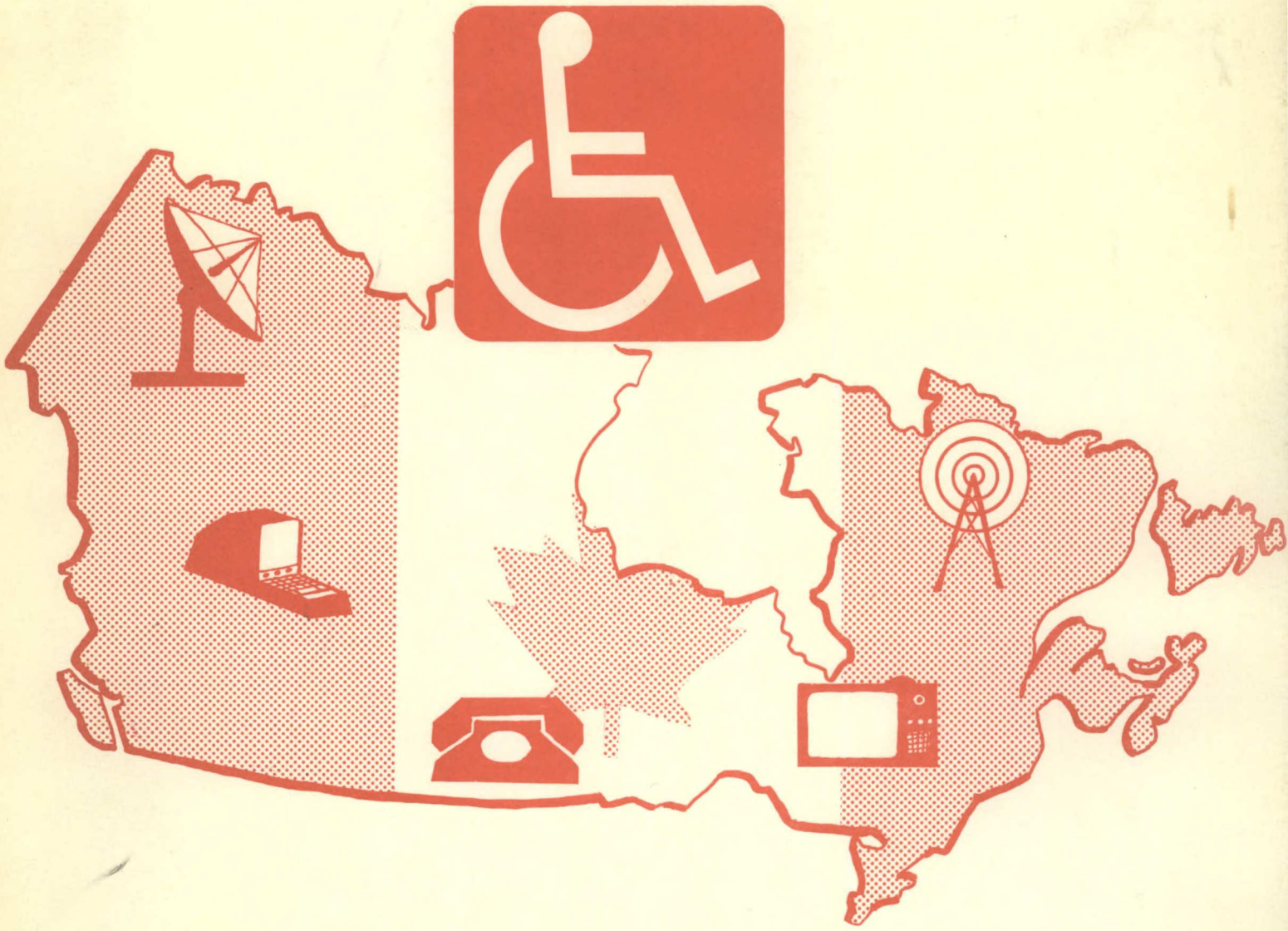
Some Policy Perspectives on Research and Development of Assistive Telecommunications Devices for Persons with Motor and Dexterity Impairments



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NOTE TO READER

This study was carried out by Paul J. Mc Grath on behalf of the Department of Communications of the Government of Canada. The conclusions and any recommendations contained in this report are those of the author, and do not necessarily represent the views of the Government of Canada, or the Department of Communications.

It is hoped, however, that the basic needs data and perspectives on research and development strategies contained in this report will prove useful for all interested parties (government, industry and mobility impaired persons and organizations, and especially those involved in the research and development of assistive telecommunications devices) in the planning and implementation of improved telecommunications services for Canadians with a mobility and dexterity impairment.

Department of Communications
Ottawa, 1984

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Finally, to all the people who reviewed this document in its various stages, and offered advice and comments, I offer a generous "thanks".

Paul James Mc Grath
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TABLE OF CONTENTS

EXECUTIVE SUMMARY

The objective of this report is to outline the main difficulties which those people suffering from upper trunk mobility and dexterity impairments experience in regard to accessing telecommunication devices, services and systems. Furthermore, the author examined the current strategies of researchers/manufacturers towards research and development of assistive telecommunications devices for use by persons with a mobility and dexterity impairment.

It should be noted that telecommunications is perhaps the single most important aspect of a majority of jobs. If we consider the fact that even finding a job usually requires telecommunications of some sort, access to telecommunication systems, services and devices becomes imperative. Disabled persons have traditionally had little or no access to telecommunications services: a barrier which has often prevented them from gaining meaningful employment. With little or no income, beyond social services or disability pensions, they often cannot afford the prohibitive cost of technical aids.

A brief historical background of R & D efforts in this area has been provided to aid in understanding the current situation with regard to telecommunications technology for persons with a mobility impairment.

This report has undertaken to identify the systematic approach (as opposed to the piece-meal) to telecommunications accessibility in the belief that this is the best possible approach in making advances to further overcome the numerous obstacles to accessibility experienced by the disabled population. Such an approach moreover, is the best approach to research and development; to take an overall look at the needs of the disabled and in doing so, to obtain a clear, concise view of the necessary approach to tackling the problems of accessibility.

The piece-meal approach towards research and development of assistive telecommunication devices of the past usually involved one piece of equipment being adapted for one particular individual or group of disabled persons. As an example, the Telephone Pioneers Association, through its local chapters, did much early work in making the telephone network accessible to disabled persons. Often a specific Chapter was approached by a specific disabled person with a specific telecommunications problem. The Pioneers used their vast knowledge of telecommunication devices to address the needs of that person(s), designing special devices, interfaces, or adapting equipment to allow that person(s) to access the telecommunication network. Although this was unquestionably helpful for those to whom it applied, this piece-meal approach, unfortunately only benefited a handful of persons.

This early piece-meal work has, however, set the groundwork, and has given way to a more recent systematic approach. The need for pursuing a systematic approach to better aid the physically handicapped cannot be ignored any longer.

Although research and development through a number of agencies, institutions and government departments has provided technological alterations, improvements and advances, the state-of-the-art of research programs has not advanced far, nor fast enough. It has been realized not only by the author, but by many who have studied the disabled population and their needs, that there is insufficient data on the handicapped population, of their telecommunications needs, and an overall deficiency in co-ordination of effort by agencies, institutions,government departments and countries around the world. This is not to imply that an apathetic attitude is being assumed by those involved; nothing could be further from the truth. However, due to the immense potential that telecommunication technologies can have in releasing many physically disabled persons from their personal and social isolation, every aspect or approach must be fully exploited and utilized. A systematic approach will assist greatly in this venture.

The systematic approach to research and development of assistive telecommunications aids for persons with a physical disability has four components: 1) application, 2) minor modification, 3) major modification, and 4) by design.

Application:

The first step towards meeting the needs of the disabled would be to examine existing equipment, devices and services and alter not the devices, but their application. Indeed, this was done by many telephone companies who examined their existing stock and applied the equipment to alternate uses; the most striking example being the use of a "hands-free unit", originally intended for business use, being applied for use with persons who cannot grasp or hold a telephone. Such simple alternate uses of equipment may provide access for a great many disabled persons.

Minor Modification:

The second step towards providing access would be to make slight modifications to equipment. An example of this can be seen with the keyguard for the Teledialer-32 which was developed by the Brock Council (Maple Leaf Chapter) of the Pioneer Telephone Association. This rather simple device is a piece of

plastic which fits over the buttons of the dialer providing a "guard" around the keys so that persons whose movements are not refined, can use a mouth or hand stick to activate the buttons. Such modifications are simple, and inexpensive. Another example would be the application of a "large dialer" over the regular touchphone keypad. The large dialer is used for persons with a visual impairment, but can also be used for someone who does not have control of the finer finger movements required in dialling a telephone.

Major Modification:

This involves examining the needs of those persons not already satisfied with the previous two steps. Major modifications, and specially designed equipment may be necessary at this point. An example of this is Bell Canada's Directel, which is a major modification of the "speaker-phone" concept. It is interesting to note, however, that the basic technology (and indeed even the actual casing), if not design, for the Directel comes directly from the speaker-phone. Thus, Bell did not "re-invent the wheel".

By Design:

The final step of providing accessibility is in fact the first step - the first step towards true accessibility. Once existing equipment has been re-applied, modified slightly as

necessary, or re-designed as necessary, the future still remains. These first three steps are almost interim solutions - in that in the future the needs of disabled persons should be considered at the design stage. Many modifications now necessary to exisiting equipment may not have been necessary had the needs of the disabled been considered earlier. An example of this can be seen with Northern Telecom's newest phone, "The Harmony", which was designed with hearing aid users in mind, and so includes a fluxcoil by design. The fluxcoil is used by hearing impaired persons to activate a similar coil in their hearing aid.

Such a systematic approach to research and development of assistive telecommunications devices for mobility and dexterity impaired persons will afford a level of "equal access" to telecommunications services, equipment and facilities.

1.0 INTRODUCTION

Today's telecommunication systems are varied and complex, evolving at an incredible rate. Gone are the days of single-line terminals and multi-jack switchboards; they have given way to the micro-processor chip and transistor. Earth orbiting satellites now command the distribution of a multitude of broadcast and telecommunications channels over vast distances. The concept of Marshal MacLuan's "Global Village" is now closer to reality with underground cables, fibre optics and instantaneous satellite communication services helping to make it all possible.

Yet for all the complexity and sophistication involved in these telecommunication systems, their principal intention must not be lost. Telecommunication systems provide access to information. Reasonable access to telecommunications systems must, therefore be a prerequisite, to afford all users the same level of accessibility to information. Whether the user is able or disabled, whether the communications system is the basic telephone or the latest in teletext hardware, the emphasis must be kept on ease and simplicity of operation.

For the disabled, in particular the mobility and dexterity impaired, ease of operation is imperative. The telecommunications needs of this population are as important, if not more so, than those of the able-bodied. The impact of telecommunications on our daily lives, on our overall pyschic development and education, cannot be overstated. So profound is its impact on our socio-cultural evolution.

For the physically disabled, the need for accessibility to telecommunication systems is of the utmost importance. Man's ingenuity and sense of assisting those in need, combined, can greatly help in achieving this goal. It is with this purpose in mind that this report was prepared.

Though it is widely accepted that telecommunications and accessibility to telecommunication systems is essential for personal development and social interaction and for an independent approach to living for the disabled, there still remains a lack of a cohesive, systematic approach to accessibility. We must strive to further reduce the remaining obstacles disabled persons face daily so as to integrate the disabled more fully into society as a whole, by making accessible to them as many modes of communication as possible.

This report has undertaken to identify the systematic approach (as opposed to the piece-meal) to telecommunications accessibility in the belief that this is the best possible approach in making advances to further overcome the numerous obstacles to accessibility experienced by the disabled population. Such an approach moreover, is the best approach to research and development; to take an overall look at the needs of the disabled and in doing so, to obtain a clear, concise view of the necessary approach to tackling the problems of accessibility.

In this report there are obvious overlaps with respect to the findings and recommendations of this study and those which have been addressed in previous studies dealing with the physically disabled. It has been my intention, therefore, to build upon those earlier recommendations and to expand more fully on the planning of research and development strategies for telecommunication aids for motor impaired persons.

2.0 DEFINITIONS

As a basis for discussion, the outline below will provide a framework of reference for this report. It must be mentioned at the outset that only the "physically handicapped" population and those whose impairments (stroke and mental impairment) which affects their physical functioning, are reviewed.

The "sensory handicapped" (the blind, hearing or speech impaired) will not be discussed within this context. Special mention may be made, should a multiple disability include a sensory handicap which can hinder physical access to telecommunication systems.

The term "telecommunications" shall be used throughout this paper to imply both broadcast undertakings and telephone services. (See s. 2.3.9 for an accurate definition of telecommunications)

For purposes of discussion, the masculine gender is used throughout this paper to represent both sexes.

2.1 GENERAL TERMS RELATING TO DISABILITY

There is often controversy and discussion over the use of the words impairment, disability and handicap. In 1980, the World Health Organization (WHO) published an International Classification of Impairments, Disabilities, and Handicaps. This publication has established a unifying framework against which this report will apply.

2.1.1 Impairment

> In the context of health experience, an impairment is any loss or abnormality of psychological, physiological, or anatomical structure or function.[1]

2.1.2 Disability

> In the context of health experience, a disability is any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being.[2]

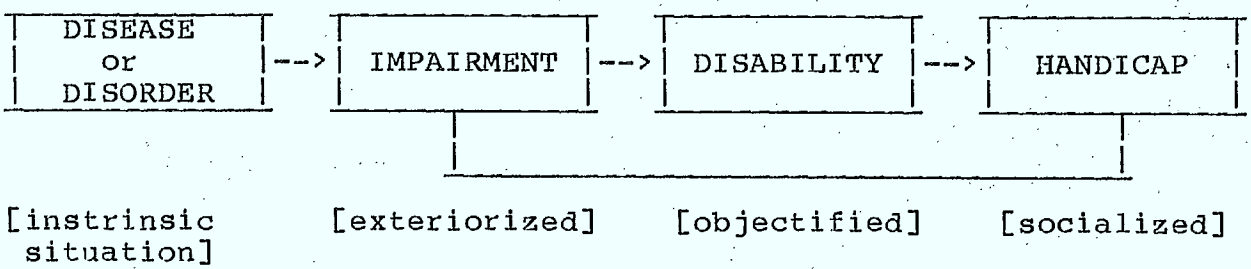
2.1.3 Handicap

> In the context of health experience, a handicap is a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfillment of a role that is normal (depending on age, sex, social and cultural factors) for that individual.[3]

2.1.4 Integration of Concepts

The preceding definitions can therefore be linked in the following manner:[4]

Figure 1: **Impairment, Disability, & Handicap:**



As we can see, a disease or disorder may be exteriorized by an impairment, and/or be objectified by a disability. A handicap then is the social consequence of an impairment and/or disability.

In the instance of telecommunications, a quadriplegic (disorder) may have only limited use of his arms (the impairment) and thus may not be able to access a telephone (the disability). The resulting social consequences (the handicap) could range from isolation to lack of employment opportunities.

2.2 DISABILITY DESCRIPTIONS

2.2.1 Amputee

An amputee is a person whose limb(s), either upper (arm), lower (leg), or both, have been dismembered or amputated due to injury or disease or necessary surgery. Within this context birth defects (such as Thalidomide), which resulted in the loss or severe deformity of limbs, are also included.[5]

There are various types or categories of amputation: amputation of fingers, hand, below-elbow, above-elbow, the entire arm up to and including the shoulder, foot, toes, below-knee and the entire leg(s) right up to the hip. For the purpose of this report, the amputation of the arm will be the focal point.

It is commonly agreed that the greater the amputation of a limb, the less maneuverability is afforded the user of a prosthetic limb. The below-elbow amputee has greater flexibility, maneuverability and precision in operating a prosthetic arm because he has the full use of his natural elbow movements. The above-elbow amputee must compensate for the loss of the elbow by utilizing every

stimulus repsonse (eg. surface pressure) from the stump and shoulder to aid in the operation of a mechanical prosthetic limb. The need to efficiently operate the prosthetic arm under any condition and to facilitate a co-ordinated movement is the prime concern of the above-elbow amputee. The degree of difficulty is heightened by a decreased stump-length.

With the advent of myoelectric prosthetics - as well as further advances in conventional mechanical prosthetic limbs - amputees with proper training can overcome many obstacles to telecommunications accessibility in whatever form.

2.2.2 Arthritis and Rheumatism

Arthritis is a term frequently used to indicate any disease involving pain or stiffness of the musculoskeletal system. It is considered to be synonymous with rheumatism, however, the term "rhuematic disease" is a broader term and refers to conditions in which there are changes in the connective tissue including muscles, tendons, bursae, joints and fibrous tissue.[6]

The term rhuematism covers a wide variety of disorders marked by inflammation, degeneration and/or derangement of the connective tissue structures and attended by pain, stiffness or limitations of motion. They are often referred to as arthritis, ostaeoarthritis, bursitis and siatica.

Symptoms that affect motor abilities are experienced in the hip, legs, ankles, toes, knees, shoulders, spine, arms, wrists, fingers, thumbs and neck, and often cause deformities in those areas. Common limitations are loss of mobility, loss of hand and finger dexterity, and general weakening of muscular ability; inabilities to grasp and to support objects are also deteriorating abilities.

2.2.3 Brain Damage

Although brain damage may also cause cognitive impairments, the loss of motor control caused by brain damage is the primary factor relating to this study. Brain damage can occur in a variety of ways - through birth trauma, pre- or post-natal disease, or from trauma of unknown genetic origin. Persons with cerebral palsy, stroke victims and persons with an intellectual impairment

are examples of the more widespread results of brain damage. Thus, damage to the different regions of the brain can result in differing physical symptoms.[7]

Abilities affected can include: loss of speech, loss of hearing, loss of mobility, loss of control of either arm once the limb is outside the direct field of vision (with only gross movements of the arm remaining intact), loss of perception, inability to grasp, etc.

Due to the diverse effects of varying degrees of traumatic brain damage, it becomes difficult to generalize both about the abilities affected and also the selection of the varying aids and interfaces to be used in accessing telecommunication equipment.

2.2.4 Cerebral Palsy

Cerebral palsy is a neurological dysfunction manifested by physical impairments and possible intellectual and sensory impairments resulting from damage to certain regions of the brain. It is a major crippler of children, resulting from damage that occurs prior to or during birth. There are five characteristic forms of CP:[8]

i) the spastic (the most common form), characterized by loss of voluntary control of muscles, gross reflex movements and abnormal postures;

ii) the atrophoid individual who suffers from slow movements in the limbs of the body;

iii) the ataxic individual who has deficiencies in balance and muscle tone;

iv) the individual with tremors; and

v) the individual with rigidity; resistance to almost all movements.

2.2.5 **Multiple Sclerosis**

Multiple schlerosis is a disorder of the nervous system which is characterized by hardened patches scattered throughout the white matter of the brain and spinal cord. A chronic disease, there are alternate periods of improvement and worsening. The effects of MS vary with how much of the nervous system is affected. It is, therefore, quite difficult to describe a typical case. MS occurs most often in adults between 20 to 40 years of age, and can occur in chronic form lasting a normal lifetime or in an acutely progressive form with a lifespan of three years.[9]

Acutely progressive multiple sclerosis affects various abilities. Typical symptoms include fatigue, tremors, shaking limbs and interference with dextrous movements such as those involved in writing, dialing, and grasping, along with poor physical co-ordination. In the later stages of the disease, MS tends to effect the upper limbs, severely decreasing the ability to access telecommunication equipment.

Acutely progressive MS affects different functions and abilities and is often accelerated by emotional disturbances. Telecommunications technology has great potential in assisting emotional well-being by providing personal security as well as discussion facilities.

2.2.6 Muscular Dystrophy

Muscular dystrophy is actually a group of genetically-determined diseases affecting the muscular system which is painless, degenerative and crippling because the muscles are gradually weakened and eventually atrophied. The disease can often be assisted temporarily; not all forms of it are totally disabling. With muscular dystrophy the muscles suffer a vital loss of protein; the muscle fibres

are gradually replaced by fat and connective tissue until in the latter stages of the disease the voluntary muscles become virtually useless. This is in marked contrast to multiple sclerosis where the muscles are rendered impotent by damage to the nerves that control them.[10]

Those affected by MD do not normally suffer from a cognitive impairment, and as the small muscles are the last to be affected, there is a progressive deterioration of the gross movements but often retention of the finer finger movements. Limitations would include loss of mobility or the ability to bend or stoop, to grasp or support an object and some loss of power in the fingers depending on the advancement of the disease. With progressive modification of telecommunications equipment, even the most advanced sufferer of MD can often retain the ability to access some telecommunication systems.

2.2.7 Poliomyelitis

Poliomyelitis (Polio) is a viral infection which attacks the central nervous system and injures or destroys the nerve cells that control muscles; the result is often paralysis. Leg and arm muscles, and those muscles used to control breathing and swallowing are most often affected.

The loss of abilities varies with the severity of the disease and it would, as with multiple sclerosis, be difficult to describe an "average" polio victim; however, the following examples of a severe/profound polio victim and a moderate/severe case can indicate the more common loss of abilities due to polio. One victim may be totally paralyzed from the chin down; the other is paralyzed in the lower extremities, suffers loss of some dexterity but gross movements in the arm remain intact. Both victims use a respirator.[11]

Telecommunication accessibility while confined to a respirator is restricted; remote control facilities, however, enable people in the severe category to independently access telephone, radio, and television. In fact, customization can also enable access to computer terminals. A moderate extent of disability in polio sufferers may require upper trunk accessibility aids, which need only be customized according to the user's needs.

2.2.8 Spinal Cord Injury

Paraplegia is the partial or total paralysis of the legs and in some cases the lower part of the body. **Quadriplegia** is the partial or total paralysis of all

four limbs. Paraplegia and quadriplegia usually result from either disease or injury to the spinal column. Various disease such as tumours of the cord, infection, genetic disorders such as spina bifida, and other neurological conditions injure cord tissue and produce marked interference in functions. Likewise, all types of traumatic injuries which totally or partially severe the cord will result in a loss of sensation and/or paralysis. The parts of the body affected and the extent of the loss of function will depend on the level of the injury to the cord and the severity of the damage.[12]

Persons with a spinal cord injury experience many physical limitations, ranging from those with arm movements and finer finger dexterity to those with gross movement of the upper limbs or head (mouth) movement only. The common limitation is usually the lack of mobility; they are almost always confined to a wheelchair or a bed. Among those affected in the upper extremity most are unable to grasp, support, pick-up, or finger-dial a phone.

Paraplegics do not generally have a problem in using the ordinary telephone, typewriter, keyboard, or any telecommunications device. The problem lies more in physical access to telecommunications in public places

because of the lack of wheelchair maneuverability or obstruction. Quadriplegics with lower level spinal cord involvement and paraplegics with higher level involvements can usually have their telecommunications needs provided for by the use of the various interfaces and control systems available to them. Needless to say, customization and correct training is essential for the user to derive optimum use of these devices.

2.2.9 Stroke

A stroke is defined as the rupture of a blood vessel in the brain, which deprives parts of the brain of its blood supply. The result is a loss of consciousness, paralysis or other symptoms depending on the site and extent of brain damage.

The limitations which a stroke imposes vary greatly, depending on the cause, location, and the extent of damage to brain cells. The area of paralysis is directly related to the site of damage; if the left side of the brain is affected, paralysis of the face, arm and leg will be present on the right side. Speech disturbances are also related to the area of brain cell damage. If the left side

of the brain (where the speech centre is located) is affected, then aphasia as well as heiplegia may be present. When the thalamus is involved there may be emotional disturbances resulting in the person having difficulty controlling his emotions.[13]

The symptoms of a stroke are almost unlimited in type, severity and permanency; some may eventually subside while others are never completely eliminated. Stroke victims generally tend to be over 50 years of age and the more serious cases tend to be institutionalized. While some stroke victims are likely to benefit from special facilities, others are able to live at home. Access to various telecommunications equipment for this population is imperative to independence. This can be achieved with the introduction of interfaces, "hands-free" telephone units, etc. For those people with slight speech difficulties, super sensitive microphones or voice amplifiers could be introduced to improve access to the telephone system. Where needed, Environmental Control Units (ECUs) can also aid those whose dexterity is severely limited.

2.3 TELECOMMUNICATIONS DEFINITIONS

2.3.1 Access

The point at which entry is gained to a circuit or facility or telecommunications system. In the context of this study, it can be interpreted as the physical capability to reach and to operate a telecommunications system, equipment, device or interface.[14,15]

2.3.2 Broadcasting

The transmission of a program of sound, vision or facsimile for general reception.

2.3.3 Communication

The definition of "communication" is simply the act of transmitting or imparting information.

2.3.4 Communications

The aggregate of several modes of communication used to convey information, signals, or messages. Also, a method or means of conveying information of any kind from one person or place to another.

2.3.5 **Computer**

A device capable of accepting and processing information and supplying the results. It usually consists of input, output, storage, arithmetic, logic, and control units.

2.3.6 **Interface**

A concept involving the definition of the inter-connection between two equipments or systems: a device or system which enables a disabled persons to control another device or system.

2.3.7 **Radio**

A method of communicating sounds over a distance by modulating and radiating electromagnetic waves.

2.3.8 **Telecommunication System**

A collection of individual telecommunication networks, transmission systems, relay stations, tributary stations, and terminal equipment capable of inter-connection and inter-operation to form an integral whole.

2.3.9 **Telecommunications**

Any process that enables a correspondent to relay written or printed matter, fixed or moving pictures, words, or visible or audible signals, or signals controlling the functioning of mechanisms, by means of an electromagnetic system.

2.3.10 **Teletext**

A system which permits a limited number of pages of text to be transmitted by television broadcasting stations together with their program emissions the special signals being transmitted via unused lines in an ordinary video signal (encoded onto the Vertical Blanking Interval). A special decoding unit in homes permits selection and display of the information on the screen. All the information is transmitted on a cyclic repetition basis by the broadcasting station.

2.3.11 **Teletypewriter (TTY)**

A telegraph instrument having a signal-actuated mechanism for automatically printing received messages. It may also have a keyboard similar to that of a typewriter for sending messages.

2.3.12 **Television**

The production at a distant of a transient visible image of an actual or recorded scene by means on an electrical system of communications with or without accompanying sound.

2.3.13 **Telidon**

A sophisticated video/teletext service developed by the Department of Communications.

2.3.14 **Videotext**

Similar to teletext, except that the information is transmitted through telephone lines.

3.0 DISABILITY CATEGORIES

For the purposes of discussion, the above-mentioned classes of disability will be broken down into three major categories - loss of limbs, loss of use of limbs, and loss of dexterous control of limbs. "Limbs", for the purposes of this study, refers to the upper limbs only. Classifying the disability groups in this way will help to focus on the three fundamental problems of access to telecommunications systems, since the telecommunications handicaps caused by the various disabilities are the focus of discussion, not the individual impairments.

3.1 Loss of Limbs

This category includes bilateral amputees, both high and low level (above and below the elbow). In the case of loss of a limb, one if often faced with a unique accessibility problem. If the amputee uses prosthetic devices, the telecommunications interfaces should take into account prosthetic technology. An example of this would be where an amputee (using prosthetic arms) may not need an elaborate interface, but rather the prosthesis itself acts as the

interface. In this instance, the adaptation of dials or knobs, such as those on a radio or television, may be all that is required, as opposed to elaborate environmental control devices.

3.2 Loss of Use of Limbs

This category includes those who have no use of their arms or hands. In this case one is dealing with someone whose interface needs are greater. The alternatives to arms, hands or even prosthetic arms are generally more complex.

3.3 Loss of Dexterous Control of Limbs

This category includes those who use their arms and hands to access telecommunication systems, but whose co-ordination is such that they may require some adaptation of control devices.

4.0 STATISTICAL DATA

There are at present, no reliable statistics available on the number of disabled persons in Canada. Indeed, the Special Parliamentary Committee on the Disabled and the Handicapped recommended in its report Obstacles,

> That the Federal Government direct Statistics Canada to give a high priority to the development and implementation of long-term strategy which will generate comprehensive data on disabled persons in Canada, using populationbased surveys and program data.[16]

Recognizing the lack of reliable statistics on disabled persons in this country, the Federal Government reported in Surmounting Obstacles, that;

> In June 1982, Cabinet approved Statistics Canada's submission proposing collection of information on the country's disabled population through the addition of supplementary questions to the montly Labour Force Survey. The supplementary questions will both provide estimates of the numbers of persons who are disabled and investigate the nature of their disability and its effect on their life-style (for example, education, employment, self-sufficiency, etc.)
>
> The Disability Survey is scheduled to be conducted in October 1983 and again in the spring of 1984. The first results from these surveys should be available in early 1984, with additional information forthcoming before the end of that year.[17]

Many people still feel, however, that a question or questions should be included with the 1986 Census which would facilitate a post-censal follow-up survey. Statistics Canada is currently studying this approach.

It is because of this lack of reliable statistics that this report does not quote any population statistics. This actual number of physically disabled persons does not, however, in any way affect the basic findings of this paper.

5.0 GENERAL HISTORICAL PERSPECTIVES

The objective of this report is to outline the main difficulties which those people suffering from upper trunk mobility and dexterity impairments experience in regard to accessing telecommunication devices, services and systems. A breakdown of telecommunication needs and objectives, and general findings on how these needs have been met to date, follows.

A brief historical background might prove useful in understanding the present situation with regard to telecommunications technology for mobility impaired persons.

Society's traditional approach to the handicapped has undergone drastic changes in the last 200 years. Moreover, with rapid advances in technology, these changes are taking place at an accelerated pace. Technology is removing the "dis" from disability. For example, Louis Braille, developed a system for the blind which allowed them access to many printed materials previously inaccessible to them. With the advent of high speed word processors and other technology such as computer translation programs, books printed in braille are now more readily available. Furthermore, recent advances in synthetic voice technology have made print-reading machines a

reality. Thus we can see how a simple technology (braille) has developed into a more sophisticated system (computerized braille translation and print-reading machines). Blind persons who had to rely entirely on braille in the past were unable to obtain meaningful employment which required a great deal of reading, due to the high cost of translation of material to braille. Now with cheaper, more efficient devices, such as micro-computers capable of processing a braille text, their opportunities are expanding.

From a historical perspective, access to telecommunications has not traditionally been considered a right. Recent legislation in both the United States and Canada has indicated that not only is access now considered a right, but that society has a responsibility to provide that access.

The National Civilian Vocational Rehabilitation Act (1930), in the United States was the first piece of major legislation which was concerned with the disabled. However, until 1954, the emphasis was exclusively related to demonstrable vocational potential. In 1954, research provisions were included in legislation for the first time. The Rehabilitation Act (U.S. - 1973) provided for the severely handicapped [most notably in sections 503 and 504]. Furthermore, it set a precedent by establishing that access was a fundamental right of all persons.

In Canada, the Charter of Rights and Freedoms, entrenched in the Canada Act, (1982), provides that;

> 15.(1) **Every individual** is equal before and under the law and **has the right to the equal protection** and equal benefit of the law **without discrimination based on** race, national or ethnic origin, colour, religion, sex, age or mental or **physical disability.** [emphasis mine][18]

The report of the Special Parliamentary Committee on the Disabled and the Handicapped, Obstacles, stressed that, "Disabled Canadians must have the same opportunity to participate fully in all of the educational, employment, consumer, recreational, community and domestic activities which characterize everyday Canadian society."[19] Moreover, "All Canadians are responsible for the necessary changes which will give disabled persons the same choice of participation that are enjoyed by those who are not disabled."[20] In that spirit, amendments to the Canadian Human Rights Act were proclaimed on July 1st, 1983.[21]

In the past, access to telecommunications, or access in general, was considered a "social issue". Whenever one spoke of a company offering goods or services for disabled persons, it was part of their "corporate conscience", or the "social responsibility" of a business. Of late, there has been emphasis on the good business practice of providing access for disabled persons. Disabled persons as a whole, it is argued,

constitute a very large potential market which is at present untapped. While there may be certain validity to both these reasonings the Charter of Rights and Freedoms and the amended Canadian Human Rights Act together have demonstrated that provision of facilities, goods and services, is compliance with the law of the Parliament of Canada. Basic human rights, including the right to reasonable access to facilities, goods and services, are now constitutionally guaranteed; they are now legal rights.

5.1 EARLY TECHNOLOGICAL DEVELOPMENTS

Prior to the 19th Century, little if anything was done in an attempt to integrate disabled persons into society. Technologically, there was little that could be done; Attitudinally, little was done. For the most part, disabled people were considered non-citizens, and institutionalized as a matter of course. By the middle of the 19th Century, some advances had been made towards the integration of disabled people into society. During this period, Louis Braille developed a writing system for the blind and l'Abbe Sicard developed a sign language for the deaf. From a technological point of view, however, some of these advances were of limited

value and accessibility. Braille, for example, was time consuming and costly to produce, thus affording little access to the common blind person.

The aftermath of two World Wars resulted in a society with a large and highly visible disabled population, which necessitated greater attention to the needs of this population. Technological advances in the late 1940's and early 50's were a result of this increased awareness, as well as economic and mass-market motivations. Two major technological breakthroughs contributed to the rapid advances made in technology: the invention of the transistor and the microprocessor.

The introduction of the transistor was the first step towards miniaturization. Some disabled persons were able to benefit from this technology immediately, through developments such as electronic hearing aids for the hearing impaired. The invention of the micro-processor sparked one of the most rapid successions of development man has witnessed. The micro-processor has permeated almost every aspect of man's life. The disabled population is one of the groups which may well benefit most from this technology, since many tasks can now be performed by a computer for a person.

Since the early days of these breakthroughs, people have been applying technology to the disabled. Often, however, it was applied in a "piece-meal" fashion, because this was often the only solution available. This piece-meal approach to interface design **has** provided access to those who were fortunate enough to have equipment specially designed to meet their needs. It did **not**, however, prove an effective means for providing access to telecommunications for the general disabled population. One of the greatest contributing factors to its ineffectiveness was that even if the device provided greater access, the potential market was so small that it rarely provided a profit-making venture for a business. Such small scale production necessitates a higher per-unit cost.

Piece-meal devices are often "bread-board" designs, and as a result are inherently bulky. Also, because these devices are usually the first generation of a technical aid, they more often lag behind the current state-of-the-art technology. Moreover, by the time the device reaches the production stage, delays have meant that the system now being produced is far inferior than is technologically possible. Because these devices are rarely profit-making units, they are given lower priority on production schedules. A production delay of six months can mean a delay of a life-time in an industry which shifts direction overnight. Recent developments in the

memory-chip industry bear this out. In 1977 when the first micro-computers hit the market, 4K-bytes of memory (1K[ilobyte] = 1024 bytes, or "characters" of information) was all that was practically possible. The "standard" by 1980 was 64K. Even more recent developments suggest a new "standard" of 256K or 512K is evolving.

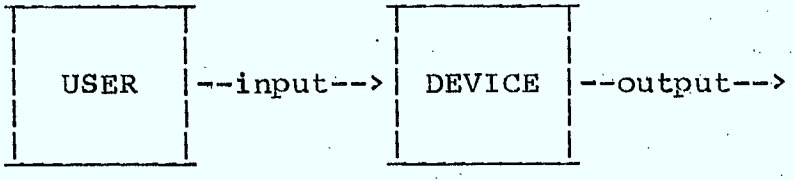
The piece-meal approach to telecommunications technology, in most cases, has become ineffectual in terms of cost effectiveness. Although a piece-meal approach to accessibility does provide short term access to telecommunication systems, a systematic approach utilizing existing technologies designed for the larger non-disabled population presents a better long term alternative. Supply and demand play a large role as a cost-stabilizing factor, as well as ease in making alterations to the device, or by adding on to it as needs change. One fine example of this approach is Bell Canada's modification of their exiting equipment to adapt it for the telecommunication needs of the disabled user. Through utilization of exiting equipment, modified slightly in design, initially intended for business users, telecommunications equipment is now being used by mobility and dexterity impaired persons.

6.0 ACCESS TO TELECOMMUNICATION SERVICES

There are basically two means of access to telecommunication systems, services and related devices/equipment. The first method calls for direct physical contact by the user with the apparatus, be it a radio, television, telephone, or keyboard. The second method is to circumvent the device utilizing an interface aid or tool which can facilitate the operation or control of the device. The disabled user can use a multitude of different switching methods or interfaces which serve as the activator of the device to be engaaged. The various types of switches and interfaces are outlined in Appendix A (See s. 11.1).

Direct Access:

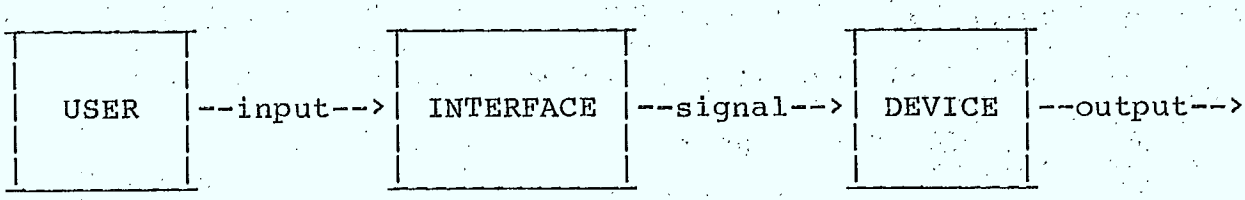
Figure 2: **Diagram of user/device relationship**



Accessing broadcasting devices directly by the disabled user can be accomplished through simple alterations of knobs, switches, or keys. Adding larger tuning knobs; providing switches which can be pushed "on" or "off"; or making knobs which "slide", are examples of the various methods which can make access easier.

Indirect Access (Interfacing):

Figure 3: **Diagram of user/interface/device relationship**[22]



Frequently, high-level quadraplegics and those with severe or progressive neuromuscular diseases can access a radio, television, or telephone with the aid of an environmental control unit (ECU); the ECU controls the receiving device. An ECU can be any computer-related processor, a specially designed ECU such as the TOSC-2(TM) or ENCO-5(TM), a multi-purpose device such as the Abilityphone(TM), or any central processing unit into which are connected the electrical devices or appliances to be operated.

6.1 Broadcast Services

Let us begin our examination of accessibility with broadcast services. There is a multitude of aids, switches and interfaces providing most categories of disabled persons with accessibility to, and ease of control of a radio, television set, cassette or tape recorder, TV and channel selector, CB radio receiver, etc.

There are basically two methods of accessing a radio or television apparatus. One way is to physically alter or adapt the receiving unit, such as changing or adapting the volume and tuning knobs or switches so they can be manipulated by persons with a mobility or dexterity impairment. This can be done simply through the use of various materials readily at hand or from a hardware store; the key here is a little ingenuity. It should be noted that this method of physically altering devices to suit the needs of the disabled user can be done (and more than likely will be done), on a piece-meal basis. It is this type of situation where the peice-meal approach becomes almost unavoidable, if not the most practical. This is the logical starting point to best assist the disabled radio/television user.

The second method of accessing a radio or television would be through the use of an ECU or similar interface, of which there are numerous kinds. Here, the user has no control over the radio or television itself; the receiver is never handled by the user, but is accessed through a more sophisticated interface.

The single most important aspect of the ECU control box is the interface between the user and the peripheral device(s). There are a number of switching techniques:

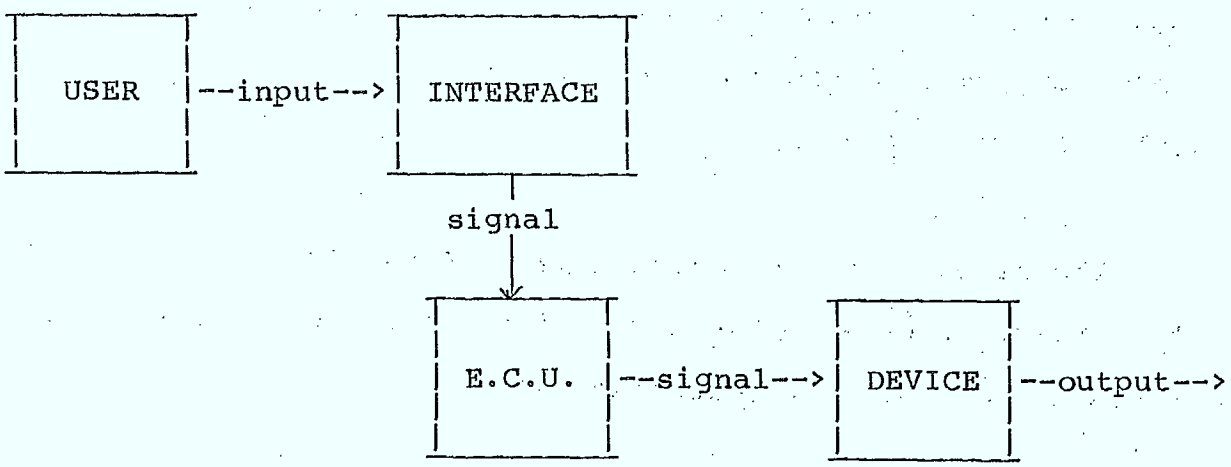
i) microswitches, operated by very minimal movement of any body part: tongue, finger, eyes.

ii) pneumatic or breath switch, operated by gently blowing or sucking on a tube.

iii) touch sensitive switches, which only need some form of body contact.

It should be mentioned that while an ECU is often considered an interface, it is more of an intermediary control interface, in that a user may still need an added interface (in this case a switching device) depending on the extremity of his disability. [See Figure 4] An example of ECU use would be a high-level quadraplegic using a two-switch touch plate interface. The first touch of the plate by the user activates the ECU to scan its function modes. When the desired fuction is shown (usually with a small LED light), the user touches the switch again, activating the selected function and thus the device (e.g. turning the radio or television ON or OFF).

Figure 4: Diagram of environmental control relationship22



A radio tuning motor, designed to turn tuning or volume control knobs is now commonly used by persons suffering from a mobility, dexterity or co-ordination impairment. The tuning motor can be operated through an environmental control unit which can be operated by using any of the various switches (rocker, joystick, pneumatic, touch sensitive, etc.)

With respect to accessing television in particular, a normal or adapted television channel selector may be attached to most standard sets, permitting the user to select any VHF, UHF or cable station as well as to turn the television on or off, or adjust the volume. This device can be used as an accessory to an ECU main control unit, or as a separate unit, depending again on user need.

The major criticism from users of these enviornmental control units is the bulkiness of the entire system, the time-delay factor of selection, the lack of mobility of the system, the system's unattractive appearance, as well as the high cost.

6.2 Telephone Services

A more systematic approach towards access to telecommunication systems by the mobility and dexterity impaired is evolving. There are those within the telecommunications industries who have, at an early stage, recognized that the disabled population as one of the prime groups benefiting directly from the numerous developments brought on by the telecomunication technology explosion. Examples of the marriage between the piece-meal and systematically-developed telecommunication aids, equipment and services is demonstrated through the opening of "Special Needs Centres" by many telephone companies. These Centres cater specifically to disabled persons, providing the greatest possible access to telecommunications services and equipment for the largest portion of the disabled population. Many telecos have exhibited not only a social awareness to the needs of the disabled, but are also stimulating further research and development into assistive devices for the disabled.

As with broadcast services, there are two methods of accessing a telephone device. One method is through actual contact with the telephone, handling the receiver and using the dial. The other method is through the use of some sort of control interface, enviornomental control system, or terminal device (computer).

Accessibility to telephone systems has increased dramatically through the use of aids, interfaces and services being provided to disabled persons. One example of this is the "Operator Service", offered by some telecos. If a user has a problem operating a telephone due to a physical/mental impairment, operators are now specially trained to assist. The user simply dials "0" and says, "This is a special call"; operators have been trained to recognize this phrase and will complete the user's call without question, charging the same rate as a customer-dialled call on long distance. This service is available for both long distance and local calls. A similar service is given for those over 65 years of age and those who are unable to use a telephone book due to some disability. Here, the operator will perform that task and expemt the user from the directory assistance charges. [N.B. Contact your local phone company for specific information about the availability of these services in your area.]

Through companies like Bell Canada, Northern Telecom Ltd., and American Telecommunications Corporation, several physical abilities which disabled persons possess can today be exploited further, utilizing these manufacturer's "special needs" services/devices. A brief breakdown of these devices is provided below:[23]

Mobility	Shut-in	Personalized Services
-Directel(TM)	-school/home system	-operator services
-touchtone	-Bellboy Paging(TM)	-directory assistance
-Teledialer-32(TM)	-automatic answer & record equipment	-special needs centres
-hands-free units		
-Contempra(TM)		
-lightweight handset		

For those telephone users unable to access the telephone directly, environmental control units activated through various control interfaces can perform most telephony functions. The Automatic Dialing Telephone,(TM)24 an accessory that can be used with all three Prentke Romich Company environmental control models, permit the user to answer incoming calls independently and to dial outgoing numbers. Some models allow for about 10 telephone numbers, including the last number dialed, to be stored and automatically recalled from memory.

The Rehabilitation Technology Unit of the National Research Center in the United States, has developed and refined the Telco telephone unit since its introduction in 1980. The unit is another example of a hands-free telephone receiver and dialer, and can be operated via several special switches. This particular unit was designed for single switch operation, and can be readily accessed by most levels of disablity.

Most telephone companies offer a variety of aids to access telecommunicaitons systems for those users who experience an inability to lift and hold the handset, as well as dial the telephone. Here are some of the aids that have been developed:

The **lightweight headset** weighs less than 30 grams and will suit anyone who needs the benefit of hands-free telephoning, as it requires practically no physical motion. However, for those who suffer extreme dexterity impairments, getting the device on their head may pose a serious problem.

The **Teledialer-32**(TM) is an automatic dialer, originally developed for general business use, which gives the handicapped user who is unable to dial a telephone, the ability to select and dial up to fourteen pre-set numbers simply by pressing one button. This device works well with the **hands-free** unit which allows the user to talk without lifting the receiver. This aid combines a microphone with a loudspeaker, resulting in freedom of conversation without the use of a handset. Both these units are ideal for disabled users suffering from motor and dexterity impairments. As well, there have been attempts to modify the Teledialer-32 even further by providing an overlay for the keys, thus providing a hole-guide for use with a mouth stick. This further adapation will help those with severe impairments.

Bell Canada, in collaboration with Bell Northern Research and Positron Inc., has developed the **Directel** unit, which permits severely disabled individuals who are unable to use a regular telephone set or dialer, to contact the operator for assistance to place a call. The Directel aid is a speakerphone device (hands-free unit) designed to facilitate access to the telphone system by automatically dialling "zero" when activated. The Directel connects the caller to the operator, who will then dial the number given by the disabled person. The Directel unit is supplied with a boom mic permitting adjustable positioning with an internal blow switch for easy access by the user. Utilizing the various built-in jacks allows for auxilory switches (foot, touch sensitive), headphones, earphones, pillow speaker or different michrophone.

A School-Home system is available for those handicapped students unable to attend school in person. It utilizes a two-way transistorized intercom system which provides immediate and efficient communication between the classroom and the shut-in user. This system can have many benefits for the user not only for educational contacts and advancements, but for employability.

There are numerous telecommunication aids and devices which can be easily adapted to telephones to make access easier, most being of a simple design (ie. enlarged numbers, on/off switch,

hand stick). These telecommunication interfaces, aids and devices, whether simple or complex, mostly entail some contact with the telephone. However, there are disabled users of telephones who have greater difficulty handling the apparatus and who need an even quicker, more efficient system, perhaps a system that can perform other functions as well.

Most environmental control units can supply telephone hook-up so that with any switch, aid or "user interface", a call can be placed or received. One such multifunctional telecommunications device is the **Abilityphone**(TM)25. This aid, a micro-processor-based telecommunications and environmental control unit, was developed for severely- or multiply-disabled persons by Basic Telecommunications Corporation (BTC). The terminal has over forty features to accomodate the needs of the disabled, and allows for changes for those users who have a progressive disorder.

The Abilityphone has a built-in telephone mode featuring automatic answering, automatic dialing of up to nine pre-programmed numbers, and automatic redialling of calls which have not been answered. The device will also confirm a phone number that has been entered before that number is dialed; confirmation is through both a visual display (for any deaf users of the device), and optionally through speech synthesis

(especially helpful for any visually impaired and otherwise print-handicapped users). Also, the telephone transmitting and receiving functions can be accomodated through various interfaces for hands-free operation and privacy of calls.

The Abilityphone has many other functions as well as being a telecommunications device. It is an environmental control unit capable of turning on or off sixteen lights, devices and appliances by sending control signals over standard house wiring. Depending upon the options selected, the Abilityphone can interface with various other equipment such as tape recorder, alarms, keyboards, priters, other ECUs, automatic door locking systems, medical equipment, radios and television sets. An interesting option of the Abilityphone is its voice synthesizer which speaks all of the keyboard characters and index functions, thus providing audible output for the visually impaired or otherwise print-handicapped. Another interesting feature of this voice is its use by speech impaired persons; the device can, in the case of an emergency, dial a pre-selected individual(s), relaying an emergency message via synthetic voice.

For the severely disabled who have great difficulty in manipulating a phone, either in using the handset or accessing the dial, the advent of the ECUs and the rapid development of

micro-processor technology which can so easily incorporate telecommunications capabilities offer a vast opportunity to further develop and apply increased access to telecommunications systems.

6.3 Micro-computers and Environmental Control Units

Severely physically impaired people, primarily high-level spinal cord injured quadriplegics and those affected with progressive neurological dysfunctions, have a need for enviornmental control units which permit the individual to control a full array of electrical appliances and devices independently.

The general approach for control has been the two-switch operation - an binary condition of either ON or OFF - with one switch to select the function to be performed and the other to operate that function.

Most interfaces are of this "ON/OFF" type; in fact, it can be said that the majority of enviornmental control units are simply switches with different forms of acutation, in that they have only two states: open or close; on or off. Anyone familiar with computers will of course recognize that this ON/OFF principle is also the basis of all computer logic.

There are three basic means of using these interfaces to initiate specific user-controlled functions:

Scanning:

Access to many ECU, telecommunication matrices, and computers is by a row of lights (or a cursor on a screen). Selection of a desired symbol, word or action is obtained by "scanning": the lights are illuminated, one at a time, until the desired one is reached. Each light corresponds to a symbol, word or action. This scanning process can, if necessary, be activated by a single switch. Given the great variety of switches available, it is therefore, operable by the severely handicapped.

Direct selection - Manual:

Direct selection, on the other hand, is faster. The most common example of this is the keyboard. Here, there is a separate key for each symbol which is selected "directly" by pressing that key. This is, of course, how most able-bodied persons use a typewriter or computer keyboard; the keys each represents a letter or function. The advantage of this method is that there is no delay since there is no extra scanning involved. It does, however, require greater dexterity than scanning, although hand function is not necessary if a mouth- or headstick is used.

Direct selection - Voice input:

The other direct selection technique which is becomming available for some computers is voice command. Here the user simply speaks the required function into a microphone, the voice pattern of the speaker is analyzed and matched against a library of pre-stored voice patterns. Once found, the computer then performs a command attached to the identified word. It is, at present, applicable to the operation of the computer itself, or to an ECU via the computer. There is, however, an inherent difficulty with this system. Since it matches voice patters against a library of stored patterns, each user must "educate" the computer on his voice patterns. The manufacturers claim a 90%+ accuracy rate for the initial speaker (whose patterns are stored), but make no claim about being able to use someone elses patterns. This of course limits the machine to one user at one time. Also, many physically disabled persons who also have speech impediments might find this device frustrating since they would have to be able to repeat the same word exactly the same each time - a difficult task for people without a speech impediment.

There have been rapid technological advancements to facilitate, through ECUs, increased operator control over the user's environment. One such development is the environmental control link-up to a stationary or portable computer designed

for those disabled persons who are users of exppressive communication adis. It can be argued that this latest adaptation to ECUs (i.e. serial computer interfacing), currently available as an option, is today regarded as the overall direction of future aids for physically disabled persons. Because there is a need by disabled persons to access computer terminals, that these features should be incorporated into ECUs.

The question remains whether any new device which features the latest technological designs can maintain a high function capability and still be available at low cost to the consumer. Manufacturers of ECU systems such as the Control-1(TM)[26], belive that disabled user demand for specific ECU features is on the increase and, therefore, high costs may be unavoidable:

> The two extremes are therefore either a system with optional components for each function, or a system which provides all possible functions in one package. A unit which provides all possible functions in one package would of course have a high cost and low flexibility. With these extremes in mind, one can see why the different models of ECUs exist on the market today.[27]

ECUs have existed long enough to have become firmly established as a multi-functional accessability tool utilizing various configurations. There is no doubt that their existence has greatly aided the disabled community as a whole, and in

particular those whose physical impairment directly relates to this report. When one looks at existing enviornmental control units, however, limitations do become apparent. Usually those limitations involve cost effectiveness, as noted above. Because not all ECUs are designed with a "component approach", to give the user the option of purcahsing additional functions, the cost effectiveness for a complete ECU package runs high, higher than most disabled individuals are able to afford. Should this trend continue, a total ECU package developed specifically for a minority population, considering that a small demand is being weighed against the high costs of research and development, may continue to result in serious cost problems.

It might be argued that as the market for technical aids expands, lower prices and better service should be expected. With the speed of technological advances, these aids are becoming more compact, reliable and less expensive. The overall trend towards modular systems allows the disabled user to purchase only what is required.

The range of abilities of enviornomental control systems, it is said, is expanding at a rapid rate in conjunction with technological demands being made by the non-disabled population. Thus, micro-processors can maintain their cost

effectiveness due to supply and demand on a grand scale. Small computers can today also function as an environmental control unit if provided with the appropriate software and hardware modifications. Today's technology can provide the many different switches and interfaces, simple or complex, needed by the disbled user to access the computer keyboard.

The question must now be raised whether an ECU with an access mode to a computer terminal is a viable alternative to a computer which can incorporate an ECU as one of its multitudinous functions? The author clearly favours the latter.

6.4 Prosthetic Technology

In accordance with the focus of this report, this section will deal only with upper extremity prosthetics.

Over the years, many improvements in the design and reliability of current electro-limb components and the development of new and more functional systems have allowed greater dexterity and comfort for the amputee. At the Ontario Crippled Children's Centre (OCCC), Rehabilitation Engineering Department, functional ability of the prosthetic user and reliability of the artificial limb is a prime concern:

"Experimental work is proceeding on 'onionized' prosthetic sockets in an effort to effect ready sizing adjustments with growth, and to reduce porsthetic maintenance costs".[28]

Other programs and services are being offered throughout North America, similar to those found at the OCCC, involving the refinement of upper extremity prostheses which are myoelectrically- and microswitch-controlled. The designing and fitting of prosthetic limbs is a multidisciplinary task demanding competent professionals from various fields. This has been pointed out quite precisely by Barbara J. O'Shea, of Dalhousie University:

> The goal of upper limb prosthetic restoration should be full, spontaneous, bilateral function in all activities. This goal will not always be achieved, especially if the losses are severe, but nevertheless that ultimate goal should be held as the ideal.
>
> With the technology available currently, a prosthesis restores only one element of hand function, grasp and release, in one pattern of pinch. The functional hand, mechanical or electrical, replaces the pattern of prehension or three-jaw clutch grasp. Thus with a prosthetic hand, the approach to objects is not altered significantly from normal hand function. The hook terminal device replaces lateral prehension, a pattern little used in normal activities. Hence, motor planning problems are more marked when a hook terminal device is used.[29]

Accessibility to and use of telecommunication systems and devices by the upper extermity amutee can genearlly be performed with relative ease. A number of factors provide this accessibility capability. Many prosthetic limbs are of the standard mechanical type usually equipped with a hook terminal device operated through shoulder movements. With the myo-electric type, electromyographic (EMG) signals concmitant with muscular contractions are utlized to serve as controllers of switches which direct a current to electomechanical prosthetic elements. When a process EMG signal reaches a pre-determined level, the relevant prosthetic action follows. Furthermore, "mechanical pull-switches activated by body movements such as expansion of the waistline or shoulder shrugging can be exploited. Movements of shoulder remnants for high-level upper extremity amputees can be utilized to activate switches housed on an aluminum-frame body jacket to effect prosthetic hand opening and closure, wrist rotation, and artificial elbow flexion and extension".[30]

Other factors which may affect accessibility would involve the length of the amputation itself: whether the amputation is above or below the elbow, and whether the amputation is uni- or bi-lateral (one or two arms). Another consideration would be the individual's functional capabilities to operate the

prosthetic limb. Here, training time to properly use the prosthetic limb plays a major role as well as overall experience aquired over years of use.

It can be seen that the user of prosthetic limbs need not necessarily change or alter telecommunication devices, be it a telephone reciever, radio or television set, or keyboard. However, again depending on the factors outlined, whatever changes must be made can be done with relatively simple alterations to knobs, switches or dials, the use of a speaker-phone, and so on, to better aid the prosthetic-using amputee with telecommunication devices.

Another interesting thing to note is that now that biomedical engineers and other prosthetic technologists have learned to "tap" and amplify the electrical nerve impulses in muscles, there a a multitude of possible ways to harness this energy. Certainly the concept of direct input (where the electrical signal by-passes the keyboard and is input directly into the computer) is not that far off?

7.0 FINDINGS

7.1 General

It should be noted that telecommunications is perhaps the single most important aspect of a majority of jobs. If we consider the fact that even finding a job usually requires telecommunications of some sort, access to telecommunication systems, services and devices becomes imperitive. Disabled persons have traditionally had little or no access to telecommunications services: a barrier which has often prevented them from gaining meaningful employment. With little or no income, beyond social services or disability pensions, they often cannot afford the prohibitive cost of technical aids.

Perhaps the most significant finding of this report is that to date there has been little systematic research and development, or manufacturing and distribution of technical aids for the disabled. There are literally hundreds of devices available, but because the market for such items is limited, their availability is also limited. As a result, many disabled persons are not even aware of such technical aids or where to locate them. Nor for that matter are many professionals aware.

The Obstacles report recommended that:

> The Federal Government, in cooperation with the Provinces and the private sector, assist in the establishment of a Canadian Information Resource Centre on Disability to link up and coordinate information resources and to assist regional showrooms of technical aids.
>
> That, pending the establishment of a centre, the Federal Government prepare and publish a directory of Federal Programs and Activities of interest to disabled persons, as well as a catalogue of relevant research projects and studies.[31]

There is a severe shortage of these local and regional "information resources and technical aids" showrooms and programs, though they are slowly emerging in hospitals, rehabilitation centres and through various social service agencies. One good example of this is the "Technical Aids Program" in Vancouver, operated by the Kinsmen Rehabilitation Foundation of British Columbia. This program provides technical assistance in the form of equipment and services to the most severely physically handicapped to improve or help maintain their level of personal independence. The only criterion for service is a demonstrable need for technical aids (all of which are displayed at the centre); current information is also available to professionals and the disabled population and general public alike.

One should not assume that because of recent technological advances in telecommunication aids everything can now be solved. Micro-processors have made revolutionary progress in telecommunication systems, with the disabled community becoming a prime benefactor; the problem, however, does not lie soley within the technology itself. As Bruce Baker stated in this article, "Minispeak":

> Neurological damage sufficiently extensive to hamper intelligible vocalization is regularly accompanied by difficulty in control of physical movements. To use any communiction aid, the user must be able to actuate a switch. Consequently, existing communications systems do not solve the basic human-engineering problem of transferring information from the mind of the communicator to the communication aid, because all systems for complete communication voice or invoided, have been based upon actuating letters, words, word parts, or phonemes (minimal sound units).[32]

Here, the message is that the difficulty lies outside the realm of technology; that the alphabet may be at the very centre of the problem for people with some disabilities, and that perhaps a particular semantic approach can better the problem to some degree. The computer has the potential for equalizing physical differences. However, other factors may come into play, and the circumstances of each individual case must be carefully considered.

In Canada, Technical Aids and Systems for the Handicapped Inc. (TASH), affiliated with the National Research Council of Canada, is an example of an agency dedicated to fulfilling the needs and requirements of disabled persons by providing technical aids and systems which are not easily available.

7.2 **The Most Significant Approach**

As the direction of this report has indicated, the early method of piece-meal application and development of aids, devices and systems for the physically handicapped is, for all intents and purposes today, outdated. Today's technology, and the reality of pure economics, indictes that the piece-meal approach cannot remain a viable option in most circumstances.

The high output and low cost of a systematically-developed system designed for use by the genearl public yet which at the same time is readily adaptable or applicable to disabled users, suggests that this system of telecommunication aids for the disabled may now be the best route of the future.

It can be said that current environmental control systems have recently begun to follow this approach. More compact units are now appearing utlizing modular component technology, yet which remain adaptive to virtually any input interface.

However, the cost for such special devices continues to hinder the potential user, whereas almost any micro-computer provided with the proper software can perform the same functions, and can be reasonably adaptive and very expandable, yet at only a fraction of the cost of a full ECU system.

It may be predicted that within the next few years, systematically-developed micro-computers with ECU-functioning software will outpace currently competing systems and become available at fair cost to the consumer. The "pros" and "cons" may still exist today, over which telecommunication aid can best meet the disabled user's needs, but all indications seem to point to computer-related technology as the ultimate leader.

7.3 Degree of Change to the Disabled Person vs. Equipment

Over the years, the disabled person's telecommunication needs were seen as a problem which was being addressed by various concerned service agencies or groups, or it was assumed that little more could be done to modify or adapt telecommunications equipment to their needs.

One popular approach that was taken by the manufacturers of special aids, was to adapt the equipment to the disabled user. Though this approach remains advantageous to specific

handicapped populations, it can also be a hindrance. Those piece-meal-designed aids and devices have made it more difficult for the disaled user to access "standard" telecommunications equipment, which have remained a barrier to accessibility. An example of this would be the design of a circular keyboard with a different arrangement of keys, situated to make the most often used keys easier to reach. Though this does provide accessibility, it does not address the problem of how a physically disabled person can access a standard "QWERTY" keyboard [so named because the top row of the keyboard spells QWERTY], which is used throughout the world on any equipment utilizing a keyboard. It would seem obvious that interfacing a person with "standard" equipment is more desireable in terms of employability than necessitating specialized equipment and designs.

Another example would be the altering of telecommunication equipment, (a telephone dial, handset, radio/TV switch, keys on any type of keyboard, etc.) for upper-trunk amputees. It would seem that major modifications to these devices are fine for use within the home or modified work environment, but they severely limit the disabled person to using only those special devices, eliminating the hundreds of other pieces of equipment they will encounter everywhere.

A rule of thumb might be to evaluate the level of modification necessary; the disabled person might be better off adapting to existing standard devices rather than "matter-of-factly" adapting the equipment to the person. By doing so, the door remains open for these disabled users of telecommuniction devices to be able to access a wider variety of devices. There must, therefore, be a balance between the level of adaptation to the device, and the adaptation to the person involved.

The question being raised by physically handicapped users, as well as professionals, is why existing equipment is not utilized as opposed to designing a special device from scratch to perform the same function(s)? The specialized approach involves, for many, an aid that costs more to purchase as well as limiting access to this special equipment.

7.4 Less is Best

Conversations with disabled individuals and professionals in most levels of health care indicate that the need for telecommunication accessibility is clearly understood by all concerned. The numerous switches, interfaces, aids and devices adapted or developed to help achieve this goal have proven themselves useful to a greater or lesser degree.

Because of the number of categories and ranges of impairments, different aids are adapted for different impairments - some are fairly simple and others more complex. A basic interface can mean a simple mouth-, head- or handstick to access a standard keyboard or activate a switch. More complex systems can be applied where the user must utilize a pressure-sensitive switch or interface, which is then connected to a control box (interface), which in turn controls the device. This system may be a single control unit with various components connected to operate specific appliances. The greater the needs of the individual user, the greater the chances of a more complex electronic system.

Though unavoidable for some, this complex system approach is sometimes ignored by those disabled users who can manage a more simple system. "Less is best" is another rule of thumb in this context.

8.0 CONCLUSIONS

8.1 Piece-Meal Approach: The Past

The piece-meal approach of the past usually involved one piece of equipment being adapted for one particular individual or group of disabled persons. As an example, the Telephone Pioneers Association, through its local chapters, did much early work in making the telephone network accessible to disabled persons. Often a specific Chapter was approached by a specific disabled person with a specific telecommunication problem. The Pioneers used their vast knowledge of the telecommunication devices to address the needs of that person(s), designing special devices, interfaces, or adapting equipment to allow that person(s) to access the telecommunication network. Although this was unquestionably helpful for those to whom it applied, this piece-meal approach, unfortunately only benefited a handful of persons.

This early piece-meal work has, however, set the groundwork, and has given way to a more recent systematic approach by some telecommunication carriers. Many companies, such as Bell Canada[33] for example, took a careful and closer look at their existing equipment, and assesed it for possible use by the disabled population. The "hands-free" unit, for example, a unit

originally designed for business use where a person needed to leave their hands free while they talked on the phone, or for tele-conferencing, was applied to a disabled person who is unable to hold the handset.

In reviewing the findings of this report, it would seem that the need for pursuing a systematic approach to better aid the physically handicapped cannot be ignored any longer. Although research and development through a number of agencies, institutions and government departments has provided technological alterations, improvements and advances, the state-of-the-art of research programs has not advanced far nor fast enough. It has been realized not only by the author, but by many who have studied the disabled population and their needs, that there is insufficient data on the handicapped population and their needs, that there is insufficient data on the handicapped population and an overall deficiency in co-ordination of effort by agencies, institutions, government departments and countries around the world. This is not to imply that an apathetic attitude is being assumed by those involved; nothing could be further from the truth. However, due to the immense potential that telecommunication technologies can have in releasing many physically disabled persons from their personal and social isolation, every aspect or approach must be fully exploited and utilized. I believe a systematic approach will assist greatly in this venture.

The mandate of this report has been to identify telecommunications accessibility problems which persons with a motor and dexterity impairment may encounter, and to identify those existing aids and devices which can increase telecommunications accessibility for this population. This problem of accessibility is of a physical nature. Yet, it must also be understood that many of the problems of the physically handicapped transcend these physical aspects. The disabled may face attitudinal problems towards their handicap by the "general non-disabled" public, though this is slowly changing as increased awareness and acceptance of this sector of the population is being demonstrated by the various government and public fora.

For the physically handicapped, however, many psychological problems remain, due mainly to social isolation and the difficulty in obtaining "equal opportunites" for employment. In his paper Communications and the Physically Handicapped, J.R. Lucyk pointed out:

> It is seen that the roots of the problems of the handicapped are largely social, psychological and economic in nature. Psychological and social attitudes of and toward the handicapped need to be modified if the potential of 'communications' is to be realized. There are clear indications, too, that the handicapped are poor and socially isolated. Communications holds inestimable potential for getting to the roots of all these problems.[34]

It now becomes imperative that telecommunication systems be made accessible to the disabled in order to help alleviate these psychological problems. Today's rapid technological advances are aiding in this cause, and promise to continue doing so. It is felt that with more accessibility to telecommunication systems, psychological benefits for the disabled must follow, allowing for reduced isolation, increased employability (by means of computer-aided instruction to name one technique), and a more healthy attitude generally towards the disabled population as they become socially "exposed".

There have been great strides over the past decade to provide accessibility to telecommunication aids and systems for the disabled. Though it is widely held that technical aids reduce health care and rehabilitation costs by providing programs that take disabled persons out of institutions and help them back into the mainstream of society,[35] and that depending on the severity of their handicap, a fuller independence can be achieved with the use of these aids, there still remain problems. Once a telecommunications aid or device specifically designed for use by the disabled has been identified, designed, developed and applied, the device has already in many cases become obsolete. It has been said that technology is rapidly moving ahead; this can for the most part, become the downfall to any piece-meal design, from its blueprint stage to final market

readiness. Since a full year or more is in many cases needed for a device designed specifically for the disabled to emerge as a tool or aid, large numbers of systematically-designed devices for use by the general public have technically surpassed the piece-meal produce. This can be attributed largely to strong competition on the open market.

An example of this arguement is the Abilityphone(TM), a micro-processor-based communication and telecommunication device which is extremely functional for most any disabled user. The device incorporates all telephony functions, can act as an environmental control unit, a calculator, has status monitoring and automatic help call functions, a synthesized speech module, a Telecommunications Device for the Deaf (TDD/TTY) modem, and a serial interface option for computer communications. All in all, this device is a multi-functional aid of great use to the disabled population. It is also of a piece-meal design, however, and available to only a small population who can afford its retail price of $6,000 (Cdn).[36]

The cost problem becomes further compounded when those disabled users of telecommunication aids and devices are moved from the care of an institution which usually absorbs these costs, to the home environment where the devices are needed by the disabled person to function independently. It is a

"catch-22" situtuation because often the only way a person will get the necessary devices is if they are institutionalized, yet the devices they want and need are required to make independent living possible.

Today's computers can also perform most of the functions of a devices such as the Abilityphone, at a substantial reduction in costs. A computer keyboard may not be accessible to some; further components and software may be needed which increase the overall price of the computer, but various interfaces can be obtained to access a computer keyboard by virtually all levels of physical impairment. I belive any extra costs required to make a micro-computer accessible for a disabled person would be well spent given the gained employability of that person.

8.2 **Systematic Approach: The Present?**

The Concise Oxford Dictionary defines **systematic** as "methodical, according to a plan, not casual or sporadic or unintentional, classifacatory. Considered principles of procedure".[37]

Large numbers and groups of handicapped people are demanding greater accessibility to telecommunication systems through the use of readily available or easily adaptable aids and interfaces

taken "off the shelf". The cost effectiveness of utilizing existing devices substantially reduces the users' difficulty in acquiring telecommunication aids. Those suffering from a motion handicap can adapt to use of a lightweight headset for the telephone, or to an automatic dialer, and/or a "hands-free" unit - the result being an ability to access the existing telecommunications network and system with existing equipment. For the severely disabled, a specialized device such as the Directel(TM) can be utilized. All of these telephone services for special needs are now readily available from most telephone companies at a reasonable cost - usually on a "no-profit" basis - due in part to a systematic approach whereby current telephone equipment was developed for general use by the public and then systematically re-applied in usage to meet the needs of the disabled population.

This is a fine example of how existing telecommunication aids can be altered with minimal cost to the user, using a methodical plan of adjusting the use of the aid or service to a meet the needs of a particular audience, the result being a lower cost to the consumer.

Another example of the systematic approach to adapting existing aids to the disabled is the voice entry terminal for accessing a computer, Shadow/VET(TM)[38] being one example.

Designed for the everyday user of computers either at home, industry, business or for educational purposes, the Shadow/VET provides an example of how a severely handicapped individual can control his environment, by programming a computer via voice to control the immediate environment (eg. "lights on"). As well, the disabled user would have the use of a computer for other functions: calling up electronic mail, word processing, inventory control, dialing a telephone number, problem solving, etc. It would seem obvious that with this kind of control of one's environment including accessibility to telecommunications, the employability of such a person has been increased substantially.

The piece-meal approach continues to have its benefits in certain cases where existing telecommunication aids cannot be adapted for uniquely disabled or multiply handicapped persons. However, with the hundreds of interfaces, aids, and services for disabled persons readily at hand, this approach cannot be practically applied for every user or group without an "outflow" of confusion, cost inefficiencies, and overalpping systems/aids development.

One has to step back and consider the needs of the disabled population wishing to access communication equipment and weigh them against services which already exist and which can be modified with little or no expense, while remaining cosmetically

attractive. The next logical step is, therefore, a systematic approach. Where the use of a simple mouth stick to control telecommunications equipment suffices, it should be used. But the potential of developing an access tool through the use of a voice entry terminal can benefit not only those using a mouth stick, but an entire range of disabled persons who may not even be able to use a mouth stick for keyboard entry.

Today's technology allows for the "removal" of multiple aids and interfaces developed for use by one user, and replace them with more streamlined systems. Equipment wiring need not run throughout a person's home when remote control switches are available. Complicated and expensive devices which are often an eye-sore can now be replaced by one micro-processor-based device in conjunction with the necessary software, at a considerably reduced cost to the user.

The piece-meal approach to research and development was appropriate during the early stages of interface design. However, continuing this approach to the problem might in fact cause more problems. Where a single device is designed to solve a single problem for one person (or a small population) the piece-meal approach to research and development can often result in the "re-inventing of the wheel".

With a systematic approach, the researcher looks at the whole disabled population to be served, at the existing devices that can be re-applied in usage, the current state-of-the-art technology situation, and how to match them effectively, bearing in mind some basic considerations such as simplicity of design, cost efficiency, adaptability, obsolecense, and expandibility.

8.3 **The Future**

The major objective of this paper is to identify the telecommunications needs of the mobility and dexterity impaired and detail existing devices and services which can improve basic telecommunications for this population.

The physically disabled population studied suffer varying degrees and levels of impairment. Those groups suffering degenerative muscle diseases require increased attention to reasses needs as thier handicaps increase. The common denominator for all lies in the difficulty of accessing telecommunication devices and services and in the problems which hinder ease of interaction with these devices and systems.

Although profound developments have surfaced over the past years and research is continuing to further serve this

population's needs through more efficient interfaces and aids, this research remains sparodic and technically unattuned to the systematically-developing technologies.

In the past, various levels of impairment and their degree of severity called for the various piece-meal developments and approaches, resulting in numerous aids, devices, services and interfaces to accomodate each level and degree of impairment. over the years this approach has given birth to a profusion of overlapping aids and devices throughout North America, and gave rise to mirrored research and development programs based on piece-meal blueprints. Out of this, however, evolved technological prodigies which act as a basis for future designs and imporvements. These improvements utilized more and more the ever increasing technological advancements and breakthroughs which occurred rapidly in a systematically-oriented technology. However, because of shortages of funds and qualified personnel, and the overwhelming outflow of technology effecting the general direction of directly involved research and development, a serious lag may now have occurred.

It is possible that this lag can be reduced or eliminated altogether by fully integrating existing systematically-developed technologies to the aids and devices needed by the disabled population. In this context, the computer revolution and its wide applicability and adaptability become the strongest contender.

Large computer manufacturers have introduced components specifically designed to be used by the physically handicapped, or which with slight modifications remain ideal for their use. However, these corporations are business enterprises developing and supplying a product for the demanding majority. Herein lies the problem. Direct benefits towards the disabled population from on-going computer developments are today marginal in comparison to the immediate impact these developments have upon the business community, educational institutions, government, social services, and increased home applications. Society's "able-bodies" majority, the so called "mainstream of society", is where corporate earnings originate, and so, is where research and development is directed. The disabled minority, at this stage, are only reaping the technological "spin-offs" of the computer revolution.

It can be argued that computer technology will evolve to a degree as to service the whole of society, including the disabled minority. however, with the vast amounts of corporate resources input into R & D aimed at serving the wants and needs of the mainstream, the disabled population is forced to take "a back seat" and wait until their rightful basic needs are fully attended to.

A prime example of how the disabled community can benefit greatly from information services via a computer or home television set equipped with a "decoder device", is provided by videotext systems. "Videotext" is generally accepted as the generic term for viewdata/videotext/teletext technologies and services. The primary distinctions between video- and tele-text systems is the medium by which the information is transmitted to the user -- generally phone lines for videotext and broadcast signals for teletext. In both forms the receiver must be equipped with a decoder which will accept the signals being sent, decode them, and display the appropriate image on the screen of the television or monitor.

Telidon, a creation of the Federal Department of Communications, is a consumer-oriented information retrieval system available in both formats. Telidon as a technology, is a world leader, having been the basis for the North American Broadcast of Teletext Standard (NABTS) of Point Definition Information (PDI) graphics. It allows for a television set in the home or office to receive up-to-the-minute textual and graphic information of superior quality graphics from a network of computer data banks, drawing upon thousands of "pages" of available information spanning a multitude of topics and categories.

With a Telidon terminal, the user can call up a wide variety of information, from current weather and news, shopping guides, to statistical analyses and education lessons. Some Telidon terminals have typewriter-like keyboards which allow users to write reports, leave messages, or search for information in computer data banks by typing in keywords. Other terminals have a simple keypad with numbers that enable the user to retrieve information from numbered indexes, (using a tree-structured menu system) or to perform calculations, place an order and leave their credit card numbers, or to play computer games. It is quite evident that this Telidon system has enormous potential not only for the public in general, but for the disabled community as well - a community which has traditionally been "information-starved".

Numerous companies and organizations have proposed services which indirectly can be of great assistance to the physically handicapped. Among the many applications proposed are an "electronic journal" for the handicapped; courses to train sudents in page design and maintenance, and videotex marketing, computer-aided teaching devices and an advertising system with touch-sensitive terminals and large screen disaplays for shopping malls and public areas, similar to those being used at Toronto's Eaton Centre. Many more aids and services can be added to assist the home-bound disabled to directly access

needed information or to utilize information which can enhance education and employability. For many, Telidon can become "a new window to the world", an example of a systematic technology capable of serving the **whole** of society.

Computers and the physically handicapped have a juxtaposed future, with the rapid growth of the computer constantly eroding the many obstacles hindering the goal of telecommunications accessibility. The future computer may incorporate a voice input interface, disregarding a keyboard entry system altogether. A voice recognition is already becoming available many mini- and micro-computers. Though still years away from being totally refined, this system can provide the disabled individual with voice capabilities for total accessibility to telecommunications, total environmental control, and access to most, if not all, telecommunications systems, services and devices.

This trend towards alternates to the keyboard as an input device is evidenced by recent developments in the micro-computer industry which has seen the introduction of menu-oriented, "mouse-driven" home computers. Designed for the "computer illeterate" market, the computer is operated by means of a small "mouse" which is rolled on a desk top. The mouse controls a cursor which is used to select options from a menu. The button(s) on the mouse are used to select the item when the cursor is atop it.

The trend to develop total control of one's environment through the use of remote control devices for the non-disabled person may have been the science fiction of yesteryear, but it is the technological reality of today. These devices, which will control the environment, can be singularly designed components or packaged within a micro-computer system.

Cost effectiveness of telecommunication systems and related aids and services has always been one of the prime concerns of the physically handicapped. The severity of an individual's impairment will usually dictate the final cost of the disabled person's equipment needs. A high-level qudraplegic can expect to pay a substantial amount for his required aids and devices. Taking into consideration that the average severely handicapped adult is unemployed, or at best under-employed, many severely disabled people cannot cope with the added financial burden of specially-designed equipment and services. Today, independence has a price.

For many severely disabled persons who for one reason or another are not under the direct care of family, hospital or institutionmay be the only alternative. Here, society must pay the cost of their daily care, and generally at a substantially greater cost when compared to the overall price of current aids and services along with the cost of a private attendant for

those who can afford it. Depending on the government, the current trend for the more severe levels of physically impaired peole is to shift away from costly instituional care and to encourage disabled people to take up private residence (which includes group homes).

9.0 SUMMARY

The objective of this report was to outline the main difficulties which those people suffering from upper trunk mobility and dexterity impairments experience in regard to accessing telecommunication devices, services and systems. Furthermore, the author examined the current strategies of researchers/manufacturers towards research and development of assistive telecommunications devices for use by persons with a mobility and dexterity impairment.

It should be noted that telecommunications is perhaps the single most important aspect of a majority of jobs. If we consider the fact that even finding a job usually requires telecommunications of some sort, access to telecommunication systems, services and devices becomes imperitive. Disabled persons have traditionally had little or no access to telecommunications services: a barrier which has often prevented them from gaining meaningful employment. With little or no income, beyond social services or disability pensions, they often cannot afford the prohibitive cost of technical aids.

This report has undertaken to identify the systematic approach (as opposed to the piece-meal) to telecommunications accessibility in the belief that this is the best possible

approach in making advances to further overcome the numerous obstacles to accessibility experienced by the disabled population. Such an approach moreover, is the best approach to research and development; to take an overall look at the needs of the disabled and in doing so, to obtain a clear, concise approach to tackling the problems of accessibility.

The piece-meal approach towards R & D of the past usually involved one piece of equipment being adapted for one particular individual or group of disabled persons. As an example, the Telephone Pioneers Association, through its local chapters, did much early work in making the telephone network accessible to disabled persons. Often a specific Chapter was approached by a specific disabled person with a specific telecommunication problem. The Pioneers used their vast knowledge of the telecommunication devices to address the needs of that person(s), designing special devices, interfaces, or adapting equipment to allow that person(s) to access the telecommunication network. Although this was unquestionably helpful for those to whom it applied, this piece-meal approach, unfortunately only benefited a handful of persons.

This early piece-meal work has, however, set the groundwork, and has given way to a more recent systematic approach by some telecommunication carriers. Many companies took a careful and

closer look at their existing equipment, and assesed it for possible use by the disabled population. The "hands-free" unit, for example, a unit originally designed for business use where a person needed to leave their hands free while they talked on the phone, or for teleconferencing, was applied to a disabled person who is unable to hold the handset.

In reviewing the findings of this report, it would seem that the need for pursuing a systematic approach to better aid the physically handicapped cannot be ignored any longer. Although research and development through a number of agencies, institutions and government departments has provided technological alterations, improvements and advances, the state-of-the-art of research programs has not advanced far nor fast enough. It has been realized not only by the author, but by many who have studied the disabled population and their needs, that there is insufficient data on the handicapped population and their needs, that there is insufficient data on the handicapped population and an overall deficiency in co-ordination of effort by agencies, institutions, government departments and countries around the world. This is not to imply that an apathetic attitude is being assumed by those involved; nothing could be further from the truth. However, due to the immense potential that telecommunication technologies can have in releasing many physically disabled persons from their personal and social

isolation, every aspect or approach must be fully exploited and utilized. I believe a systematic approach will assist greatly in this venture.

The systematic approach to research and development of assistive telecommunications aids for persons with a physical disability has four components: 1) application, 2) minor modification, 3) major modification, and 4) by design.

Application:

The first step towards meeting the needs of the disabled would be to examine existing equipment, devices and services and alter not the devices, but their application. Indeed, this was done by many telephone companies who examined their existing stock and applied the equipment to alternate uses; the most striking example being the use of a hands-free unit, originally intended for business use, being applied for use with persons who cannot grasp or hold a telephone. Such simple alternate uses of equipment may provide access for a great many disabled persons.

Minor Modification:

The second step towards providing access would be to make slight modifications to equipment. An example of this can be seen with the keyguard for the Teledialer-32 which was developed by the Brock Council (Maple Leaf Chapter) of the Pioneer Telephone Association. This rather simple device is a piece of plastic which fits over the buttons of the dialer providing a "guard" around the keys so that persons whose movements are not refined, can use a mouth or hand stick to activate the buttons. Such modifications are simple, and inexpensive. Another example would be the application of a "large dialer" over the regular touchphone keypad. The large dialer is used for persons with a visual impairment, but can also be used for someone who does not have control of the finer finger movements required in dialling a telephone.

Major Modification:

This involves examining the needs of those persons not already satisfied with the previous two steps. Major modifications, and specially designed equipment may be necessary at this point. An example of this is Bell Canada's Directel, which is a major modification of the "speaker-phone" concept. It is interesting to note, however, that the basic technology, if not design, for the Directel comes directly from the speaker-phone. Thus, Bell did not "re-invent the wheel"

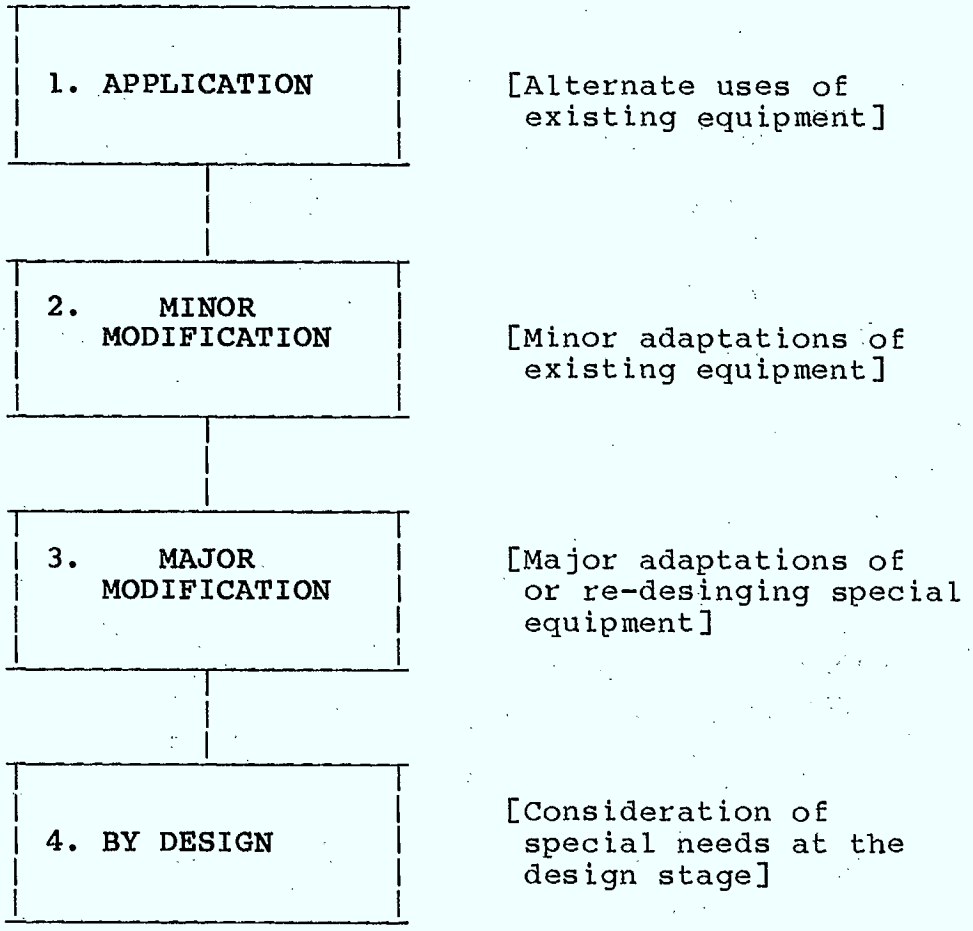
By Design:

The final step of providing accessibility is in fact the first step - the first step towards true accessibility. Once existing equipment has been re-applied, modified slightly as necessary, or re-designed as necessary, the future still remains. These first three steps are almost interim solutions - in that in the future the needs of disabled persons should be considered at the design stage. Many modifications now necessary to exisiting equipment may not have been necessary had the needs of the disabled been considered earlier. An example of this can be seen with Northern Telecom's newest phone, "The Harmony", which was designed with hearing aid users in mind, and so includes a fluxcoil by design. The fluxcoil is used by hearing impaired persons to activate a similar coil in their hearing aid.

9.1 INTEGRATION OF CONCEPTS:

The following diagram should serve to illustrate these concepts:

Figure 5: **Systematic Approach to Access**



10.0 FOOTNOTES

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2. ibid. p. 28

3. ibid. p. 29

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6. Telecom Australia, "Report on an Investigation into the Needs of Telecommunications Needs of Disabled Persons", Telecom Australia, Melborne, 1981 p. 54

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14. Graham Langley, Telephony's Dictionary, Telephony Publishing Corp., Chicago, 1982 (some of the definitions in this section are from this source).

15. R.A. Bones, Dictionary of Telecommunications, Philosophical Library Inc., London, 1970 (some of the definitions in this section are from this source).

16. Report of the Special Parliamentary Committee on the Disabled and the Handicapped, "Obstacles", Minister of Supply and Services Canada, Ottawa, 1981, p. 131

17. Government of Canada, "Surmounting Obstacles", Minister of Supply and Services Canada, Ottawa, 1983, p. 111

18. Government of Canada, "The Charter of Rights and Freedoms: A Guide for Canadians", Minister of Supply and Services Canada, Ottawa, 1982, p. 15

19. "Obstacles", p. 4

20. ibid. p. 4

21. Canadian Human Rights Act [SC 1980-81-82-83, c.33]

22. Nelson D. Durie, "Interfaces - Enablers for the Disabled", Biomedical Engineering Research Program, National Research Council of Canada, Ottawa, undated, p. 1

23. Contmpra is a registered trademark of Northern Telecom Ltd.
Teledialer 32 is a registered trademark of American Telecommunications Corp.
Directel is a registered trademark of Bell Canada

24. The Automatic Dialing Telephone is manufactured by Prentke Romich Company, Ohio

25. The Abilityphone is manufactured by Basic Telecommunications Corporation, Colorado

26. Control 1 is maunfactured by Prentke Romich Company, Ohio

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28. Ontario Crippled Children's Centre pamphlet, "Rehabilitation Engineering Programmes", Ontario Crippled Children's Centre, Toronto, undated, p. 2

29. Barbara J. O'Shea, "Upper Limb Amputees: Functional Evaluation", a paper presented to the Canadian Congress on Rehabilitation, Ottawa, 1983

30. Morris Milner, "What's In A Switch?", a paper presented to the Canadian Congress on Rehabilitation, Ottawa, 1983

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11.0 APPENDICES

11.1 A LIST OF INTERFACES (See Note 38 for reference)

Break light beam:

The trigger for this type of device is a beam of light (usually visible, not infrared) broken by interposing a body part such as a finger. In one configuration, four holes in a plate, each with a light beam, represent the four directions of motion of a wheelchair (or scanning matrix). Inserting a finger in one hole triggers the control system, initiating the corresponding wheelchair activity. No strength is required, but some accuracy is needed to insert the finger into the correct hole.

Electromyogram (EMG):

Tensing of muscles is accompanied by an electrical output, the EMG. This signal may be detected by electrodes on the skin, amplified, and used as a control method. This is a common technique for control of prosthetic hands, usually used in an on-off mode. If the muscle control is good, however, it can be a proportional method, wherein the effect produced is proportional to the amount of muscle tension.

Expanded keyboard:

The term "expanded" refers to the fact that these keyboards are much larger than normal. Also, the keys are larger. With a cover plate surrounding them, upon which the hand can rest. The net result is to make this direct selection technique accessible to persons with poor hand control. As mentioned earlier, direct selection is faster than scanning, and is, therefore, the method of choice where feasible. Mouth-or-headstick operation is also facilitated. Even foot operation is possible. Some models have low force, low travel switches as their keys.

Eye blink:

Many attempts have been made to use the eye as an input to a controlled system. Presumably, the attraction is that eye motion control is usually not greatly impaired by disability. There have even been prototype devices which could directly select symbols simply by looking at them. Unfortunately, all have so far failed to reach the commercial stage, because of various technical problems such as drift and difficult setup. Also, cost has been high.

One promising technique, however, is to monitor the blinking of the eye, and use that as the signal to the

controlled equipment. Eye blink can be detected readily by reflecting infrared off the eye, or by monitoring the electromyogram (EMG) of the muscles controlling the eyelid.

Joystick:

This term refers to a "stick" or small lever, usually projecting vertically from a box. The lever can be moved in any direction to activate switches. For greater hand dysfunction, a "gate" may be used, in the form of a cross, which constrains the motion to only two planes (4 directions).

When the joystick is connected to potentiometers instead of switches, it becomes a proportional device. Then, the output signal is proportional to the amount (and direction) of movement.

Light beam or light sensor:

Controls have been devised which consist of a light source mounted on a headband. Motion of the head causes light to fall on one of a group of detectors (usually part of an alpha-numeric matrix). The light detector then sends a signal to the controlled device, such as a typewriter.

The advance of technology has caused this type of detector to be superseded by other devices. Now, the matrix contains an array of light emitting diodes, one for each symbol in the matrix. Light from these diodes is picked up by a sensor on a headband. Thus, if the eyes and head are fixated on a particular symbol, light from the adjacent diode is received by the sensor. This initiates the desired action (usually typing). This is a direct selection technique.

Puff and sip:

By blowing into, or sucking on a tube, pressure-sensitive switches may be activated. These two actions can control scanning of matrices for typing, environmental controllers, and electric wheelchairs. For the wheelchairs, some combination of puffs and sips (coding) may be needed in order to control all functions.

Attempts have been made to use puff-and sip in a proportional manner, wherein the effect (output signal) is proportional to the amount of pressure applied. For example, blowing harder causes a wheelchair to go faster. This works, but it is fatiguing to maintian the pressure for long periods.

Push switches:

Conventional switches, being spring loaded, require some force to actuate. Also, the button usually travels some distance. Both factors may present problems for arthritics, for example. There is another variety of switch, usually called a "membrane" switch, which does not have perceptible motion (a few hundredths of a millimeter). The force required is low. Hence the term "low force, low travel" switch.

Sound-operated switch:

Persons with severe physical disabilities, plus aphasia, may still be able to make their vocal cords produce sounds. These, when picked up by a throat microphone, can act as the control systems are possible. Here, the effect may be made proportional to the loudness of the tone or to its pitch. Pitch discrimination can also be used to initiate several indepedent functions, each controlled by a particular voice frequency.

"Target" (mouth-operated keyboard):

This device has a "keyboard" in the form of a section of the inside of a sphere. The "keys" are metal spots placed on the concave curvature of the base. A finger or follower is pivoted at the centre of curvature of the sphere, and extends

close to the sphere. The other end of the pivoted follower is held in the mouth of the quadraplegic user. By small movements of the head, the user is able to aim the follower at any desired "key". A puff on the mouthpiece then causes the symbol to be typed. This device provides the speed benefits of direct selection to quadraplegic users.

Touch-Sensitive Switches:

This type does not require either force or motion for activation. The presence of the hand (or cheek, chin, etc.) is sensed electronically. It is only necessary to touch the metal sensor (plate, ring, etc.) in order to cause a signal to be transmitted to the controlled apparatus. The latter, of course, must be designed to accept that kind of signal.

11.3 FOR MORE INFORMATION...

N.B. The addresses provided below are for information only and not an endorsement of the product(s) and/or companies listed. The author has not reviewed the equipment sold/distributed by these companies and provides these addresses based on information printed by the companies.

CANADA

1. Bell Canada, Bell Trinity Square, 483 Bay Street, Fl. 1, North Tower, Toronto, Ontario, M5G 2El Ph. (416) 581-4551, (416) 364-8654 (TDD), Toll Free: 1-800-268-9243 (voice), or 1-800-268-9242 (TDD)

2. BETACOM, 6140 Vanden Abeele, St. Laurent, Quebec, Canada, H4S 1R9 Ph. (514) 335-1058

3. Canadian Paraplegic Association, 520 Sutherland Drive, Toronto, Ontario, M4G 3V9 Ph. (416) 422-5640

4. Canadian Rehabilitation Council for the Disabled (CRCD), 2210 - -1 Yonge Street, Toronto, Ontario, M4E 1E5 Ph. (416) 862-0340

5. Contemporary Artistic Technology Co. Ltd., P.O. Box 58430, Station "L", Vancouver, British Columbia, V6P 6K2 Ph. (604) 324-8119

6. Coalition of Provincial Organizations of the Handicapped, 926 - 294 Portage Avenue, Winnipeg, Manitoba, R3C 0B9 Ph. (204) 947-0303

7. The Kinsmen Rehabilitation Foundation of British Columbia, 2256 West 12th Avenue, Vancouver, British Columbia, V6K 2N5 Ph. (604) 736-8841, Toll Free (BC only): 112-800-663-1555, (604) 738-0603 (TDD)

8. National Research Council of Canada, Biomedical Engineering Research Program, Ottawa, Ontario, K1A 0R8 Ph. (613) 993-3285

9. Ontario Crippled Children's Centre, 350 Rumsey Road, Toronto, Ontario, M4G 1R8 Ph. (416) 425-6220

10. Technical Aids and Systems for the Handicapped Inc. (TASH), c/o Sunnybrook Medical Centre, 2075 Bayview Avenue, Toronto, Ontario, M4N 3M5 Ph. (416) 486-3569

(See note: 11.3)

UNITED STATES OF AMERICA

11. Alternative Communication System Project, University of Washington, Seattle, Washington, USA 98195 Attn: Dr. Wesley R. Wilson, WJ-10, CD 393 Ph. (206) 543-7039

12. Basic Telecommunications Corporation, 4414 East Harmony Road, Fort Collins, Colorado, USA 80525 Ph. (303) 226-4688 (voice/TDD)

13. The National Institute for Rehabilitation Engineering, 97 Decker Road, Butler, N.J., USA 07405 Ph. (201) 838-2500

14. Prentke Romich Company, 8769 Township Road 513, Shreve, Ohio, USA 44676-9421 Ph. (216) 596-2906

15. Scott Instruments, 1111 Willow Springs Drive, Denton, Texas, USA 76201 Ph. (817) 387-9514

16. Serota Engineering Consultants, P.O. Box 43286, Birmingham, Alabama, USA 35243, Ph. (205) 822-3425

EUROPE/OTHERS

17. British Telecommunications, OLC6.1.1, Broad Street House, 55 Old Broad Street, London, UK, EC2M 1RX
Ph. (International): (+441 588) 5739

18. Home Automation Ltd., Pindar Road, Hoddesdon, Herts, UK, EN11 0ET Ph. (099 24) 60355

19. Standard Elektrk Lorenz AG (SEL), Postif. 400749, D-7000 Stuttgart 40, Germany

20. Technical Aids for the Speech Impaired, ICTA Information Centre, Stockholm,

21. Telecom Australia, 199 William Street, Melbourne, Victoria, 3000 Ph. (03) 606-5757

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