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Access to Transport Systems and Services
An International Review

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Access to Transport Systems and Services
An International Review

by
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16. Abstract

This report summarizes the result of a literature review on the accessibility problems of elderly and disabled people. It forms the first part of a study of the scope for improving accessibility of transport through the application of intelligent transportation systems (ITS) and other advanced technologies. It considers the size of the disabled population, the capabilities of individuals and the access problems experienced by pedestrians, bus passengers, train passengers and car drivers. There are many well-known design and operational improvements that could be applied to increase accessibility without involving advanced technology. However, even after physical accessibility has been improved there will remain barriers that could be overcome by better information and the application of intelligent transportation systems and other advanced technology.

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16. Résumé

Le présent rapport récapitule les résultats d'une recherche documentaire sur l'accessibilité des transports aux personnes âgées et aux handicapés. C'est la première partie d'une étude sur les possibilités offertes notamment par les systèmes intelligents de transport (SIT) pour améliorer cette accessibilité. L'étude tient compte de la taille de la population handicapée, des capacités fonctionnelles motrices des individus et des difficultés d'accès éprouvées par certains usagers : piétons, passagers d'autobus et de trains et conducteurs de voitures privées. Il existe des moyens simples et peu coûteux d'améliorer l'accessibilité des transports, sans devoir faire appel à des technologies de pointe. Ils sont peu coûteux et n'attendent qu'une mise en oeuvre. Malgré cela, il y aura toujours des barrières que seules l'implantation de SIT et d'autres technologies permettra de surmonter.

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EXECUTIVE SUMMARY

Introduction - This report summarizes the result of a literature review on the accessibility problems of elderly and disabled people. It forms the first part of a study of the scope for improving accessibility of transport through the application of intelligent transportation systems (ITS) and other advanced technologies. The review has concentrated on literature from Europe and North America, but puts the experience from those areas into a Canadian context as appropriate.

Accessibility - Access to transport is made possible by information, 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 often overcome many problems of unsuitable equipment. 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. 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.

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.

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.

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. Average walking speed is 0.5 - 0.8 m/s. 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 at doorways 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 and are now in widespread use in Europe and 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 Canada and the U.S. about 2 - 3 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.

Scope for Intelligent Transportation Systems (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. For pedestrians, one application is to intelligent traffic signal controls to allow more time for elderly and disabled people to cross the road when, and only when, they are waiting to do so. Another application is to hand-held location and guidance systems for people with visual impairments.

Public transport users would benefit from better information during travel, as well as better planning information. Real-time transit information could reduce the time people have to wait for a bus. Warning of upcoming stops reduces the pressure on people who need time to alight from a bus or train. Visual displays of information can be made to talk when activated by a proximity transponder. 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 providing optional information on traveller requirements on smart payment cards, to ensure that all stages of a multi-modal trip are equally accessible.

ITS equipment for private cars that is already available can partially compensate for the effects of aging that make driving more difficult. In the next few years, further application of ITS should reduce the risk of elderly drivers encountering conditions that they find difficult. A more detailed analysis of the scope for improving accessibility through the use of ITS and other advanced technology will be provided in the final report of this study.

Applications in Canada - Despite Canada's position as a world leader in accessible transport, there is still experience in Europe that would be directly applicable in Canada. This includes standards for vehicles and infrastructure and operating practices, where Europe has paid more attention to pedestrians and ambulant disabled users of public transport. There are European design guidelines for urban buses that would improve the vehicles in use in Canada. Guidelines for urban infrastructure and transport interchanges could well suggest ways in which local accessibility could be improved at little cost. Studies of the benefits of accessible transport could well be repeated for Canada to inform policy on the provision of accessible services.

SOMMAIRE

Introduction- Le présent rapport récapitule les résultats d'une recherche documentaire sur l'accessibilité des transports aux personnes âgées et aux handicapés. C'est la première partie d'une étude sur les possibilités offertes notamment par les systèmes intelligents de transport (SIT) pour améliorer cette accessibilité. La recherche documentaire s'est concentrée sur les travaux réalisés en Europe et en Amérique du Nord, en les mettant chaque fois que faire se peut en parallèle avec les travaux faits au Canada.

Accessibilité - L'accessibilité peut être favorisée par l'information, l'argent et par des véhicules et des installations appropriés qui n'exigent pas de l'usager plus qu'il ne peut apporter. Elle est favorisée aussi par des préposés bien formés et par des procédures bien pensées, de manière à suppléer aux lacunes des équipements. Les progrès réalisés dans le domaine de l'accessibilité sont le fruit d'un processus laborieux d'améliorations techniques et administratives visant à supprimer les barrières gênant les déplacements de différentes catégories d'usagers. Ces dernières années ont vu la mise en oeuvre de systèmes de transport intégrés faisant place à des groupes particuliers d'usagers, les personnes en fauteuil roulant, par exemple, au lieu de les tenir à l'écart en leur fournissant des services séparés.

Les handicapés - Les personnes ayant une déficience quelconque forment, d'après l'estimation de la plupart des pays, environ 12 à 14 p. 100 de la population, alors que de 5 à 10 p. 100 ont un handicap de mobilité. Au Canada, la proportion de personnes ayant un handicap de mobilité est estimée à 10 p. 100. Grosso modo, de 0,5 à 1 p. 100 de la population est en fauteuil roulant, souvent pour une partie de la journée ou pour effectuer une tâche particulière. La population des personnes âgées augmentera de façon sensible dans la plupart des pays, au rythme du vieillissement de la population dans son ensemble.

Critères ergonomiques - Durant les années 1980, la recherche a mis en lumière les aptitudes fonctionnelles motrices des personnes âgées et des handicapés ainsi que les critères de conception ergonomique de voitures, d'autobus, d'installations terminales et de zones piétonnières. La recherche s'est ensuite penchée sur les besoins des personnes ayant un handicap sensoriel, dont elle a défini les besoins d'information et d'affichage de celle-ci.

Piétons - Les personnes âgées et les handicapés ne peuvent pas marcher de grandes distances et ils le font lentement. Près de la moitié des personnes en fauteuil roulant et des handicapés ambulatoires ne peuvent pas faire plus de 150 m d'un trait, et à une vitesse moyenne entre 0,5 et 0,8 m/s. Entre 30 et 50 p. 100 des personnes handicapées ambulatoires éprouvent des difficultés lorsque la route est en pente ou lorsqu'il s'agit de traverser une rue, et si on y ajoute des marches et la cohue, ce chiffre atteint près de la moitié de tous les handicapés inscrits. Les personnes malvoyantes se déplaçant seules

connaissent un taux d'accident élevé lorsqu'elles marchent dans la rue, traversent une rue et utilisent les chemins de fer.

Autobus urbains - Plusieurs parmi les pays européens ont publié des recommandations visant à rendre accessibles les autobus urbains aux personnes âgées et aux handicapés, et menant à la réalisation d'autobus sans équivalent en Amérique du Nord. Sans être accessibles aux personnes en fauteuil roulant, ces autobus sont beaucoup plus accessibles que les autobus standard nord-américains, grâce à un plancher à quelque 550 mm au-dessus du sol, des marches d'escalier basses et larges, des dispositifs d'appui, des appuis verticaux en grand nombre et un revêtement très contrasté en couleur (appuis revêtus de plastique jaune) pour aider les personnes malvoyantes.

Autobus à plancher bas - Les autobus à plancher ont fait leur apparition en Allemagne vers la fin des années 1980. Ils se sont vite répandus en Europe et commencent à entrer en service en Amérique du Nord. Il n'avait pas été prévu qu'ils soient accessibles aux fauteuils roulants, mais on s'est rendu compte qu'ils pouvaient l'être et qu'ils le sont devenus depuis. Dans les autobus à plancher bas européens, les personnes en fauteuil roulant circulent dos à la circulation dans un compartiment spécialement aménagé où il n'est pas nécessaire d'ancrer les fauteuils au plancher. Aux États-Unis, le fauteuil roulant est placé face à la circulation et l'immobilisation de l'occupant est facultative mais non celle du fauteuil lui-même. Le temps d'accès pour une personne en fauteuil roulant est d'environ 40 secondes en Europe et de 2 à 3 minutes au Canada et aux États-Unis. La mise en service des autobus à plancher bas donne aux personnes en fauteuil roulant l'impression qu'elles sont traitées comme tout le monde et non plus à part.

Trains et métros - Les difficultés éprouvées par les usagers handicapés et surtout en fauteuil roulant lorsqu'elles utilisent le train ou le métro viennent de la distance entre le quai et le plancher du train, de l'exiguïté des portes et des couloirs et de l'accès aux quais. On construit maintenant des métros totalement accessibles et on modifie les anciens en conséquence. Il existe maintenant des critères de conception ergonomique des trains et métros.

Voitures privées - La population des conducteurs âgés ou handicapés augmente, malgré les changements physiologiques apportés par l'âge qui rendent la tâche de conduire de plus en plus difficile : réflexes ralentis, aptitude amoindrie à s'occuper de plusieurs choses à la fois, vision affaiblie, surtout la nuit. Dans la plupart des pays, les conducteurs âgés connaissent un taux d'accidents par conducteur et par an parmi les plus bas, du fait qu'un grand nombre prend la décision de conduire moins souvent et moins longtemps. En revanche, le taux d'accident par mille parcouru commence à augmenter autour des 65 ans, et monte en flèche à partir de 75 ans.

Intérêt des SIT - Tous modes confondus, il existe des moyens simples et peu coûteux permettant d'améliorer l'accessibilité des transports, qu'il s'agisse d'adaptation des véhicules, des installations ou des procédures. Ils sont bien connus et n'attendent qu'une mise en oeuvre. Mais, ensuite, il y aura toujours des barrières que seules l'implantation de SIT permettra de surmonter. Une façon parmi d'autres, valable pour tous les modes, est l'organisation préalable à un déplacement. Pour les piétons, les SIT pourraient mener à l'implantation de feux qui donnent aux piétons âgés ou handicapés plus de temps pour traverser une rue, mais qui interviennent sélectivement seulement lorsqu'un piéton âgé ou handicapé se présente. Il y a et aussi l'implantation de systèmes portatifs de localisation et de guidage pour piétons malvoyants ou aveugles.

Une information de meilleure qualité, avant un déplacement et en cours de route, profite à l'ensemble des usagers des transports en commun. Une information en temps réel aux arrêts d'autobus réduira les temps d'attente. L'annonce des arrêts successifs permet aux usagers malentendants de se préparer à descendre. Il existe aussi une télécommande qui permet de déclencher des annonces parlées reprenant le message des annonces écrites. Les cartes à mémoire pour la perception automatique des tarifs permettent d'affranchir les personnes âgées ou handicapées de la pression de faire vite. Leur utilité pourrait être étendue à d'autres services, notamment les téléphones publics. Il y a aussi la possibilité que ces cartes puissent stocker de l'information concernant le porteur, de manière à lui assurer un déplacement sans problème et sans interruption, du début à la fin.

Il existe des SIT qui permettent d'atténuer quelques-uns des effets de l'âge sur l'aptitude des personnes âgées à conduire. Dans quelques années, il y en aura qui leur permettront d'éviter certains ennuis de la circulation et qu'ils trouvent stressants. Dans le rapport final de l'étude seront analysées plus finement les possibilités offertes notamment par les SIT pour améliorer l'accessibilité.

Applications possibles au Canada - Malgré la position du Canada comme chef de file dans le domaine de l'accessibilité des transports, il existe en Europe des utilisations SIT qu'il pourrait être utile d'appliquer directement au Canada. Il y a tout d'abord les normes concernant les véhicules, les installations et les procédures, l'Europe ayant accordé beaucoup d'attention au sort des piétons âgés ou handicapés. L'Europe a également adopté des critères de conception ergonomique des autobus urbains, que le Canada pourrait mettre à profit, et des critères concernant les infrastructures urbaines et les centres de correspondance grâce auxquels l'accessibilité pourrait être améliorée à peu de frais. Il serait sans doute également utile de reprendre les études sur les avantages de l'accessibilité des transports au Canada pour orienter les décisions quant aux types de services accessibles à implanter.

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1. INTRODUCTION

Transport is a derived demand. People rarely travel solely for the pleasure of travelling. Rather, they travel to reach a location at which they can participate in an activity. Thus transport provides the mobility that is necessary to reach the range of activities that make up a person's way of life. Transport includes walking, publicly available transport (buses, trains, taxis, aircraft and ferries), and private individual transport (cars and bicycles). Private transport is available on demand, for travel door to door. Publicly available transport is usually shared with other users and operates on set routes at scheduled times (but taxis have the characteristics of private transport).

Transport is accessible to those people who are able to use it. Access 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 its existance or on how to use it). Access can be prevented by lack of competence or qualification (a driving licence 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 revising the design or operation of the system to make it easier to use. Having well-trained staff available to assist can often overcome many problems of unsuitable equipment or infrastructure.

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. 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.

Safety and security are aspects of transport that may limit its accessibility. As people age they become more vulnerable to the effects of accidents. Accident rates increase for pedestrians and for drivers aged over about 75 years. Older people are more likely to have accidents when travelling on public transport. The fear of an accident is an important factor in limiting the travel people are willing to attempt.

During the literature survey for this report it became apparent that in Europe and the U.S. research on accessibility has gone through a number of phases. From the late 1960s to the late 1970s research tended to concentrate on the travel behaviour 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 display (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.

The changing emphasis of research in Canada for accessible transportation has been noted by Vespa (1995). Vespa identified three phases of development of accessible transport, which match the changes in research priorities noted above for Europe and the U.S. These were: 1972 - 1984, when the focus was on mobility, the objective was travel in any way possible and the human need addressed was to be independent; then 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; finally, 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. The emerging technologies that will improve accessibility are largely electronic.

This report reviews the problems that prevent particular groups of people from having access to particular modes of transport, including private and public transport and walking or using a wheelchair. The literature reviewed is largely from Europe and the U.S. and the findings of the review are interpreted in a Canadian context. The report 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 current state of accessible transport in Canada has recently been reviewed in “Access and mobility for all” (Transportation Development Centre, 1997) and it seems redundant to repeat that review. In particular, it seeks to identify technologies, operating procedures and services that have proved successful in Europe but are not yet available in Canada.

Where possible, reference is made to international or national standards, guidelines and codes of practice. It is concerned with all barriers to access, rather than examining only the physical improvements to transport vehicles that are necessary to allow them to be used by people in wheelchairs, important as is this aspect of the topic. It includes the safety and security aspects of travel by the different modes. These aspects are particularly important for elderly drivers, where fear of an accident or of not being able to manage a difficult situation is a significant factor in causing older people to stop driving. Pedestrians with visual impairments are particularly at risk and have a high accident rate.

This the first of a series of reports that will focus on the potential for using intelligent transportation systems (ITS) and other advanced technologies to further improve the accessibility of transport systems of all kinds. ITS is the general term which covers the application of information systems, telecommunications, sensors and control systems 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). ITS has the potential to increase the capacity and productivity of the road transport system and to improve the reliability and safety of road transport.

2. PEOPLE WITH MOBILITY PROBLEMS

2.1 General

In Europe, concern for the mobility of people with physical disabilities seems to have developed during and after the First World War. Throughout Europe, the presence of large numbers of men with amputations or damaged sight led to the provision of wheelchairs and of services for blind people. 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. The implications of the aging population have been questioned recently (Cohen, 1996) but 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 ammendments; the National Transportation Act, 1987 and the Canadian Transportation Act, 1996 (National Transportation Agency of Canada, 1995).

The U.N. 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. 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 (Dejeammes et al., 1988), were only starting to be developed at that time. 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. 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.

2.2 The Population with Reduced Mobility

The vocabulary of disability defines three factors: impairment, which is a medically definable lack of function; disability, which is a consequential lack of capability; and handicap, which is, in a given situation, the inability to perform some task (Harris, 1971). Thus the lack of a lower limb is an impairment. The consequential disabilities would be the inability to walk or climb steps (but this disability may be removable by the use of a suitable prosthetic). The handicap that results from the inability to walk or climb steps might be the inability to visit a destination that can only be reached by climbing stairs. Handicap only arises when the person with the impairment wants or needs to do something that the impairment, and consequential disability, makes impossible.

Estimates of the numbers of chronically and acutely handicapped people were produced in the U.S. in the mid-1960s, while the first survey of disability in Britain was by Harris (1971). A summary of the numbers of people with impairments in different countries was given by ECMT (1986). It 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. It is 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 could complete everyday activities, which represents a significant drop in the number of disabled old people in the population.

2.3 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 and 1989). In particular, the proportion of the population who are disabled is now estimated as 14.2 percent, and those who use wheelchairs as 0.5 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 projected to be

3.81 million, or 17.1 percent of the adult population. Persons with transportation disabilities in 1995 number 2.19 million, or 9.9 percent of adults.

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)

2.4 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.

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., 1989 for Britain and Goss Gilroy Inc., 1995 for Canada)

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 late 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) gives recommended movement distances for elderly people of increasing age and with different walking aids. These are reviewed in detail in section 3.3.2.

3. REVIEW OF MOBILITY PROBLEMS

3.1 General

Surveys of the transport problems of people with reduced mobility date from the late 1960s, with a major survey in U.S. by Abt Associates Inc. (1969). This 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. In Britain, Harris's survey of handicapped and impaired people (1971) included estimates of the numbers of people who had limited transport-related capabilities. 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. This section will establish whether current problems cover the same mix of social, financial and physical design factors.

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. Surveys of travel by the Swedish population in 1978 and 1984/85 included information about disabilities, and showed that the proportion of disabled people increases with age. About 70 percent of those who report a disability are aged over 65 years. Disabled people travel less frequently than others (Börjesson, 1989).

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 populations aged 65 years and older were transportation handicapped.

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 or transport provided by welfare organizations were little used. Forty-four percent of the sample of people aged 65 or over had difficulty walking.

They travelled a little less often in total than those who did not have difficulty. Despite having difficulty walking, they walked more frequently than those without difficulty. Because the physical factors that made walking difficult made using buses even more difficult, this group made less use of buses than those who had no difficulty walking.

Another British ergonomic study of elderly and disabled bus passengers assessed the proportion of the population that could climb steps of various heights and established preferences for seat and handrail dimensions (Brooks et al., 1974). A more extensive French study (Flores et al., 1981) considered steps, doors, handrails, gangways, seats, environmental factors and comfort under dynamic accelerations. The results of these studies are summarized in section 3.4.2. The Greater London Association for Disabled People (GLAD, 1986) and Cranfield University (Oxley and Alexander, 1994) examined problems with public transport in the London area.

A study by the University of Leeds (Leake et al., 1991) measured the mobility capabilities of people with various disabilities moving about on foot or in wheelchairs in urban areas. A survey by Cranfield University of 302 visually impaired independent travellers established whether respondents had been involved in any accidents while travelling by rail, underground, bus or coach. Respondents were also asked about accidents whilst walking, involving the footway, crossing roads, steps and plate glass windows (Gallon et al., 1995).

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 identified the problems that still remained and 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 small, for trains, airplanes and subways.

3.2 Travel by Elderly and Disabled People

All surveys of travel by elderly and disabled people show that these groups travel less than do younger people. Abt Associates Inc. (1969) 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. This was due in part to lower automobile ownership (58 percent of handicapped in households with an automobile, compared with 75 percent generally). Fewer handicapped people were licensed to drive, fewer were employed and more were poor, with an income of less than $4 000.

Hopkin et al. (1978) found that retired people aged over 65 who had difficulty walking made 0.86 return journeys per day, compared with 0.96 journeys per day for those who did not have 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.

In Sweden, the annual number of trips by active people was 883, for people with impaired locomotion 371 and for disabled people 198 (Börjesson, 1989). Excluding work and business trips, the annual trip totals were 492, 301 and 186 respectively.

This situation still persists. Rosenbloom (1992), using 1983 survey data, quotes annual trip rates for urban dwellers that decrease steadily with age beyond 60 years. For people with driver licences, the range is 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 drivers' licences, the corresponding trip rates are 750, 510 and 270 trips per year.

3.3 Problems with Walking

3.3.1 Barriers to walking

The Abt Associates Inc. (1969) survey of transportation needs of the handicapped (1969) showed that a mobility limitation acts as an obstacle to employment. For example, 84 percent of handicapped people who were unemployed but looking for work said they had difficulties going up stairs, compared to 49 percent of those in work. The report discusses travel barriers but does not include ergonomic information. Bednar (1977) contains a general discussion of a barrier-free environment.

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+ (Figure 1). 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 (Table 3; disability is greatest in left column, least in right column).

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 (Table 4).

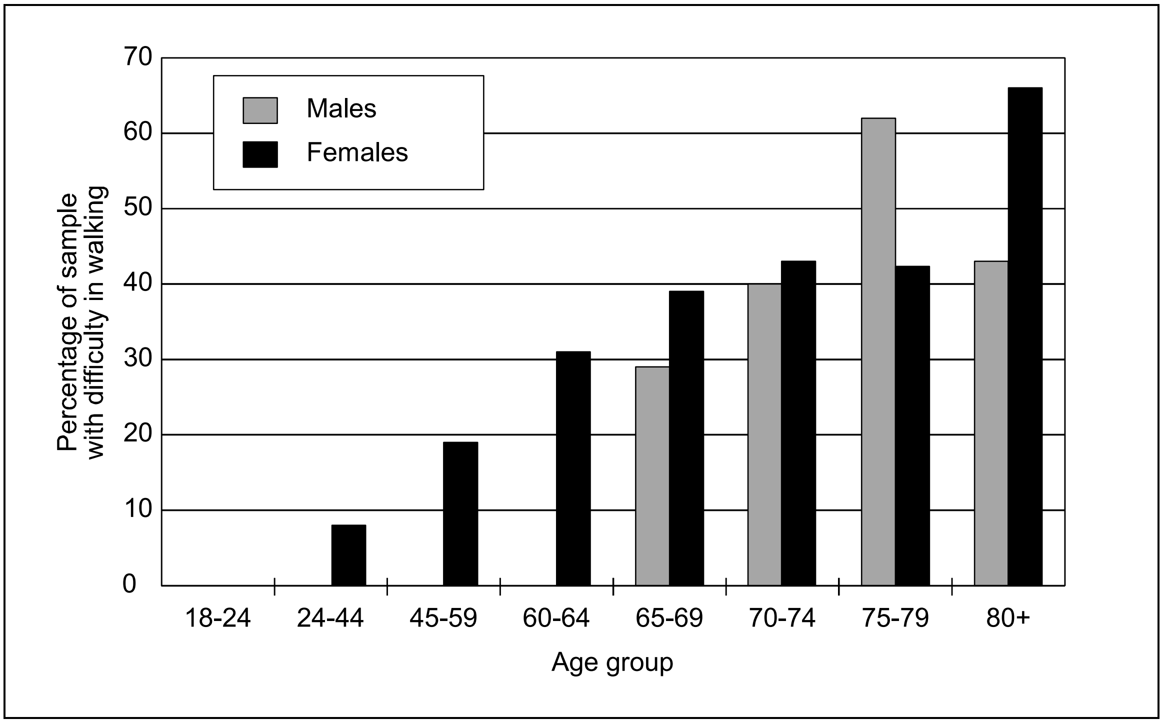


Figure 1 Percentage of people in Guildford who had difficulty walking (Hopkin et al., 1978)

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 Steps	12 58	5	4	4	2
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

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).

This section has largely quoted British research on the problems experienced by disabled people as pedestrians. There has been relatively little research on the capabilities of disabled people as pedestrians, and most of the research that could be found is British. Much more research has been done on the safety of pedestrians in general and elderly pedestrians in particular (OECD, 1985).

3.3.2 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 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 (Table 5b). While there is clearly some misperception of their abilities by the disabled people, 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.

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)

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/metre, 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. Disabled people's range of movement 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. More recently, Knoblauch et al. (1995) analysed accidents to elderly pedestrians and reported a field study of walking speeds. This measured a mean speed of 1.25 m/s for pedestrians aged over 65 years, appreciably faster than measured by Dahlstedt and Leake et al.; the speed of the slowest 15 percent was 0.97 m/s.

Bails (1986) postulated that the acceptable walking distance to a destination for fit elderly people varied with age as shown in Figure 2. This acceptable distance would be modified to take account of slopes. Another set of acceptable distances are given by Bails for users of electric wheelchairs, manual wheelchairs and other mobility aids.

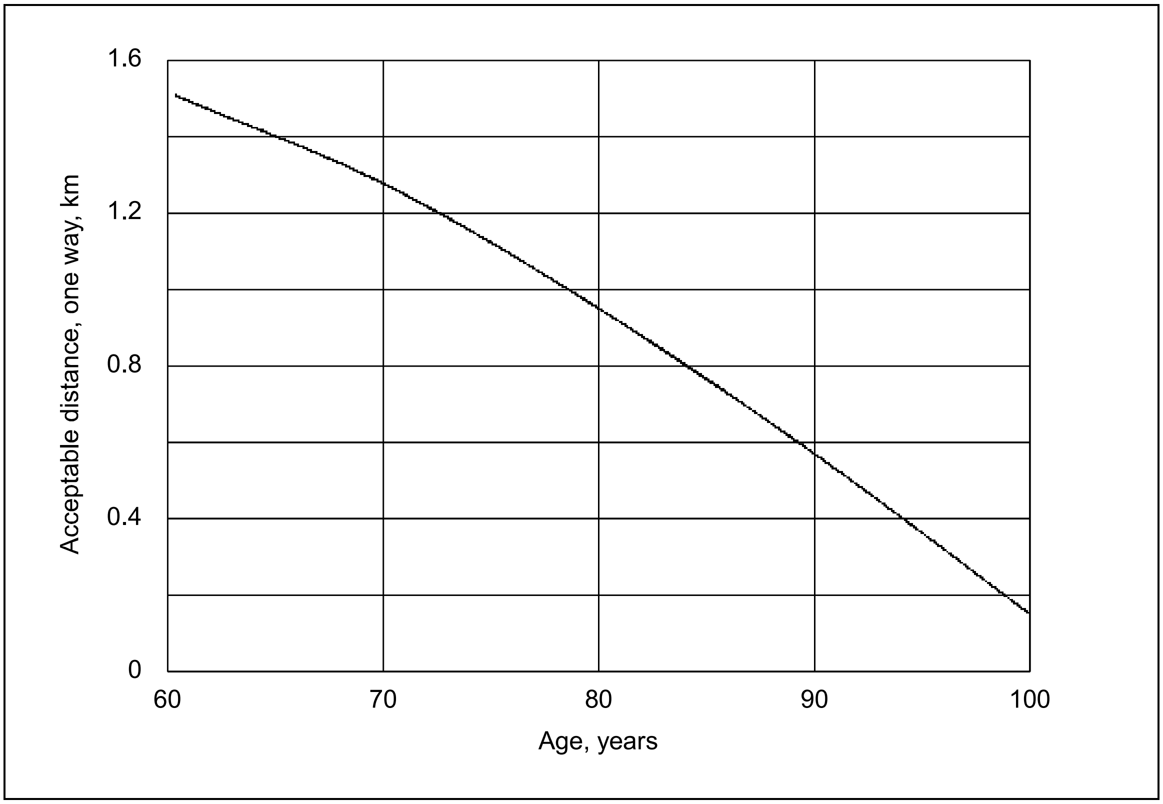


Figure 2 Acceptable walking distance (one way) to a destination (Bails, 1986)

3.3.3 Safety of pedestrians

Older persons have the highest rate of fatal accidents of any age group of pedestrian (see Figure 3) (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. Measures to improve the safety of all pedestrians should have a disproportionately beneficial effect for older pedestrians.

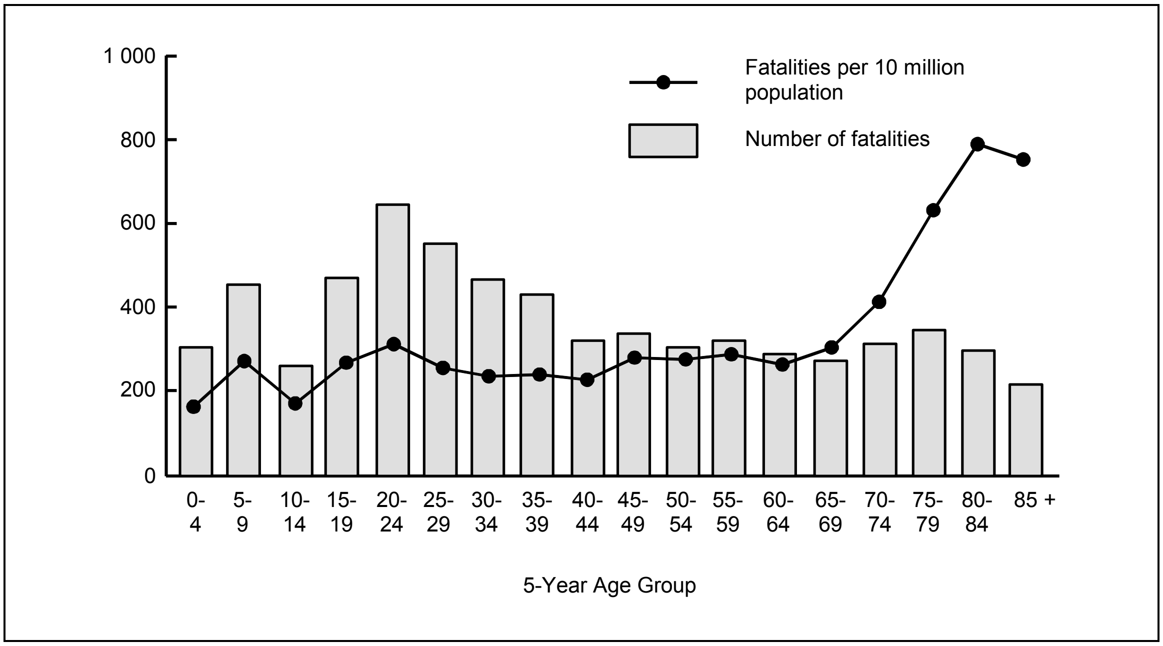


Figure 3 Pedestrian fatalities and fatality rates by age, 1986 (NHTSA data; TRB, 1988)

3.3.4 Accidents to visually impaired pedestrians

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.

This section has largely quoted British research on the problems experienced by disabled people as pedestrians. There has been relatively little research on the capabilities of disabled people as pedestrians, and most of the research that could be found is British. Much more research has been done on the safety of pedestrians in general and elderly pedestrians in particular (OECD, 1985). Some studies on pedestrian problems and on design for pedestrian accessibility have been reported (see, for example, Bodnar, 1977 and Abt Associates Inc., 1969), but they tend to be rather general.

3.3.5 Possible applications of ITS

Most of the problems of disabled and elderly pedestrians are concerned with the geography of an area and the physical design of the infrastructure. The first priorities must be to build and maintain the infrastructure to a satisfactory condition. This requires standards that reflect the requirements of elderly and disabled people, a consultation and inspection process to ensure that those standards are applied to new construction and a maintenance process to ensure that the condition of the infrastructure remains satisfactory. Existing road condition monitoring equipment such as laser profilometers are being modified for routine monitoring of the condition of sidewalks and other infrastructure at much lower cost than the usual process of visual inspection and pen and paper recording of defects (Spong, 1994). It should be possible to develop a manually pushed profilometer for sidewalks with a differential GPS and on-board data store.

Development in Europe, since the 1960s, of acoustic devices to warn blind pedestrians of obstacles have not proved useful (Weetman and Baber, 1992). The main problem for a visually impaired pedestrian appears to be the complex one of spatial location and route finding, rather than detecting and avoiding local obstacles. Initial considerations would suggest that the role of ITS for elderly and disabled pedestrians is probably limited to:

- Making crossing roads easier and safer, for example by adjusting the time available for elderly and disabled people to cross, but only when they are at a crossing;
- Using people-detectors to illuminate additional lights to mark pedestrian crossings and warn motorists when pedestrians are on the crossing or about to cross;
- Assisting visually impaired people with route finding;
- Warning of local obstacles, after location and routefinding has been provided.

3.4 Problems with Buses

3.4.1 General

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.

Because elderly and disabled people have relatively low levels of car ownership and driving licences, 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 are 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 in more detail 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 the same 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 central business districts. Access to 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 autos 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 move quickly, because of the need to keep to schedule.

3.4.2 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. The definitive study in Britain was by Leyland Buses (Brooks et al., 1974), which investigated 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 distance they could reach between stanchions and their strength to pull on a stanchion, the step heights they could negotiate with and without a handrail (see Figures 4a and 4b), and their preferred seat height, handrail diameter 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 the study 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. A sub-sample of 188 elderly or disabled subjects identified the problems they had with buses in practice. Eighty-six percent had problems with the height of bus steps and 50 percent had problems getting in and out of bus seats.

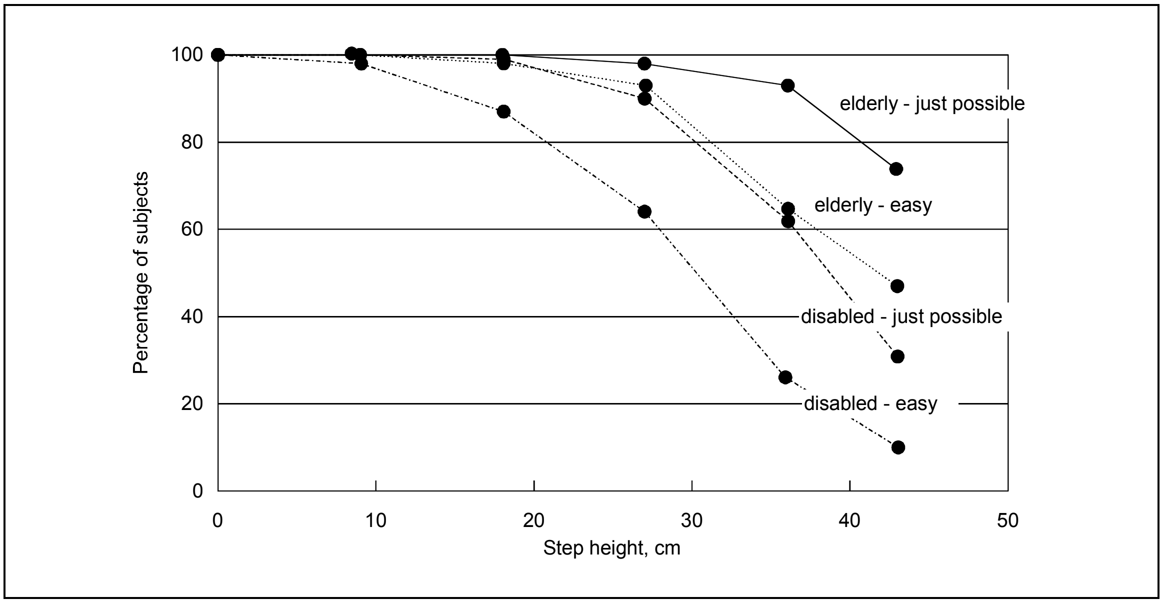


Figure 4a Percentage of elderly and ambulant disabled people able to negotiate bus entrance steps using handrails

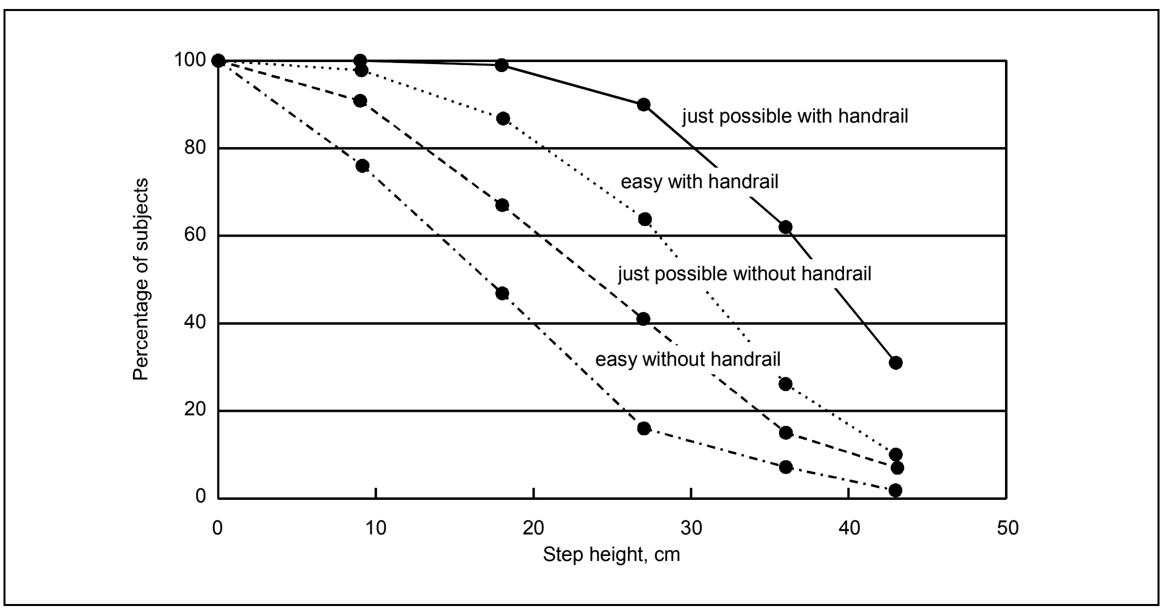


Figure 4b Percentage of ambulant disabled people able to negotiate bus entrance steps with and without handrails (Source: Brooks et al., 1974)

Brooks et al. (1974) was followed by a second study of the problems passengers had on moving buses (Leyland Vehicles Ltd., 1980). This showed that the majority of injury accidents to bus passengers were the result of falls while the bus was in normal operation, that elderly passengers were over-represented in this type of accident and that the comfort of passengers and the forces that standing passengers needed to exert on stanchions to retain balance depended as much on jerk (rate of change of acceleration) as on acceleration. It confirmed the most suitable geometry for handrails at the entrance to a bus and showed that a retractable step improved the ease of boarding for elderly and disabled passengers.

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. Figures 5a and 5b show the percentages of the total population aged 17 to 74 years who are limited by steps of various heights, and the percentage who find steps of different heights with comfortable to use. Good handrails enable people to manage steps some 4 cm higher than they could manage without. Handrails extending outside the bus help passengers alighting, because they can retain support until they have stepped down to the ground. Only in Sweden have handrails of this type been introduced extensively (Figure 6).

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).

On buses which had a split entrance, one side of which had one internal step (37 cm from road, 24 cm internal step), the other two lower steps (28 cm from road, two internal steps of 16.5 cm), a significantly higher proportion of elderly and disabled passengers used the side of the entrance with the lower steps. There was no significant difference in the boarding times for buses with a split entrance and those with a standard entrance with the two higher steps for both entrance streams. Observing passengers boarding and alighting showed:

- Elderly and disabled passengers are much more likely to place both feet on each step while the younger and more agile place one foot on each step.
- Elderly and disabled passengers are more likely to use the handrails, often reaching for them before stepping onto the bottom step.

Elderly and disabled passengers are likely to have a shorter stride length than younger passengers. Thus they are more likely to step down into the road before boarding if the bus is unable to stop very close to the curb.

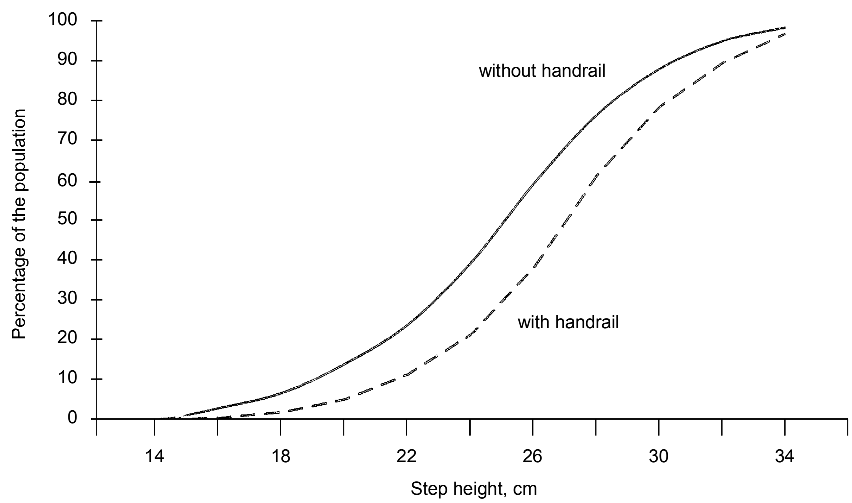


Figure 5a Percentage of the population aged 17 to 74 years limited by steps of various heights

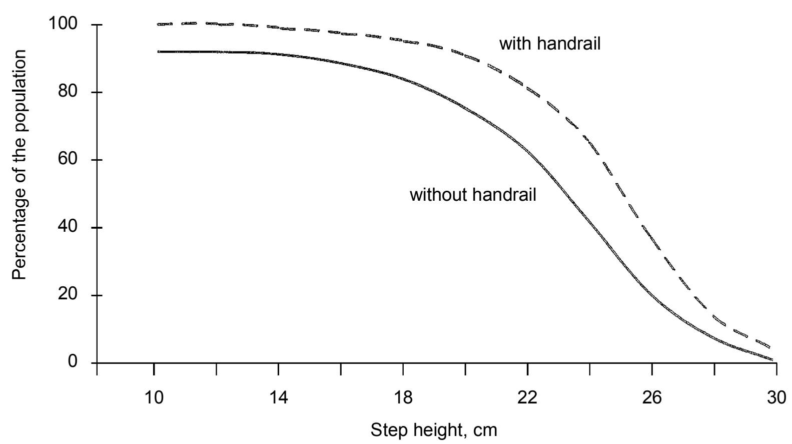


Figure 5b Percentage of the population aged 17 to 74 years who find steps of various heights comfortable to use (Flores et al., 1981)

Figure 6 Handrails that extend beyond the entrance of a Swedish transit bus

Oxley and Benwell published a further study in 1985, in which disabled and elderly people used buses under laboratory conditions to identify and 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. Bus services were observed to collect data from which it was possible to estimate the likely delay caused by requiring buses to remain stationary until elderly and disabled passengers were seated, and to allow them to remain seated until the bus had stopped.

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 (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 complaints were made by some bus users. 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 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 results are summarized in Figure 7. 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. Allowing passengers time to be seated before the bus started and until it stopped increased the route running time by 40 seconds/hour (1 percent) in the worst case.

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.

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.

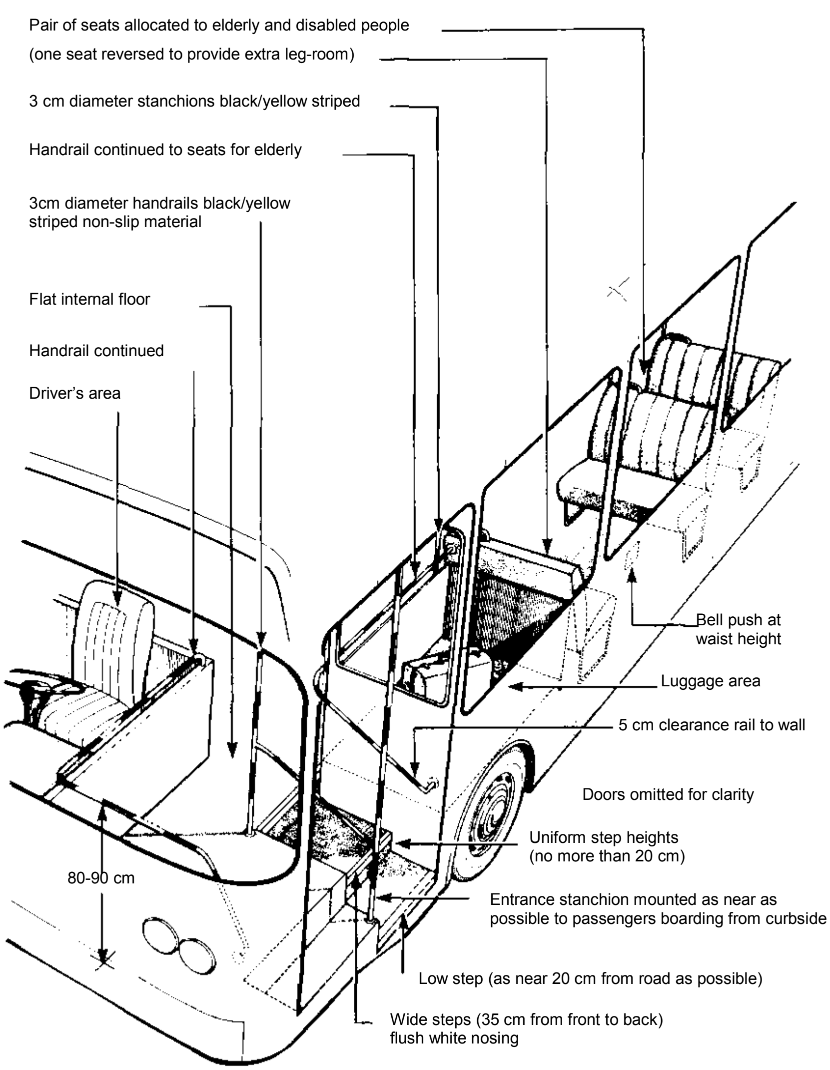


Figure 7 Bus design - desirable ergonomic features (doors omitted) (Source: Oxley and Benwell, 1985)

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)

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 legroom between seats, level flooring or colour contrast on changes of floor level, better ventilation.

Operational standards - Greater frequency, reduce distances to stops, Service Routes, reduce travel time by bus lanes, 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.

The most recent surveys, which have been associated with the introduction of low-floor buses and have been conducted in Germany, France and Britain, will be considered later in section 3.4.4.

3.4.3 Passengers in wheelchairs on buses

In Europe, until the introduction of low-floor buses in the 1990s, carriage of passengers in wheelchairs in full-size scheduled buses 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. In some ways similar to the Swedish Service Route concept (although totally different in frequency, and therefore suitability for spontaneous travel), 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 has been totally different to that in Europe. The basic vehicles have been 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 (1982) surveyed wheelchair users in Westchester County, New York, to identify those factors or parameters which contribute to the non-use of lift-equipped buses. 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 lights with 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.

The Canadian approach to urban transit for persons with disabilities has been described by Chown and Geehan (1995). This emphasized that local transport was a provincial responsibility, though the Canadian Urban Transit Association provided a national forum for addressing issues of urban mobility. Paratransit services for people with disabilities started to develop in the late 1970s and grew rapidly through the 1980s. In 1995 there were 412 paratransit services operating in Canada. Vancouver introduced its first wheelchair accessible full-size buses in 1990. By 1995, 277 buses (40 percent of the fleet) were providing wheelchair accessible services on 68 routes. The SkyTrain automated light rail system was built fully accessible in 1986, and the cross-harbour SeaBus ferry was also made accessible at that time.

3.4.4 Low-floor buses

Low-floor buses were introduced into urban transit systems in Germany in 1988, initially to reduce boarding time and to increase the competitiveness of buses relative to cars (Blennemann, 1992). It rapidly became clear that they could accommodate passengers in wheelchairs and boarding aids were added. Low-floor buses as used in Europe are described in detail in section 4.3.

Rutenberg (1995) has reviewed experience of low-floor bus operations in Canada, the 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.

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. Dejeammes et al., for example, found that people without handicaps did not perceive low-floor buses as easier to use, and Balcombe and York obtained similar results in the U.K. 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.

Earlier research has shown the need for low steps at bus entrances. European low-floor buses tend to have entrance step heights of about 320 mm, often reduced to 240 mm by kneeling. Alternatively, sidewalk height can be increased at bus stops to provide level boarding (Dejeammes et al., 1993). European low-floor buses tend to use extending ramps rather than lifts or “flip-over” ramps. These can be quickly deployed for use by ambulant disabled people who cannot manage the entrance step or who cannot stride across the gap between the bus and the curb. North American low-floor buses are tending to have an entrance step of about 340 - 360 mm, often reduced by kneeling to 250 - 280 mm. Even with well-designed handrails at the entrance, the step height of 360 mm would prove a barrier for more than 50 percent of the elderly and ambulant disabled population boarding from the road, or about 25 percent if the bus can stop close to the curb (see Figure 4a). A knelt height of 270 mm would be a barrier to about 25 percent boarding from the road and almost no one boarding from the curb. Lack of satisfactory handrails would increase substantially the percentages finding the entrance step difficult (see Figure 5b).

3.4.5 Scope for ITS

The development of the low-floor urban bus, possibly linked to the use of raised sidewalks at bus stops, has opened a new era of accessible urban transport. Although there is a long way to go with implementation in North America, there can be no doubt that the low-floor bus will become the standard means of urban public transport and will be usable by the whole population, including people in wheelchairs. This has nothing to do with ITS.

There are many applications of ITS to urban bus services that will benefit all users. These include traffic management to improve bus service speed and reliability, bus location for control of the system, and passenger information at bus stops and terminals and within vehicles. All of this is being applied in various European cities. Once the main urban public transport systems have become accessible, better provision of passenger information may well remove barriers for some people with sensory or cognitive disabilities. Figure 8a shows a display of the time to wait for the next two trains from a station in the London underground. Similar signs which display the route numbers, destinations and waiting times for the next two or three services are being introduced at bus stops in London, Paris, Southampton and many other European cities. When bus stops that provided continual audible information were tried in the U.K., complaints were received from neighboring residents, shopkeepers and workers, who objected to the frequent spoken messages. To overcome this problem, bus stops in Southampton have been made to respond to a proximity device, carried by blind people, to trigger the audio announcements only when they are needed. A similar device could expand and scroll the information for people who need large print.

Some bus operators already have equipment in vehicles to display the name of the next stop, or to announce it audibly (Figure 8b). 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. People who need to be told by the driver that they are at a particular stop could enter their requirement into a small memory unit at the driver's station, to remind the driver when the stop is reached.

Figure 8a Display of the waiting time and destination of the next two trains from an underground (subway) station in London

Figure 8b Display of the name of the next stop in a bus in Malmo, Sweden

Ståhl reports that "Service Route" hail stop bus services (see section 4.3 for details) have caused some users problems with identifying the bus in time to wave it down. It should be possible for a bus to communicate with a passenger via a hand-held receiver. This could provide the warning that the passenger needs to hail the bus, or alert the driver to the waiting passenger. The technology of communication between vehicles and the roadside has already been developed for electronic tolling.

In Germany, Deutsche Telecom, Deutsch Bahn and 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 and to make telephone calls (Wergles, 1996). It can be reloaded using any card-telephone, debiting the holder's bank account rather than requiring a cash payment. Although not suggested by VDV, such a card could be extended to cover air, ferry and taxi services and to carry optional personal information about the holder, to become a multi-modal payment and information card. This could be read when a ticket for a specific journey is booked, to record whether help is needed at stations, if a wheelchair place on a train must be reserved, if a wheelchair accessible taxi is required to meet the train, and to pass information on any special requirements of the traveller to the operators of each mode in a multi-modal journey.

3.5 Problems with Paratransit and Taxis

3.5.1 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 for dial-a-ride service 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.

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 well in advance and often a high percentage of “no shows”, which are increased by a long booking lead time.

3.5.2 Taxis

Research on taxi services accessible to disabled people has fallen into three categories. These are co-ordination of taxi, paratransit and regular public transport services (mentioned in section 3.5.1 above); 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.

Since January 1989, all new purpose-built London taxis have been required to be accessible to people in wheelchairs. The regulation was set by the Public Carriage Office of the London Metropolitan Police and did not require national or European legislation. The modifications required to the existing design of London taxi were minimal, and by 1996 some 10 000 of the London fleet of 18 000 taxis were accessible (see Figure 9). Because the purpose-built taxi is also used in all the larger metropolitan areas of Britain, the result of the regulation for London was the introduction of accessible taxis in all the major urban areas of Britain.

Figure 9 The accessible purpose-built London taxi (Photograph Carbodies LTI Ltd.)

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.

3.5.3 Possible roles for ITS

There is clearly scope for advanced communication systems to enable passengers to make reservations for both paratransit and taxi services, despite the pressure on the control office and possible communication handicaps. Communications between drivers and passengers can be improved by ITS equipment (Rutenberg and Suen, 1996). Record Electronics Inc. have developed a slave display for a taxi meter which is easy to read and which speaks the fare for passengers with impaired vision. Automated dispatching is now well proven and can improve productivity for taxi and paratransit systems. There is probably a role for ITS systems such as navigation/route finding and traffic information to help both taxi and paratransit drivers; a traffic information system using RDS radio has been in general use in taxis in Gothenberg, Sweden since 1994.

3.6 Problems with Trains and Subways

3.6.1 General

In Britain, railway platforms are much higher than in North America or 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 carried 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.

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.

3.6.2 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.

In Europe, there was a wave of development and 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. Where possible, the improvements to the suburban systems tended to concentrate on raising platform levels for level access to rolling stock and providing access to platforms (Blennemann, 1992). This period of implementation was accompanied in Europe by research, mainly concentrating on ticketing machinery, ticket barriers, colour contrasts and guidance for visually impaired people and the provision of information. Several papers in the 1992 and 1995 COMOTREDs reported the implementation of projects for various subways or light rail systems.

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 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)

The most frequently quoted problems were getting to or from the station, stairs at stations (flights of stairs are often quite long) and using escalators.

Oxley and Alexander (1994) found that only 21 percent of their sample of disabled people 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 small. Almost as many difficulties occurred getting to and from the station, and more of these were large problems. There were problems at stations and getting on and off, but these were mainly small. 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.

3.6.3 Long-distance rail

As with suburban rail services, the primary access problems for long-distance rail are boarding wheelchairs from low platforms, narrow doors and passageways and access to station platforms. In addition, lack of accessible toilets and access to catering services are additional problems on long-distance trains.

By the late 1970s, many railways 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.

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.

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%

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).

Ståhl et al. (1993) found that train trips caused great problems for disabled travellers. Getting on and off the train caused most large problems while travel on the train caused most small 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 are 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.

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.

3.6.4 Role for ITS

Obtaining information is not the largest problem of using rail transport, but for certain groups it is a real problem. There is a need for more visually displayed information in stations and in trains for people with hearing impairments. All users would benefit from better guidance to the correct platform, from information on the waiting time to the next train and its destination, and from in-train information on progress and the next station. Some subways already provide displays at stations of the waiting time for the next train and the destination of the next train. Others provide an in-train display of the name of the next station.

Disabled people are particularly affected by unreliability and equipment changes, and would benefit from a service giving real-time information on the availability of lifts and escalators, changes to rolling stock and other unusual situations that can pose difficulties or barriers to disabled people. There is scope for a personal travel card to arrange for staff assistance, to reserve wheelchair spaces and to ensure that all the necessary links are in place for a complete journey.

3.7 Problems with Cars and Driving

3.7.1 General

The numbers of elderly and disabled drivers are increasing. This is partly because previous generations of elderly people never learned to drive, partly because elderly people are getting richer and partly because the technology to help disabled people drive is improving. Elderly drivers are usually grouped with disabled drivers because aging causes physiological changes that affect driving. These are increased reaction time, deteriorating vision, particularly at night, and a reduced ability to split attention between several tasks. In addition, impairments due to strokes, arthritis and rheumatism become more common as people age. As people grow older their accident rate per mile driven increases, even though they change the times and destinations to avoid situations they find difficult. Because older people are relatively frail, the proportion of those accidents that result in death or injury rises even more sharply with age (Evans, 1991). However, in most countries the fatal accident rate per year for elderly drivers is no higher than for middle-aged drivers, and much lower than for young drivers (see Figure 10) (TRB, 1988; Highway Users Federation, 1989).

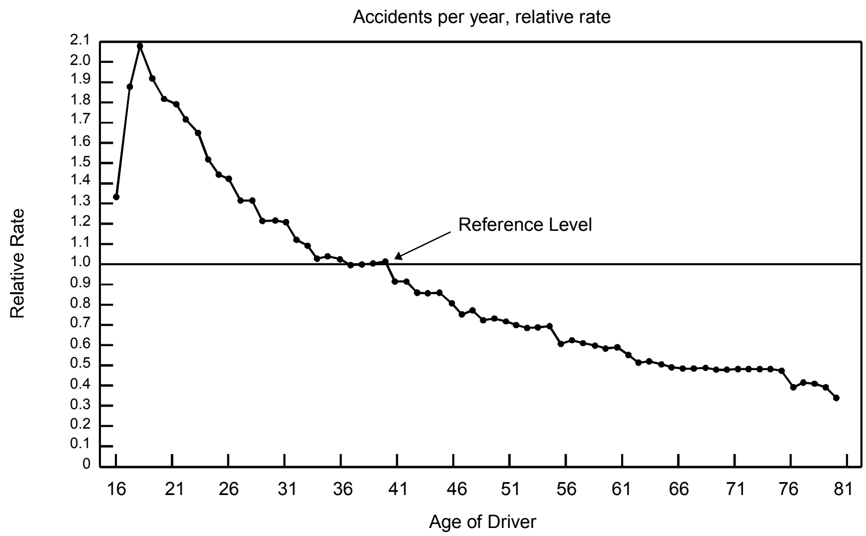
In Britain in 1975, a survey in the city of Guildford collected information on driving and licence holding by elderly people (Hopkin et al., 1978). The proportion of men driving regularly ranged from 57 percent for those aged 65 - 69 years to 11 percent for those aged 80 years and over. For women, the corresponding figures were 10 percent and 4 percent. Among people who had ever held a driving licence, 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 (see Table 10).

Table 10
Car use and licence holding among old people who had ever held a driving licence (percentage)
Guildford, England 1975

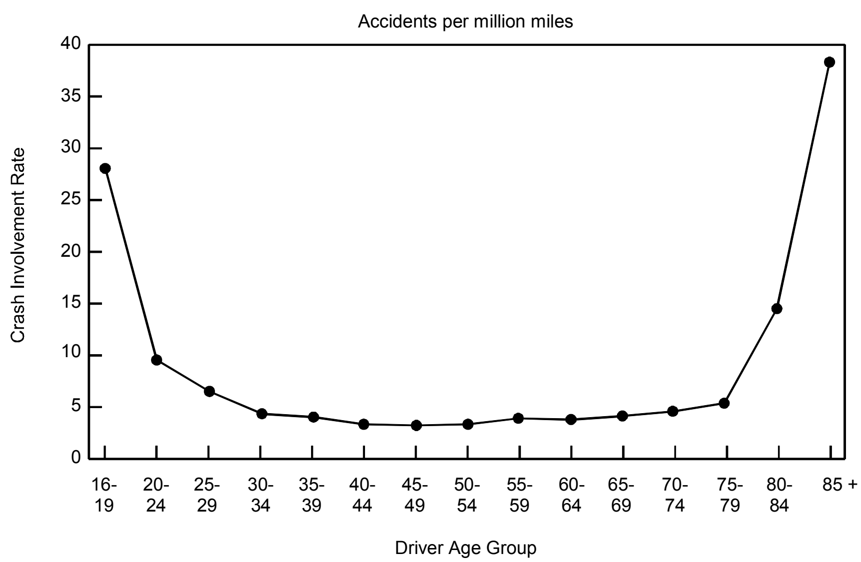
	Age			
	65 - 69	**70 - 74**	**75 - 79**	**80+**
Drive once a week or more	57	40	28	21
Drive less than once a week	*	2	0	0
Driver, frequency not stated	3	7	0	3
Have licence, don't drive	19	10	19	21
Licence given up	20	41	53	55
Number of respondents (=100%)	123	105	57	317

** less than 1 percent*
(Source: Hopkin et al., 1978)

More recent data from the British National Travel Survey suggest that men, at least, are retaining licences to older ages. In 1988-90, 41 percent of men aged 80-84 and 30 percent aged 85+ held current driving licences. The survey does not contain information on people who had surrendered their driving licence. Licence 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.



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



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

Figure 10 Elderly driver accident involvement, U.S.

Data from the U.S. show a much higher level of license holding. In 1988, 85 percent of men and 49 percent of women aged 70 and over held current driving licences (Federal Highway Administration, 1995). By 1994, these proportions had increased to about 90 percent of men and 58 percent of women. Figure 11 shows that by 1994, licence holding among men was approaching saturation for all ages, but for older women licence holding was still increasing. Since the population of older people is itself expected to increase, the number of older drivers will also increase.

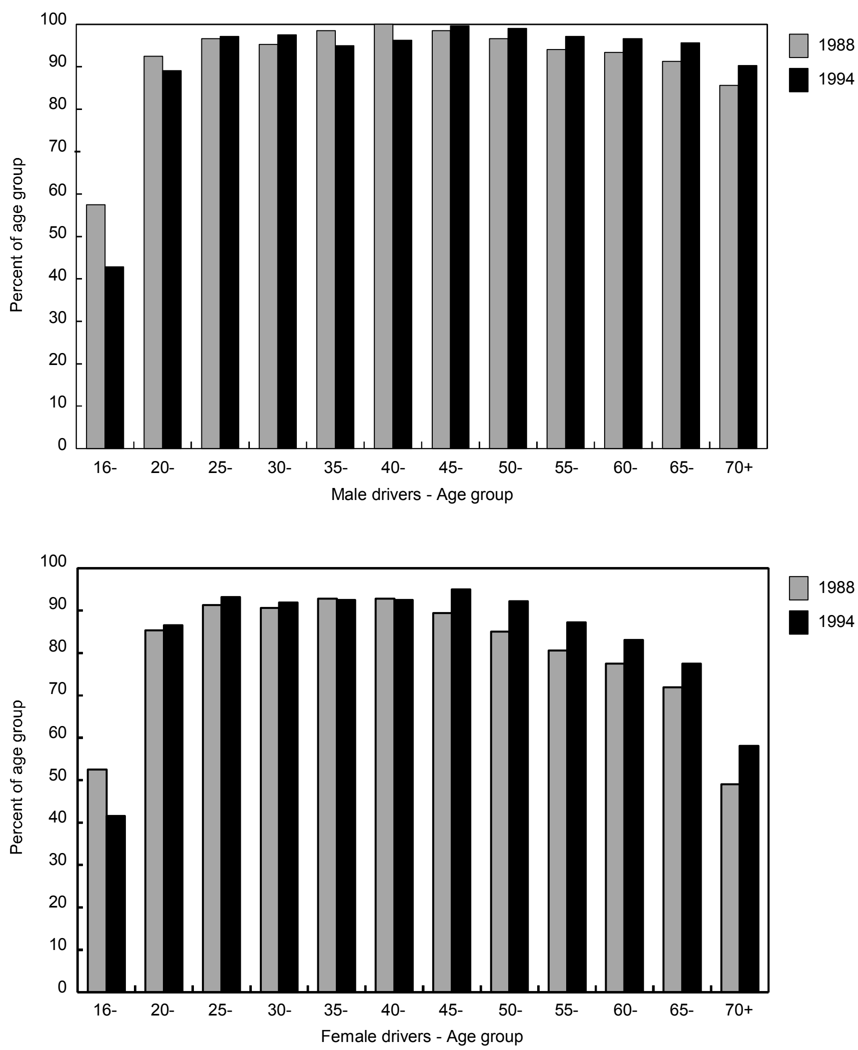


Figure 11 Percentage of the population holding driving licences in the U.S. by age group (Federal Highway Administration (1995) - Highway statistics 1994 and earlier editions)

Even for people aged 85 and over, 75 percent of men, but only 26 percent of women, held licences in 1994 (see Figure 12). 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 licences and continuing to drive.

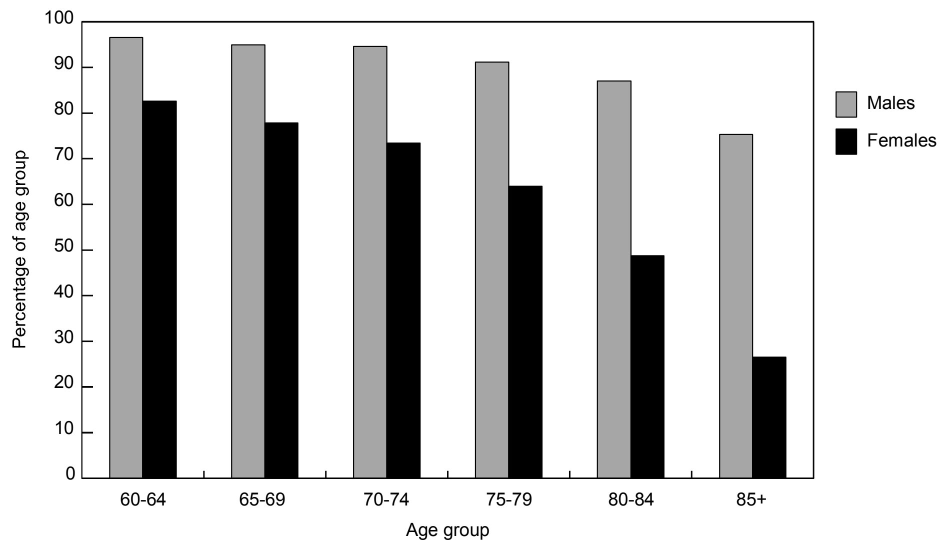


Figure 12 Percentage of the older population holding driving licences in the U.S., 1994 (Federal Highway Administration (1995) - Highway statistics 1994)

Studies have recently been made of ways in which the highway system can be improved to be easier for elderly drivers to use (TRB, 1988), and of the scope for using intelligent transportation systems and other advanced technology to compensate for the physiological effects of aging (Oxley and Mitchell, 1995; Mitchell, 1996; Mitchell and Suen, 1997).

3.7.2 Why drivers stop driving

Hopkin et al. (1978) reported the reasons given by elderly people for surrendering their driving licences (Table 11).

In 1990, Simms (1992) surveyed 269 drivers and 87 former drivers, all aged 70 or over. Eighty-two of those who had given up driving had voluntarily handed in their licence. The other five 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%

Table 11
Percentage of respondents reporting reasons for giving up driving licence

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)

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 analysed 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.

3.7.3 Situations drivers avoid

As drivers age, many of them adopt compensatory behaviors to avoid those situations which appear to create most stress (Laux and Brelsford, 1990). As a group, older drivers tend to give up driving at night, drive less frequently, avoid driving in bad weather, and avoid expressways and limited access highways. In addition, older drivers report that a smaller percentage of their trips included unfamiliar areas than did younger drivers. Another U.S. study of 664 drivers in Illinois aged 65 or over found that the conditions avoided were ice, rush hour, night and rain (Benekohal et al., 1994). The proportion avoiding night driving increased most rapidly with increasing age, from 28 percent for those aged 66 - 68 to 67 percent for those of 77 or over.

Simms (1992) listed the percentage of drivers aged 70 or over who tried to avoid certain situations on local journeys:

Town centres	87%
Complicated junctions	62%
Roundabouts	37%
Changing lanes	37%
One-way systems	32%
Merging into traffic flows	29%
Right turns (left turns in Canada)	24%

Country lane	20%
Dual carriageways	13%

The same drivers reported having actually changed their driving behavior to avoid the following situations on local journeys:

Roundabouts	38%
Right turns (left turns in Canada)	33%
Town centres	26%
One way systems	25%
Dual carriageways	23%
Multi-story car parks	22%
Merging into traffic flows	21%
Complicated junctions	16%
Changing lanes	16%
Country lanes	10%

Rabbitt et al. (1996) reported a more extensive list of situations avoided by older drivers and ex-drivers (Table 12).

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)

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. Thus, 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 effects of aging that make driving more difficult for older people.

3.7.4 Accidents to elderly drivers

Most countries find that elderly drivers have the same or fewer accidents per capita than do younger drivers, but more accidents per exposure, as was showen in Figure 10 (Federal Highways Administration, 1990; TRB, 1988; Oxley and Mitchell, 1995). This applies to the U.S. and Britain, but not to Canada, where the rate per capita increases for older drivers. The accident involvement rate per mile usually begins to increase from a minimum for drivers aged about 40 - 60, but only begins to rise steeply for ages greater than about 75. The fatality and serious injury rates are usually lowest for ages 40 - 50 and rise more rapidly with increasing age. This reflects the greater frailty of elderly people, and hence their greater likelihood of injury or death in a given accident. In Canada, the death rate per capita from motor vehicle collisions is higher or equal to that of all other age groups except those aged 15 - 24. Those aged 75 have about four times more fatal accidents per 100 million miles than the 25 - 29 group have. Their relative risk of fatality is higher than in any driver group except those aged 16 - 19 (MacLennan, 1993).

The pattern of accidents in which elderly drivers are involved is different from that for younger drivers. Elderly drivers are more likely than average to have accidents at junctions, particularly where they have to turn across traffic; due to failure to yield right of way; involving other traffic signs or signals; unsafe lane changes; and 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.

3.7.5 Making cars easier for disabled people 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. These are now so effective that if a disabled driver has the cognitive skills to drive, and can afford the vehicle conversion, he or she 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.

3.7.6 Scope for ITS

The DRIVE II Project EDDIT (Elderly and Disabled Drivers Information Telematics) specifically assessed the potential value of ITS to elderly drivers (Oxley and Mitchell, 1995). It concluded that:

> Systems for route guidance/navigation and emergency alert/Mayday services seem likely to have a positive effect on elderly driver mobility.
>
> Night vision enhancement systems would produce the greatest improvements in safety of driving. Reversing aids/obstacle detectors could make a modest contribution to improved safety, particularly in reducing the likelihood of reversing into a person.
>
> Route guidance/navigation systems have little effect on driving safety one way or the other, providing they are well designed and any adjustments to the display while driving are simple to make.

Collision warning systems appeared to have potential to reduce the junction accidents in which elderly drivers are over-represented. The trials of such systems during the EDDIT Project involved simulations of the systems and did not allow time for development in response to early results. The collision warning systems reduced the risk of a driver pulling into a gap that was too short to be safe, but increased the risk of a “near miss”, because drivers manoeuvred more slowly when the system indicated it was safe to turn. Further development should correct this problem.

Although there is little or no research evidence to confirm it, there can be little doubt that difficult driving situations for elderly drivers (as indeed for all drivers) can be caused by unusual events. These might be scheduled activities such as roadworks, road closures or special events that attract heavy traffic. They might be unexpected events such as accidents, bad weather, failure of traffic signals or street lighting. It should be possible for ITS to provide very much better information on such events, probably using RDS radio to transmit traffic messages as audio announcements or visual display. These could provide all drivers, and especially elderly people who try to avoid difficult situations, with sufficient information for them to decide not to travel, or to go elsewhere, or to take a different route. In Britain the Trafficmaster system already gives real-time information of traffic speeds on motorways and major roads, to help people avoid congestion caused by accidents, road works or volume of traffic.

3.8 Problems with Information

Earlier parts of this section have repeatedly drawn attention to the need for better information for elderly and disabled travellers. This needs to cover pre-trip planning, terminal displays and information, probably in vehicle, while the trip is progressing.

The pre-trip 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 equipment failures 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.

Information in terminals, at bus stops or subway stations, and in vehicles, needs to be available in audio form, for visually impaired people, and visually, for hearing impaired people. 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 know when they are approaching their destination and, if relevant, on which side the destination platform is. 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 the stress and need to move and act quickly while doing so, there is no doubt that it would help all travellers.

ITS offers considerable scope for providing information to travellers. At present much information is on paper or on fixed signs, but increasingly, real-time information is being displayed electronically in terminals, at bus stops, in subway stations and in vehicles. Care is needed to ensure that visual displays are suitable for elderly people (which also ensures that they are easy for everybody to use). There is scope for using ITS devices carried by elderly and disabled people to trigger audio announcements from displays that are usually visual or to change displays to large print.

Some of the ITS traffic management systems that are intended to keep traffic flowing smoothly and to guide all travellers have particular benefits for elderly and disabled travellers. Systems that already display in real time where parking space is available and guide drivers to available spaces could do the same for disabled people seeking priority parking. For the able bodied, walking an extra few hundred metres is no real problem. Many disabled people can walk less than a hundred metres, and if parking is not available near their destination, then the destination is not accessible. Similarly, 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. It should be possible to transmit waiting time for a bus to homes using cable TV, to allow an elderly person to wait indoors until the bus is due. Similarly, urban information systems should allow elderly and disabled people to make last-minute checks on travelling conditions before committing themselves to travel. The European TIDE Project TURTLE is demonstrating these services using Teletext (European Commission, 1994).

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. EUROPEAN ACCESSIBILITY SOLUTIONS

4.1 General

In most European countries, as in North America, concern over problems of transport and access to buildings by elderly and disabled people were being expressed in the late 1960s. Legislation was passed in the early 1970s and physical improvements and financial support schemes began to appear in the late 1970s and 1980s. To quote a number of sources:

> Millions of elderly people are suffering needless imprisonment - unable to go shopping, visit friends or even cross a road at will. ... Lip-service is constantly paid to the necessity of enabling elderly people to remain independent and enjoy a reasonable quality of life. If they cannot get to the shops and post office, the pub, the club, the church or the doctor, what sort of life can they have? (Norman, 1977)

> The past decade has seen an expansion in the demand for travel by all sections of the community. ... The overall effects of increased car ownership on those who are less fortunate and in particular the special case of the elderly and disabled, has thus become a topic of growing interest and importance. ... So far provisions have been piecemeal and the claiming of responsibility haphazard, which reflects the absence of a consistent policy aimed at ensuring the mobility of elderly and disabled people. (Garden, 1978)

> In the United States since 1970, there has been a growing awareness that for many people, the lack of transportation represents a serious limitation on their physical and emotional well-being. In particular, the elderly and handicapped have been identified as vulnerable, and a variety of programs have been designed to provide more (and better) transportation to these two groups. (Revis, 1978)

> The starting point for the adaptation of public transport to the differently abled during the 1980s was the (Swedish) transportation policy decision of 1979. The purpose of this decision was that the goal of transportation policy should be to guarantee all Swedish citizens access to adequate means of transportation. (Ståhl et al., 1993)

The remainder of this section is based partly on the references quoted and partly on personal experience of the research on accessibility and development of accessible vehicles and infrastructure that took place between 1982 and 1994. Accounts of the development of accessible public transport in Sweden and France have been provided by Ståhl et al. (1993) and Dejeammes and Dolivet (1995) respectively.

4.2 The Development of Accessible Transport in Europe

In the late 1970s, in Europe transport provision for disabled people consisted largely of special minibus services provided by social service departments of local authorities to take people to day centres and social clubs, special services provided by voluntary or community groups to take elderly and disabled people on excursions and to shopping or to social activities, some improvements to the design of buses and concessionary schemes to make bus travel more affordable. At the same time, new public buildings were required to be accessible and a few steps were being taken to modify existing public buildings to make them accessible.

Also by the late 1970s, air services and airports were generally accessible, mainly as a result of the new practice of loading through a jetway. Previously, aircraft had been parked away from the terminal building and boarded up a flight of steps, as is still the case in some small airports and in less developed countries. In Britain, British Rail started a program of enabling wheelchairs to be carried on mainline rail services between principal stations. As early as 1980, it was appreciated that once long-distance travel by air and rail was accessible, there would be a problem for people in wheelchairs getting to their final destinations from airports or main railway stations. Because of this, the manufacturer of the “London-style” taxi was persuaded to modify the vehicle to make it wheelchair accessible. After trials of two wheelchair accessible taxis, regulations were introduced to require new taxis in London to be accessible (see Figure 9 and section 3.5.2). In practice, this has meant that all new London-style taxis in Britain are accessible, and in particular, by 1996, 10 000 of the fleet of 18 000 taxis in London were accessible. The extra cost for new vehicles has been minimal.

Since the mid to late 1970s, new subways, light rail and suburban rail systems in most countries have been built to be accessible (Lille and Grenoble, France; Newcastle upon Tyne and Manchester, England). A number of opportunities were missed, with the re-furbished Glasgow underground remaining non-accessible and the Marseilles and Lyon subways being built non-accessible. The early, non-accessible parts of the Stockholm subway were modified for accessibility in the 1970s, and the remainder of the system constructed to be accessible. In Germany in the early 1980s a start was made to modifying the existing subway system in Munich, and in 1989 to the system in Hamburg, to make them accessible to passengers in wheelchairs. A new extension to one line of the London underground (subway) is being constructed to be accessible, and a previous rule that prohibited passengers in wheelchairs from the deeper lines of the system has been rescinded.

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 favor. 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.

Britain and the Scandinavian countries established a variety of financial and training programs to help disabled people purchase and learn to drive cars. During the 1980s Belgium, Britain and the Scandinavian countries set up advisory centres for disabled drivers, to help them select the correct car and adapted controls or to verify their qualification for state assistance with the purchase and/or operation of a car.

4.3 Urban Bus Services

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, because boarding and securing a wheelchair in a high-floor bus was taking over two minutes, and the buses were typically carrying one wheelchair passenger per bus per month, this was not an effective policy. 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. Transit buses were provided with easier entrance steps, good handrails, internal stanchions and good colour contrasts, as indicated in section 3.4.2 and Figure 7. 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.

A major change in attitudes to the carriage of wheelchairs on urban bus services occurred 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 (see Figure 13 for the layout of a typical urban low-floor bus in Germany). A slight slope at the entrance reduced 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 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 adults with children, people with walking difficulties and passengers encumbered with luggage or shopping.

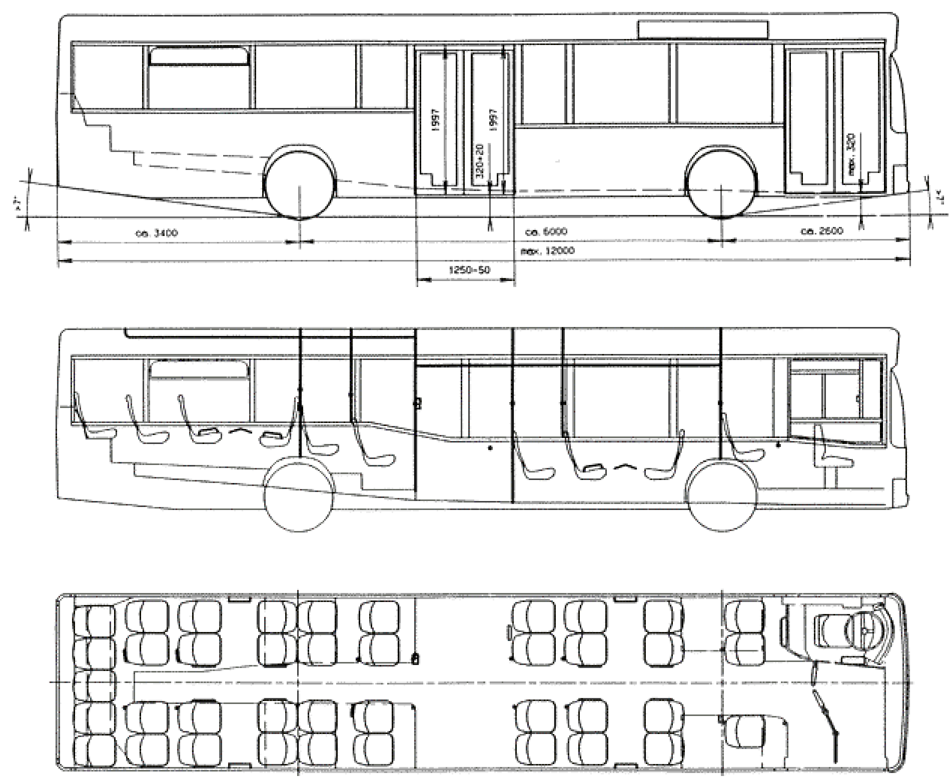


Figure 13 Overall layout of a typical German low-floor bus (VDV, 1994)

As soon as low-floor buses entered service, it became clear that they could accommodate passengers in wheelchairs and boarding aids were added. These were initially lifts, but the transit industry has now settled on ramps, almost always at the centre door. This provides easier access and is also a more protected position for the ramp. The passenger in a wheelchair travels facing backwards with the wheelchair backed against a soft bulkhead (Figure 14).

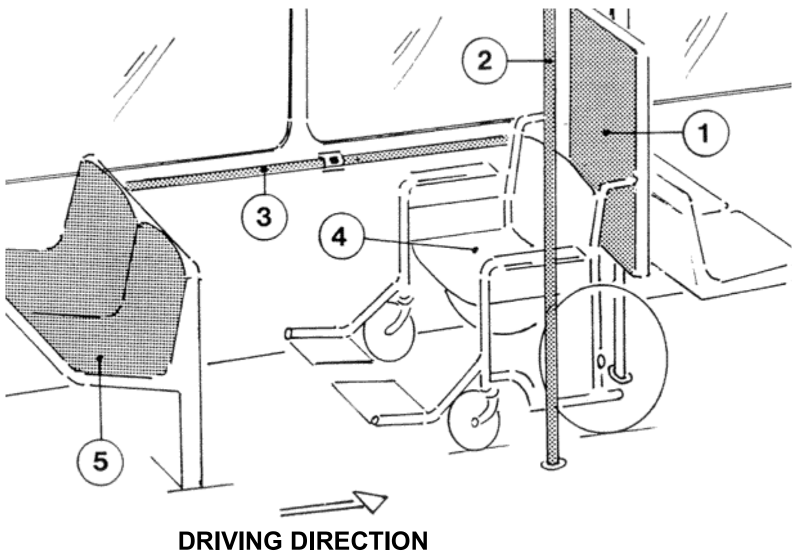


Figure 14 The European unrestrained but protected position for a passenger in a wheelchair (Rutenberg, 1995)

The dimensions and layout of the space for wheelchair passengers recommended by the European Community COST (Co-operation in Science and Technology) Action 322 “Low-floor buses” is shown in Figure 15. Both Britain and France, but not Germany, use a stanchion between the wheelchair position and the aisle, as shown in Figure 15, to prevent the wheelchair moving sideways in turns. Studies on unrestrained wheelchairs in urban buses in both France (Dejeammes and Bonicel, 1992) and Germany (Kastern, 1991) have shown that the arrangement recommended by COST 322 prevents the wheelchair moving or overturning during normal transit operations. Tests of simulated collisions show that the rearward-facing position is safe, provided the wheelchair is against the bulkhead, rather than some distance from it because of luggage on the back of the wheelchair or because the wheels of the chair have encountered a seat pedestal.

In Germany, this wheelchair place is opposite the centre door which has traditionally been a space for standees, luggage and baby strollers. In Britain and France a number of alternative wheelchair locations have been used (Figure 16); all these alternatives involve the use of the centre door. The dimensions of a typical ramp for use at a centre door are shown in Figure 17 (Dejeammes, 1996).

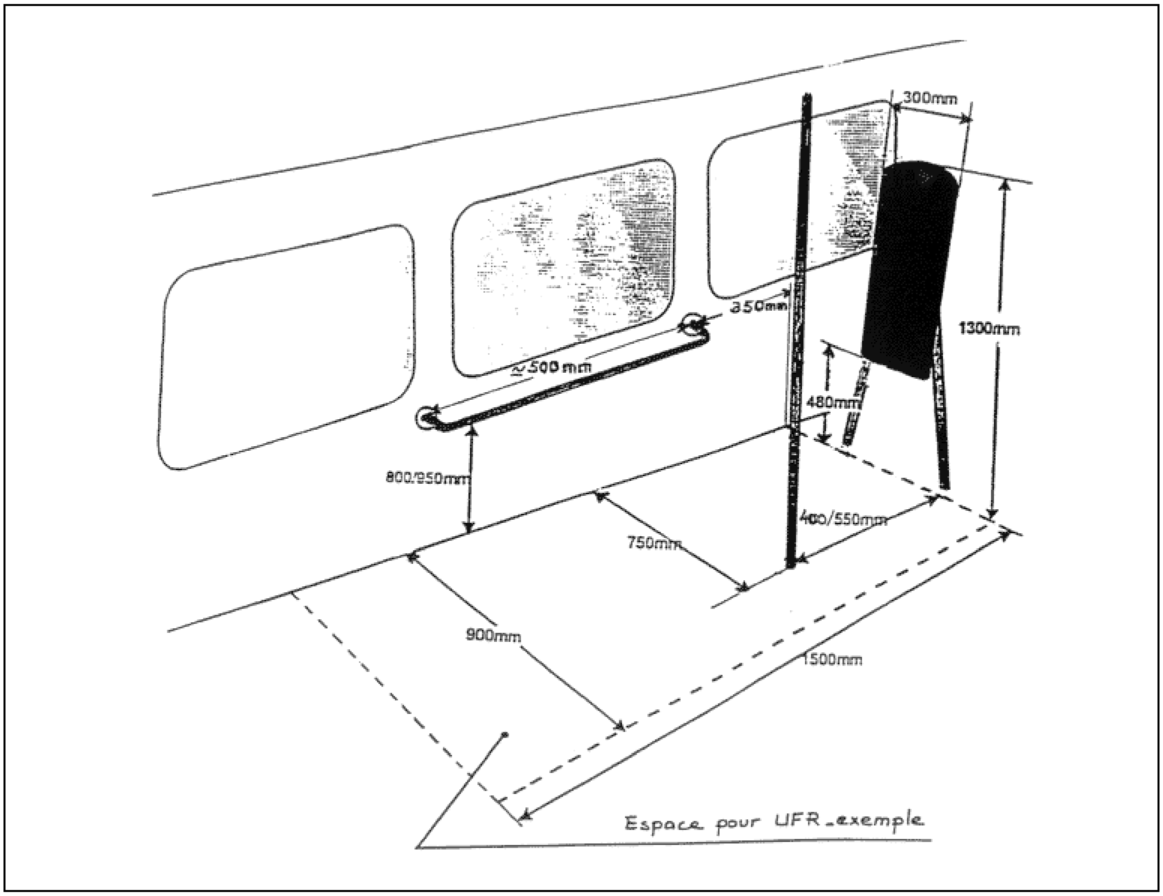
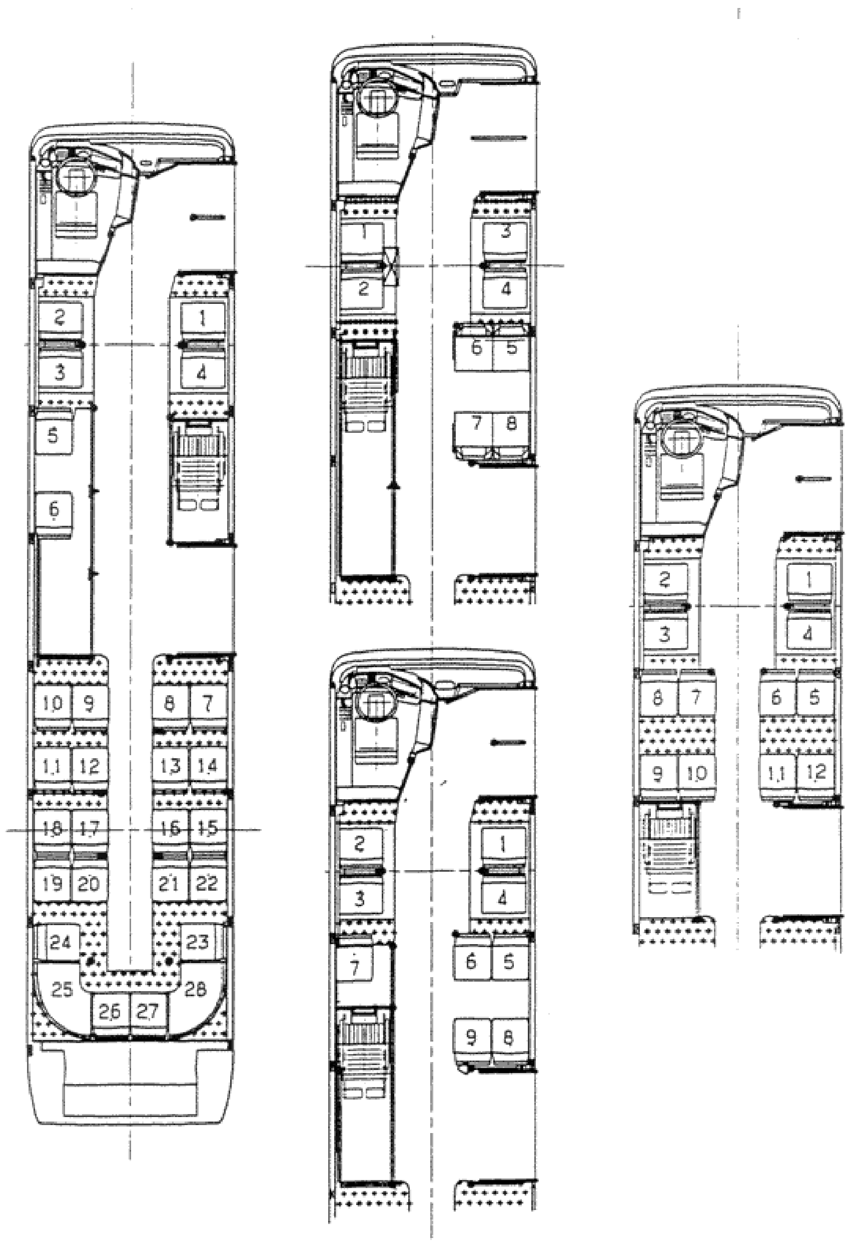


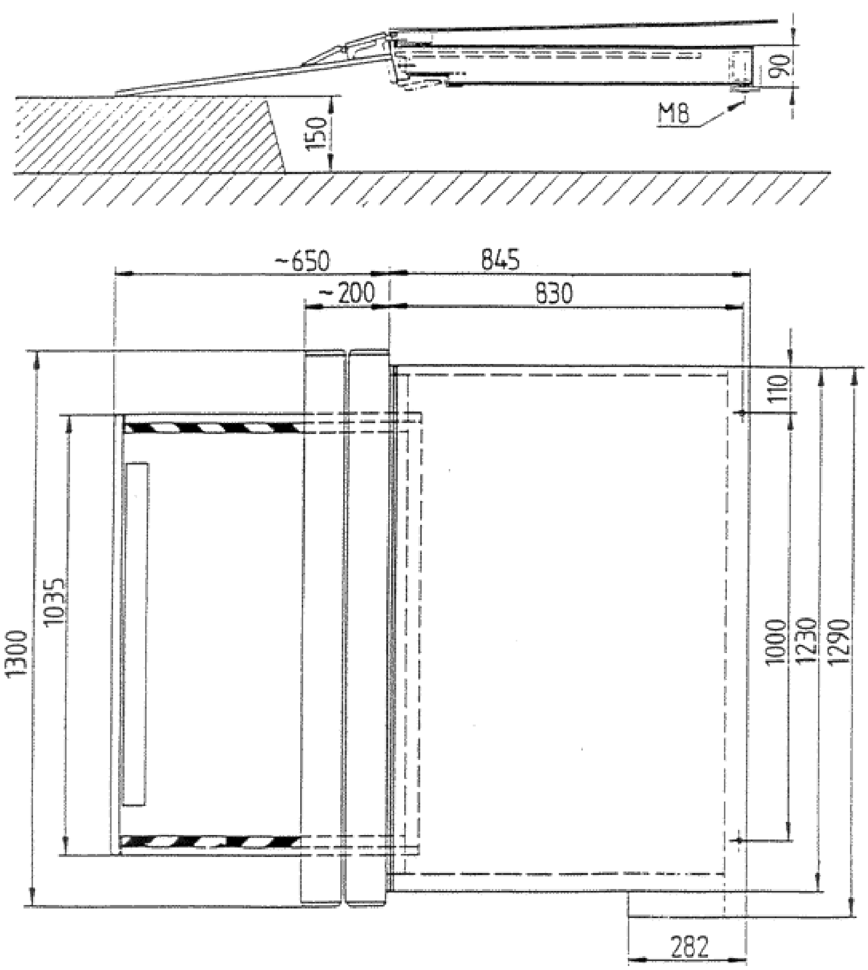
Figure 15 Layout of the position for a passenger in a wheelchair (COST Action 322, from Dejeammes, 1996)

Urban bus services have been opened to people in wheelchairs by the combination of the low-floor bus with a simple ramp at one door and permitting the carriage of a passenger in an unrestrained wheelchair. 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 not much longer than for other passengers. The driver does not need to leave his seat to attend to passengers in wheelchairs. Boarding times for passengers in wheelchairs are sufficiently short (usually well under one minute) to all these passengers to be carried in significant numbers without delaying the bus substantially. Low-floor buses now (1996) account for between 75 and 85 percent of all new urban buses in Germany and are in service in at least France, the Netherlands, Denmark and Britain.



Wheelchair passengers enter and leave by centre door

Figure 16 Alternative internal layouts for low-floor buses in France (Dejeammes, 1996)



Bus body to the right, sidewalk to the left

Figure 17 Dimensions of a typical retractable ramp for the centre door of a low-floor bus (Dejeammes, 1996)

Figures 18 to 20 illustrate typical European low-floor buses, in this case types that are in service in London.

A second major change in the provision of accessible urban transit 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.

Figure 18 A passenger in a wheelchair boards the bus at the centre door (Photo: London Transport)

Figure 19 Interior of a low-floor bus, showing the compartment for a wheelchair on the left and space for a baby stroller or shopping cart on the right (Photo: London Transport)

Figure 20 Boarding and alighting is easy for all passengers
(Photo: London Transport)

Service Route transit can be introduced both to complement other public transport services and to provide an opportunity for more people to use public transport. Where the average number of passengers is small, Service Routes can serve as both conventional and special 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.

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 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 able to work if they have an automobile available.

4.4 Pedestrian Infrastucture

Most European countries have national standards or guidelines on urban infrastructure that is accessible to elderly and disabled people. Many of these have been summarized by the Institution of Highways and Transportation (1991). This publication gives extensive advice on how to build and maintain an environment that is barrier free for the whole population. Figures 21 to 24 provide some examples of advice from Institution of Highways and Transportation, 1991. The examples given cover the lengths and widths of pedestrian groups and mobility equipment to be considered when planning urban pathways (parent with a double baby stroller, a person with a guide dog, a person in a wheelchair and so on); dropped curbs; stairs; and precautions to prevent people walking into obstacles. The document includes a checklist for accessibility that has proved useful.

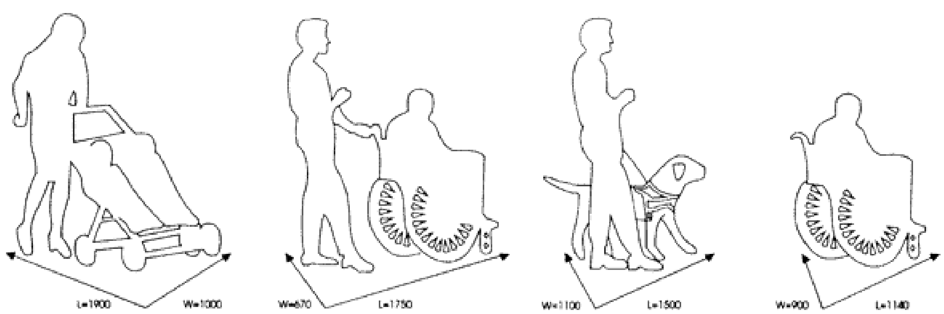
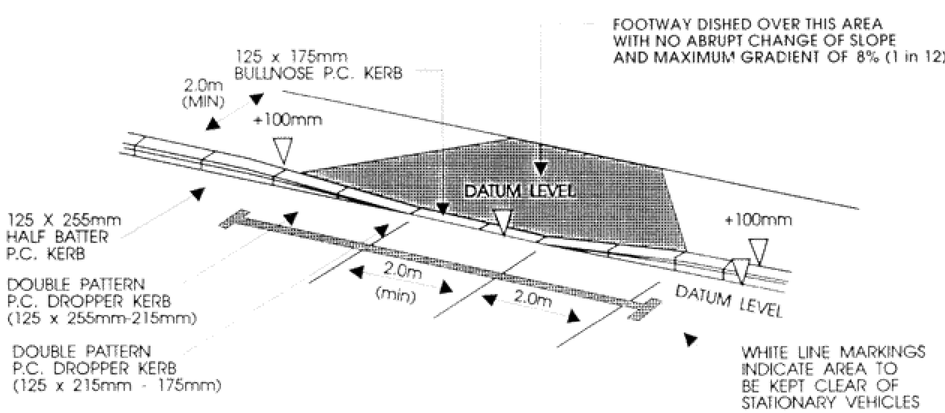
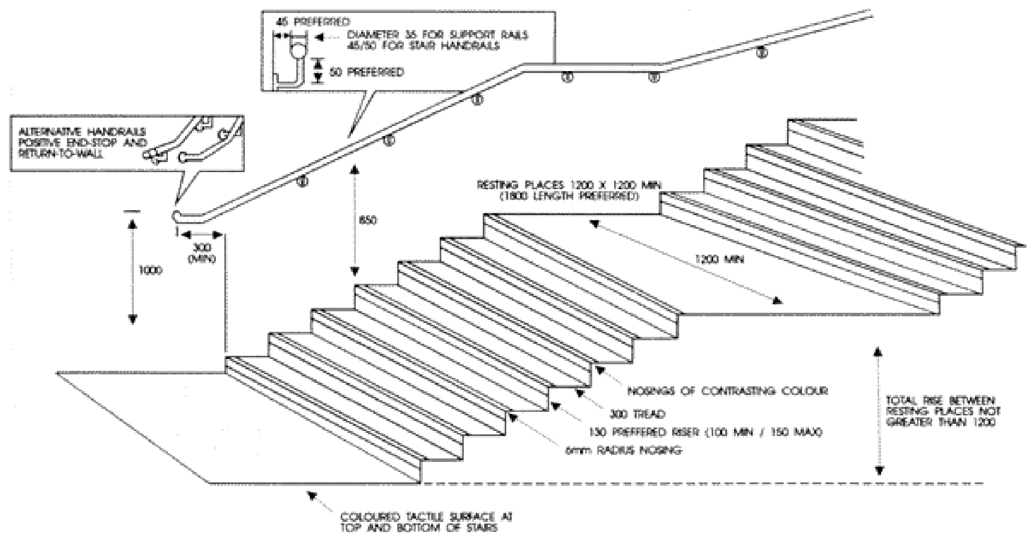


Figure 21 Typical lengths and widths of people and equipment (Institution of Highways and Transportation, 1991)



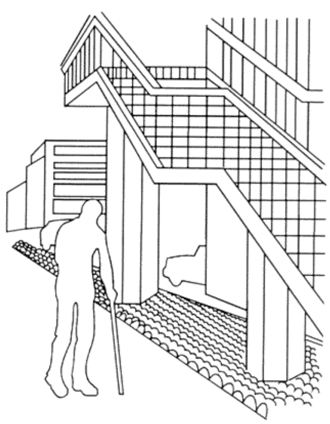
Note: The dropped curb must be absolutely flush with the carriageway

Figure 22 Dropped curb details (Institution of Highways and Transportation, 1991)

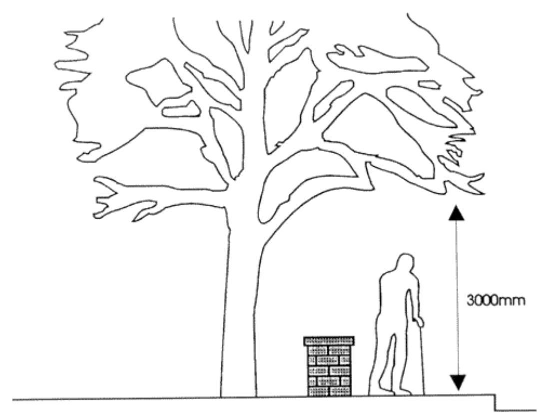


All steps to have white or coloured nosings. No overhanging nosings.
(For clarity, the near handrail has been omitted)

Figure 23 Flight of steps with a handrail (Institution of Highways and Transportation, 1991)



Safeguarding a tapering obstruction



Headroom requirement for overhanging tree branches

Figure 24 Measures to protect pedestrians from obstructions (Institution of Highways and Transportation, 1991)

Guidelines are also available on making transport terminals available. British Railways Board (1989) lists specific requirements for the design and execution of works for disabled passengers at British Rail passenger stations. Barham et al., 1994 provide design guidelines for public transport infrastructure, with particular emphasis on bus stations and bus stops. Balog et al., 1993 provide an accessibility handbook for transit facilities, with particular emphasis on the requirements of the Americans with Disabilities Act (ADA). Figure 25, from the Accessibility Handbook for Transit Facilities, shows an accessible bus stop. As more accessible buses are introduced, either low-floor or lift-equipped, the accessibility of bus stops has proved to be a significant problem.

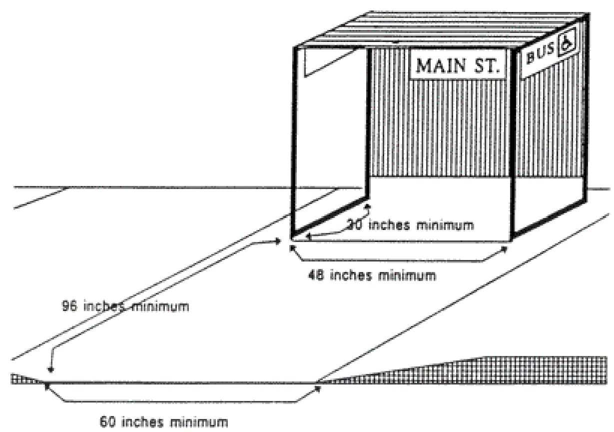


Figure 25 Accessible bus stop (Balog et al., 1993)

4.5 Information

As the physical accessibility of vehicles and infrastructure has improved, and as the financial resources available to elderly and disabled people have increased, it has been better appreciated that there are barriers to accessibility other than physical and financial. Elderly and disabled people may well not know of the existence of services that they could use; they may not know how to use services, even if they know that they exist; they may be reluctant to delay other passengers by the time they take to board or alight, embarrassed to reveal their inexperience or afraid of not being able to manage the journey. There is a growing trend in Europe to provide much better information for elderly and disabled people, and their friends, families and caregivers, about all aspects of transport. This includes the existence of services, contacts with organizations which can help with journey planning, real-time information at terminals, at bus stops and in vehicles to help select the correct vehicle and to monitor progress. Operators are taking care to display information in formats that are easy to read and understand.

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 helpline requests were received, enabling 12 700 individual journeys to take place.

External signs on buses have been improved to make them easier to read, to assist in identifying the service desired. Bus operators in a number of Scandinavian towns have equipped buses with internal signs that display the name of the next stop and whether a stop has already been requested. These are normally associated with public address announcements of the next stop, and often with name signs at bus stops that can be read from inside the bus. Real-time information on the waiting time until the next train and its destination has been shown on dot matrix displays on the London Underground for some years. Similar displays at bus stops are beginning to appear in many European cities. 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). There is a great deal still to do in applying the technology available, but already the potential benefits of that technology can be seen.

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). Examples of the information these contain have been given in section 4.4, Figures 21 to 24. This guidance can be issued by many different types of organization, 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 the most important features that affect access (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 (Disabled Persons Transport Advisory Committee, 1993; COLITRAH, 1991). The new Disability Discrimination Act (1995) in Britain will give legislative force to access standards for public transport terminals and vehicles. The vehicle standards will be implemented through detailed regulations setting construction standards for new vehicles; details of the regulations were not available at the begining of 1997. 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 to date, 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). 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 impairments and 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. They can be 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.

Cross-sector benefits have been studied by Philip Oxley of 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.

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 percent. 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.

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. EUROPEAN EXPERIENCES THAT COULD APPLY IN CANADA

7.1 General

Some aspects of the social, transport and legislative situation in Canada are very different from the situations in Europe. These differences may preclude the application in Canada of some of the experiences in Europe. This section will try to identify European experience that might be applicable, and caution where it appears that social or legislative factors may prevent the transfer of experience.

7.2 Elderly and Ambulant Disabled People

One striking difference between accessible transport in Canada and Europe is that European countries have concentrated on low-cost improvements to vehicles and infrastructure to improve access by ambulant disabled people (including the frail elderly, blind and deaf people) before committing the larger investments needed to make systems accessible to people in wheelchairs. Perhaps because of this difference in priority, in Canada, quite a number of things that could be done at low cost do not appear to have been done. An example is the quality of urban infrastructure. In Europe, sidewalks are usually built and maintained to high standards to make them easier for everybody (and also to make them possible for people in wheelchairs). On some local sidewalks, slabs present steps of up to about 30 mm, tree pits are unfilled and obstacles or unfilled pits often reduce clear widths to less than 900 mm (the safe limit for wheelchair use). Few of the many obstructions to the sidewalks are brightly coloured or colour banded to be easy for visually impaired people to see.

The ramps at ramped curbs are shallower in Europe (and in much of the U.S.) (target slopes no more than 5 percent or 6 percent). In Britain, the road edge at ramped curbs is marked by tactile paving to indicate to blind people that they are leaving the safety of the sidewalk. Pedestrian phases at traffic signals often allow turning vehicular traffic to conflict with crossing pedestrians, which can be intimidating. Where conflicting traffic is stopped for part of the pedestrian phase, this time is often too short for elderly and ambulant disabled people to cross completely.

Outdoors and within shopping centres and subway stations, stairs are often surfaced with dark materials and step edges are difficult to detect. It is not unusual to have a change of colour about one step width away from the top or bottom of a flight of stairs, which creates the illusion of an additional non-existent step. Handrails rarely extend sufficiently far beyond the top and bottom of flights of stairs. These barriers cost little or nothing to avoid during construction or major refurbishment.

Canadian urban buses are well designed, given the high floor level, but there are some details that could be improved at negligible cost to make them easier for everybody to use. Lower floors, easier steps at doorways, good handrails, plentiful stanchions and good colour contrasts have been features of European urban buses for some years. They are proving to be helpful to people who find buses difficult to use, and it is likely that their application to Canadian urban buses would not only increase accessibility but also reduce accidents to passengers.

7.3 Low-floor Buses

Canada is clearly at a critical point for the introduction of low-floor buses and the carriage of wheelchairs. Europe is standardizing on buses with a floor height between the first two doors of 320 - 340 mm and a step height from the road of 320 mm, which can be lowered by kneeling to 240 - 250 mm. These are proving easy for the whole population to use, including mothers with babies, shoppers with carts, people with luggage and ambulant disabled people. Current North American low-floor buses tend to have a floor level of about 360 mm and a step height of 340 mm which can be lowered to about 260 - 280 mm. This initial step height should be reduced by at least 20 mm to help ambulant disabled people. Reports of trials of low-floor buses in North America have not mentioned the design of the handrails at the entrances and exits; these do need to be checked.

In Europe, wheelchair users board low-floor buses, usually facing into the bus at the second door, using a ramp which is also used by people who have difficulty stepping onto the bus. The wheelchair passenger travels unsecured, facing backwards and against a padded bulkhead that supports against deceleration loads. The wheelchair compartment is also used for baby carriages, luggage, and standing passengers. Boarding a wheelchair passenger in this way adds little to the stopped time for the bus.

In the U.S., ADA has legislated that wheelchair passengers must travel facing forwards or backwards with their wheelchair secured. Occupant restraints must be provided, but their use is optional. The combination of boarding by lift to a high-floor bus and securing the wheelchair gives a boarding time of 2 - 3 minutes for a passenger in a wheelchair. The alighting time is similar. Experience in Victoria, B.C. suggests that even with a low-floor bus, the boarding time until the wheelchair is secured is over 2 minutes. This would delay the operation of the bus service, particularly at peak times when employed disabled people need to travel, if buses ever become the normal means of transport for people in wheelchairs. Securing the wheelchair nullifies many of the advantages of low-floor buses as a means of integrating passengers in wheelchairs on public transport.

Many people consider that Canada will follow the practice adopted in the U.S. with low-floor buses, for social reasons. The view is that disabled passengers are not willing to travel facing backwards, wheelchair unsecured, in a safe area or compartment. However, cities in Quebec are currently (1996) introducing low-floor buses with a compartment for an unrestrained wheelchair. European experience has already shown that this second approach causes little delay to the bus service, even if it succeeds in attracting large numbers of passengers in wheelchairs. This form of low-floor bus service provides people in wheelchairs with a transport service that is as available to them as it is to everyone else, and on which they are integrated with all other passengers.

7.4 Service Routes

Experience in Sweden shows that the Service Route concept is an effective way to increase mobility for disabled people, including people in wheelchairs, and to reduce the cost of paratransit services in the same area. Early experience with community bus services in Toronto has shown the improved mobility but no cost savings. The reason for this difference needs to be established. The existing experimental Service Routes in the U.S. and Canada need to be monitored and publicized if the concept proves useful for Canada. There may be scope for an ITS device to help people with impaired vision wave down the bus.

7.5 Information

A number of European organizations are providing travel information for disabled people, as described in section 4.4. There would seem to be a role for a document similar to “Door to Door” giving information on services available and contact addresses and telephone numbers to obtain fuller information. This could well be accessible by electronic means as well as on paper. Similarly, there is certainly a role for an organization like Tripscope, which does detailed planning of specific journeys for individual disabled people, taking account of their individual accessibility constraints and requirements.

7.6 Application of ITS and Other Advanced Technology

This report is not intended to define the scope for ITS to improve accessibility. It has not reviewed the ITS equipment that is available or being developed. Nevertheless, it is already clear that some problems faced by disabled people could be reduced by the use of ITS, and that some ITS or electronic equipment that will help disabled people is already in use in Europe. This section points to these applications for public transport passengers and pedestrians. A more thorough evaluation of the role for ITS in accessible transport will be made in a subsequent paper.

In Europe, ITS is being applied fairly extensively in public transport to provide in-vehicle displays and announcements of the name of the next bus stop or subway station.

Several cities have started fitting electronic displays at bus stops and in subway stations to show the times to wait to the next two or three buses or trains, their service numbers and destinations as appropriate. In Canada, telephone information on the times of the next few buses at specific stops is widely available. The European TIDE Program is developing a system to display when the next bus should arrive at a specified stop using Teletext or cable TV. This would help elderly people avoid waiting for long times in adverse weather conditions. There is also a need for an ITS device to assist visually impaired passengers wave down a bus on hail-stop routes.

There is probably scope for smart payment cards to carry optional personal information to allow the requirements of an individual to be transmitted to each transport operator for a journey, possibly multimodal, at the time of booking. To be really effective, these cards should apply to all modes, including taxi, air and ferry, and ideally apply to international journeys as well as domestic ones.

ITS equipment is already in use in Europe to assist pedestrians. Crossings with pedestrian phases ("walk/don't walk" signals) provide audible signals to pedestrians when it is safe to walk. Trials are in progress of people-detectors linked to traffic signals to extend the time available for pedestrians if there are pedestrians on the crossing at the end of the normal pedestrian phase. In the U.S., people-detectors are being used to cause lights mounted in the road along the edges of a crosswalk to flash when a pedestrian is on the crossing. Talking signs, which are infrared beacons that transmit spoken messages to pocket receivers (similar to receivers for simultaneous translation) are being used in transport interchanges in both Europe and North America.

Experiments have been conducted with prototype devices to give blind pedestrians warning of obstacles around them, using ultra-sound detectors. The European TIDE Program includes one project to develop vision enhancement spectacles for visually impaired people. It will almost certainly be possible to develop a navigation/guidance device for blind pedestrians using coupled differential GPS and dead reckoning, with audio messages providing information on position, road crossings and distance and direction to a programed destination.

Profilometers are being developed to allow rapid surveys of sidewalk condition, so that maintenance can be scheduled more effectively.

8. CONCLUSIONS

This report summarizes the result of a literature review on the accessibility problems of elderly and disabled people. It forms the first part of a study of the scope for improving accessibility of transport through the application of intelligent transportation systems (ITS) and other advanced technologies.

Accessibility - Access to transport is made possible by information, 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 often overcome many problems of unsuitable equipment. 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. 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.

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.

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.

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. Average walking speed is 0.5 - 0.8 m/s. Hills and crossing roads cause problems for 30 - 50 percent of ambullant 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 at doorways 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 and are now in widespread use in Europe and 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 - 3 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.

Scope for Intelligent Transportation Systems (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. For pedestrians, one application is to intelligent traffic signal controls to allow more time for elderly and disabled people to cross the road when, and only when, they are waiting to do so. Another application is to hand-held location and guidance systems for people with visually impairments.

Public transport users would benefit from better information during travel, as well as better trip-planning information. Real-time transit information could reduce the time people have to wait for a bus. Warning of upcoming stops reduces the pressure on people who need time to alight from a bus or train. Visual displays of information can be made to talk when activated by a proximity transponder.

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 providing optional information on traveller requirements on smart payment cards, to ensure that all stages of a multi-modal trip are equally accessible.

ITS equipment for private cars that is already available can partially compensate for the effects of aging that make driving more difficult. In the next few years, further application of ITS should reduce the risk of elderly drivers encountering conditions that they find difficult.

A more detailed analysis of the scope for improving accessibility through the use of ITS and other advanced technology will be provided in the final report of this study.

Applications in Canada - Despite Canada's position as a world leader in accessible transport, there is still experience in Europe that would be directly applicable in Canada. This includes some operating practices and standards for vehicles and infrastructure, where Europe has paid more attention to pedestrians and ambulant disabled users of public transport. There are European design guidelines for urban buses that would improve the vehicles in use in Canada. Guidelines for urban infrastructure and transport interchanges could well suggest ways in which local accessibility could be improved at little cost. Studies of the benefits of accessible transport could well be repeated for Canada to inform policy on the provision of accessible services.

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