure on elderly and disabled people boarding buses or entering subways. Cards can be made to apply to many services, including public telephones. There is potential for using a smart payment card to provide optional information on traveller requirements, to ensure that the operators of each stage

of a multi-modal trip are equally aware of what services are needed, so that there are no breaks in the chain of accessible links that comprise the complete journey.

Cars and driving - The capabilities of ITS are a remarkable match to the tasks which become more difficult for elderly drivers as a result of the physiological effects of aging. ITS equipment for private cars that is already available can partially compensate for the effects of aging. At present this is limited to Advanced Transport Information Systems (ATIS) and Emergency Management Systems (EM). These can provide navigational guidance, traffic information, warning of obstacles near the vehicle while manoeuvring at low speed, Touring information and emergency alert (Mayday) systems. Evaluation of these systems in Europe by elderly drivers has found a very positive response to them and a willingness to pay realistic prices for them.

In the next few years, further application of ITS should reduce the risk of elderly drivers encountering conditions that they find difficult, and make driving easier. These applications will mainly be aspects of Advanced Vehicle Control and Safety Systems (AVCSS) and include night vision enhancement, intelligent cruise control, assistance with lane following, collision warning, in-vehicle display of signs and driver condition monitoring. In the longer term, ITS will probably lead to the automation of driving on major roads and the use of electronics to prevent dangerous and inconsiderate driving on minor roads. This could introduce a form of road transport that is almost a new mode and which is usable by almost everybody.

10.4 The Market for ITS Equipment

The total market for ITS equipment in North America, Europe and Japan over the next twenty years is predicted to be of the order of \$200 billion. Of this, about \$100 billion is consumer expenditure on ATIS (Advanced Traveller Information Systems) and about \$50 billion consumer expenditure on AVCSS (Advanced Vehicle Control and Safety Systems). Elderly and disabled people form a significant part of the market for ITS equipment, probably about 25 percent of the total, and ITS equipment must be designed to take account of their requirements and abilities. At present there are no generally accepted ergonomic guidelines for the design of ITS equipment that is easy for elderly and disabled drivers to use.

10.5 Research on ITS and Accessibility

The report has identified a number of research and development tasks that are necessary if ITS is to achieve its potential of increasing the accessibility of transport to elderly and disabled people. These are:

10.5.1 Data bases and statistics

Digital maps - Many of the ITS technologies can only be applied in areas for which high quality digital maps of the road system and associated land uses and addresses exist. Natural Resources Canada has a structured digital data base for the Canadian road network which covers the whole country. Navigation Technologies Corporation will start building a digital road map data base for the major cities of Canada in 1997, starting with Toronto.

Statistics on elderly and disabled drivers - In Canada, statistics on the proportion of people of different ages holding driving licenses and currently active as drivers are not available. This is partly a result of the federal structure of the country and partly because Canada does not conduct a regular national travel survey, as is done in Britain and the U.S. These surveys are the only reliable way to measure the proportion of the population in different age groups holding driving licences and continuing to drive. Information on the number of drivers with disabilities is also lacking, as is any information on accidents involving disabled drivers and converted vehicles.

10.5.2 General

- Make the ergonomic evaluation of any ITS equipment used by the public a routine part of the design process. Include elderly and disabled drivers and travellers in these evaluations.
- Develop ergonomic guidelines for the design of ITS equipment to be suitable for elderly and disabled people. These are needed sooner than can be produced by the various international committees working on this topic, but must not be seen as competing with the work of the international committees. The identification of Canada as lead country for research on ITS harmonized through the international forum Enhanced Safety of Vehicles (ESV) provides an ideal opportunity for this activity.
- Develop a family of hand-held information storage and display equipment. This could start with a personal organizer/electronic yellow pages carrying travel and touring information; more complicated versions could include some combination of telephone, receiver for real-time data, GPS and digital map. A specialized version could provide location and guidance to people with visual impairments.
- Introduce to North America the contactless transponder to activate various types of equipment, including opening powered doors and making video displays talk when required.

10.5.3 Car drivers

- Set up, in co-operation with the U.S., long-term trials of the use of ITS by elderly drivers. Note ergonomic problems and the effect of the equipment on where and when elderly people drive, and possibly on safety. Validate the ergonomic guidelines (see second paragraph of “General” above).
- Establish whether the measures of driver fatigue that are being established for the general population also apply to the population of elderly and disabled drivers.
- Introduce a system to broadcast map corrections direct to a vehicle’s navigation system, at least at the beginning of a day’s driving and possibly on a continuous basis to reflect accidents and incidents.

10.5.4 Public transport users

- Extend smart payment cards to make a single card cover public transport operators in many towns plus railways and public telephones (as is done already by the German Association of Public Transport Operators VDV). Investigate the use of smart cards to carry optional information on traveller requirements, to help operators provide service required.
- Develop equipment for a communication system between passenger and bus to help a passenger hail a community bus.
- Establish a system that provides information on the predicted arrival times for buses at specified local bus stops, and other transit, travel and Yellow Pages information, using cable to a home computer or television, the Internet or broadcasts to a portable receiver.
- Look for other low-cost ways to use ITS to help disabled people. One possibility is the use of inductive loops in transit vehicles, to enable people with impaired hearing to hear announcements direct through their hearing aid, without interference from other conversations and background noise.

Taking account of the requirements of elderly and disabled people means, firstly, ensuring that equipment is easy and safe to use by this group of people. This will almost certainly make it easier and safer for the whole population to use. Secondly, it means seeking ways of extending standard equipment to cover the specialized requirement of elderly and disabled people. Thirdly, it means seeking ways to use existing technology to perform a service specifically for elderly or disabled people.

While specialized products are undoubtedly useful for elderly and disabled travellers, it is more important to ensure that mainstream ITS equipment helps these groups rather than creating new barriers for them. As automatic control systems for automobiles

become available, they should be checked for ergonomic suitability for elderly and disabled drivers. The standards organizations ISO and CEN are working on the general human factors aspects of ITS, but this will take some time to come to fruition. In the interim, ergonomic guidelines specifically relating to elderly and disabled people, based on existing information, are needed to ensure that current ITS equipment is easy for elderly and disabled people to use.

Unless a continuing research program maintains expertise on ITS and accessibility, there is a risk that the changes to road transport, and particularly to driving, that ITS will bring over the next twenty to thirty years, could unintentionally introduce new barriers to travel rather than improve accessibility.

10.6 A Research Program for Canada

The report develops a series of detailed research activities to improve the accessibility of transport through the use of ITS. These activities include digital maps of the road system, ergonomic guidelines for ITS equipment, long-term trials of ITS equipment for car drivers, hand-held ITS equipment, smart payment cards, development of specific ITS equipment, maintaining expertise and international liaison and the roles of ITS Canada. Specific roles for Transportation Development Centre in these activities are suggested.

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