TP 13152E

ASSESSMENT OF IN-CABIN INFORMATION TECHNOLOGIES FOR PASSENGERS WITH SENSORY AND COGNITIVE IMPAIRMENTS

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16. Abstract

Effective communication in air travel is of vital concern to travellers with hearing, speech, sight, and cognitive impairments. Current on-board information regarding safety instructions, service information, changes in flight plan, emergencies, and evacuation procedures may not be conveyed in the most effective manner.

This project presents the results of an exploratory study on selected communication technologies that address the requirements of travellers with sensory and cognitive impairments. Examples include infrared transmission of audio signals, open-captioned video, text-to-speech laptop computers, and descriptive audio tape.

Tests were carried out in an aircraft cabin simulator, with a limited number of subjects from the target groups using selected equipment. Ergonomic and technical evaluations were conducted to determine ease of use and applicability.

The results indicate that technological solutions are available to facilitate communication. In addition, training of service personnel and consumer awareness are necessary for successful implementation.

Recommendations addressing the needs of the target population are presented. Constraints related to the implementation of particular technologies in an aircraft cabin are noted.

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16. Résumé

Une communication efficace est une préoccupation de premier plan pour les passagers aériens atteints d'une incapacité visuelle ou auditive, d'un trouble de la parole ou d'une déficience cognitive. Les communications en vol concernant les consignes de sécurité, le service de bord, les changements au plan de vol, les situations d'urgence et les procédures d'évacuation ne sont pas toujours des plus efficaces.

Ce rapport présente les résultats d'une étude exploratoire de quelques technologies de communication embarquées destinées à répondre aux besoins des voyageurs ayant une incapacité cognitive ou sensorielle. Mentionnons, à titre d'exemples, la transmission de signaux audio par rayonnement infrarouge, les bandes vidéo avec sous-titrage non codé, les synthétiseurs texte-parole portables et les bandes audio descriptives.

Les technologies choisies ont été mises à l'essai dans une cabine passagers fictive, avec un nombre limité de sujets appartenant à divers groupes cibles. Les données recueillies ont été soumises à des analyses ergonomiques et techniques, afin de déterminer la convivialité et l'applicabilité des techniques.

Les résultats révèlent qu'il existe des aides techniques qui peuvent faciliter la communication en vol. Mais la mise en oeuvre de ces techniques ne sera concluante que dans la mesure où le personnel de bord aura été formé et les usagers sensibilisés à l'utilisation de ces techniques.

Enfin, les chercheurs énoncent des recommandations visant à mieux répondre aux besoins des divers groupes cibles, et signalent les contraintes reliées à la mise en oeuvre de certaines technologies dans une cabine d'avion.

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The authors dedicate this work to the memory of Tom Geehan, our mutual friend, who brought us all together.

SUMMARY

During a flight, all passengers must be able to receive information provided over the public address (PA) system, through armrest-headphones, on screen, or in person by a flight attendant. To ensure safety, all passengers must be able to receive and comprehend messages and follow instructions. Information must reach those in cabin areas as well as in washrooms, on a one-to-one basis (e.g., between flight attendant and individual passenger), and on a one-to-many basis (e.g., from flight attendant/captain to all passengers).

Information and communication requirements for passengers with sensory or cognitive impairments and elderly travellers are not always met in an aircraft cabin; consequently, they are not always aware of safety, in-flight, and emergency information, and entertainment.

According to research carried out for the Transportation Development Centre of Transport Canada, an estimated 756,000 persons in Canada have hearing, sight, speech, or cognitive disabilities. Approximately 308,000 air travellers have hearing impairments, 56,000 have speech impairments, 210,000 have visual impairments, and 182,000 have cognitive disorders (Turnbull, 1996).

The overall objective of Transport Canada is to make aircraft information accessible for passengers with sensory and cognitive problems. The objective of this study was to collect data regarding on-board information and communication systems, review on-board constraints, develop assessment criteria, demonstrate and evaluate information technologies in aircraft, and develop recommendations based on analysis of the results.

Implementation of technology is not meant to replace pre-boarding briefing by cabin personnel, but to augment the detail, clarity, and consistency of information provided.

The following technologies for each target group were selected:
- an infrared transmission system for passengers who are hearing impaired;
- a descriptive audio tape for passengers who are sight impaired or blind;
- open captioning on video monitors for passengers who are deaf or cognitively impaired; and
- a text-to-speech laptop computer for those who are speech impaired.

Infrared transmission system
The infrared system for passengers who are hard of hearing proved to have a good potential. All information provided over the PA system was much better perceived and understood. Some interference was experienced, possibly because a regular TV monitor positioned close to the infrared transmitter panel may have affected transmission. Safety implications for those wearing a neck loop receiver should be reviewed.

Descriptive audio tape
The results from participants who are blind were mixed. They felt that the descriptive audio tape has potential, but requires major improvements, especially for travellers who are blind and are unfamiliar with oxygen masks, life vests, and aircraft layout and who have had no prior hands-on demo. The tape should have more descriptive information about features, e.g., where the oxygen masks fall, what size they are, and how they feel.

Open captioning
The subjective and performance results from the participants who are deaf clearly indicate that open captioning greatly improves the amount of information received by this group. After the safety demo, participants were able to answer simple questions about safety procedures which they received with the help of the open captioning, whereas they were unable to do so without the technology.

The participants who are cognitively impaired felt that the open captioning was a positive feature and, although it did not necessarily assist them, it could be an asset to other travellers with cognitive impairments who have more difficulty understanding verbal or audio instructions.

Observers who were not disabled suggested that open captioning may benefit all passengers in an aircraft, especially when the audio quality of the PA system has deteriorated or the environmental noise level is high. Open captioning can also be presented in several languages and could address passengers' difficulties.

Text-to-speech laptop computer
The results indicated the advantages and limits of the technology as an individual communication device. It is definitely a good communication tool for those with good typing skills but not for the less skilled. No persons who are only speech impaired were available for the test and the results may have been influenced by the fact that both persons who were speech impaired were also deaf, which slowed down the communication process.

Conclusions and Recommendations

While this was an exploratory study with only a small sample of test subjects, it demonstrated the value of selected technologies by testing them with different user groups performing specific tasks in a realistic environment.

For persons who are blind, a descriptive audio tape can enhance, not replace, personal briefing. Further testing is required before implementation is possible. When individual pre-briefing is provided, descriptive audio tape, descriptive video, Braille and tactile cards can be valuable supplements. For visually impaired or blind travellers with portable tape players, implementation of descriptive audio tapes would not be a major problem.

Infrared transmission systems in the aircraft cabin and washrooms could be a valuable communication tool for persons who are hard of hearing. These systems must be tested for possible interference with the aircraft's navigational equipment, in accordance with Transport Canada regulations. Safety implications for weight and storage of personal receivers in emergency situations should also be reviewed.

Open captioned video on monitors could be used on board aircraft for safety briefings for passengers who are deaf. Open captioning should be further tested for legibility, e.g., letter size and type and placement of the message on the screen. This technology may also be useful to those with cognitive impairments.

For passengers with speech impairments, a text-to-speech laptop computer is not yet recommended. Further testing with flight attendant participation would be required.

This study did not address the needs of persons with multiple disabilities, such as travellers who are deaf and blind. Tests related to their in-service, safety, and emergency information requirements should be carried out. In addition, the needs of elderly and senior persons were not specifically addressed. The use of descriptive audio tapes for safety briefings was suggested for them. Although most seniors do not carry a portable tape player, tests should be carried out with seniors and elderly persons on the usefulness and usability of descriptive audio tapes. Open captioning and infrared transmission may also be useful for safety briefings.

Regulations require that passengers with sensory impairments receive individual safety briefings. Persons with invisible disabilities must identify themselves and make their needs known.

Current individual briefing practices were not addressed in this study. It is recognized that personal briefing cannot be replaced by technologies and therefore it is highly recommended that research and testing be carried out in this area. This would include such issues as personnel sensitization and training as well as the content and clarity of the briefing information.

The cost-effectiveness of technologies is important for both the passenger and the carrier. Comparisons of proposed technologies against existing solutions (e.g. pen and pencil, Braille cards, personal briefing, public address systems, and hand spell) should be carried out.

Reference

Turnbull, A., "Persons with Disabilities: Air Travel in Canada", Transportation Development Centre, 1996.

SOMMAIRE

Tous les passagers qui se trouvent à bord d'un avion doivent pouvoir saisir l'information transmise, qu'elle soit diffusée par le système d'annonces publiques ou par les écouteurs individuels, affichée sur un écran ou communiquée individuellement par un agent de bord. La sécurité exige que tous les passagers puissent saisir et comprendre les messages et suivre les directives données. L'information doit être transmise dans toutes les zones de la cabine, y compris dans les toilettes, de façon individuelle (p. ex., l'agent de bord qui s'adresse à un passager) ou collective (p. ex., l'agent de bord ou le commandant qui s'adresse à tous les passagers).

Les techniques d'information et de communication en vol ne répondent pas toujours aux besoins des voyageurs ayant une incapacité cognitive ou sensorielle et des voyageurs âgés; il arrive donc que ces catégories de passagers ne soient pas au fait des consignes de sécurité, du service en vol, des procédures en cas d'urgence et des divertissements offerts à bord.

Une étude menée pour le compte du Centre de développement des transports de Transports Canada évalue à 756 000 le nombre de Canadiens ayant une incapacité auditive ou visuelle, un trouble de la parole ou une déficience cognitive. Parmi les clients des transporteurs aériens, quelque 308 000 ont une incapacité auditive, 56 000 sont atteints d'un trouble de la parole, 210 000 sont malvoyants et 182 000 sont atteints d'une déficience cognitive (Turnbull, 1996).

L'objectif global de Transports Canada est de rendre l'information diffusée à bord des avions accessible aux voyageurs qui ont une incapacité cognitive ou sensorielle. La présente étude avait pour objectif de recueillir des données sur les systèmes d'information et de communication en vol, d'examiner les contraintes à prendre en compte, d'élaborer des critères d'évaluation, de mettre à l'essai et d'évaluer les technologies d'information dans une cabine d'avion, d'analyser les résultats et de formuler des recommandations.

La mise en oeuvre d'une technologie ne vise pas à remplacer les breffages individuels pré-embarquement assurés par le personnel de bord, mais à rendre plus détaillée, plus claire et plus uniforme l'information donnée.

Voici les dispositifs retenus et les groupes cibles visés :

- un système de transmission par rayonnement infrarouge, pour les voyageurs malentendants;
- une bande audio descriptive, pour les passagers aveugles ou malvoyants;
- des écrans vidéo avec sous-titrage non codé, pour les voyageurs sourds ou ayant une déficience cognitive;
- un synthétiseur texte-parole portable, pour les passagers atteints d'un trouble de la parole.

Appareil de sonorisation à rayonnement infrarouge
Le système à rayonnement infrarouge destiné aux voyageurs malentendants a montré un potentiel intéressant. Toute l'information diffusée par le système de sonorisation normal était beaucoup mieux perçue et comprise. Certaines perturbations électromagnétiques ont été notées, qui pourraient avoir été causées par la présence d'un écran de télévision standard à proximité de la source des signaux infrarouges. Il y aurait lieu d'évaluer les incidences de ce système sur la sécurité des passagers munis d'un récepteur au cou.

Bande audio descriptive
Les participants non voyants qui ont écouté la bande ont eu des réactions mitigées. Selon eux, la bande vidéo a du potentiel, mais des améliorations majeures s'imposent pour qu'elle puisse répondre aux besoins des voyageurs aveugles qui n'ont pas de connaissance précise des masques à oxygène, des gilets de sauvetage, du plan de l'avion, et qui n'ont jamais vu de démonstration de sécurité. La bande devrait être plus détaillée sur certains aspects, p. ex. : où, exactement, le masque à oxygène tombera-t-il? de quelle taille est-il? comment est-il au toucher?

Sous-titrage non codé
Les observations subjectives et les cotes de performance colligées auprès des participants sourds sont claires : le sous-titrage accroît considérablement la quantité d'information reçue. Après la présentation des consignes de sécurité et la démonstration des procédures d'urgence avec sous-titrage, les participants ont été en mesure de répondre à des questions simples portant sur l'information sous-titrée, ce qu'ils n'ont pu faire dans le cas de l'information non sous-titrée.

Les participants atteints d'une déficience cognitive ont réagi positivement au sous-titrage. Même si elle ne les aide pas toujours, elle pourrait être un atout pour d'autres voyageurs qui ont des difficultés à comprendre des instructions verbales ou des signaux auditifs.

Des observateurs non handicapés ont fait remarquer que le sous-titrage peut être utile à tous les passagers d'un avion, en particulier lorsque la qualité de la transmission audio laisse à désirer ou que le niveau de bruit ambiant est élevé. Le sous-titrage peut également être présenté en plusieurs langues, au profit des passagers peu à l'aise avec l'anglais ou le français.

Synthétiseur texte-parole portable
L'étude a mis en relief les avantages et les limites de cette technologie à titre d'aide technique individuelle. Il s'agit sans contredit d'un outil efficace pour les personnes qui maîtrisent bien un clavier, mais non pour les autres. De plus, les résultats peuvent avoir été influencés par le fait que les deux participants présentaient un trouble de la parole, mais étaient également sourds, ce qui ralentissait la communication.

Conclusions et recommandations

Malgré le caractère exploratoire de la présente étude et le petit nombre de sujets qui y ont participé, elle a permis d'établir la valeur des technologies considérées, en les mettant à l'essai dans un environnement réaliste, avec différents groupes d'utilisateurs chargés d'exécuter des tâches précises.

Pour les personnes aveugles et malvoyantes, une bande audio descriptive peut améliorer l'efficacité du breffage individuel, mais non le remplacer. D'autres essais devront être menés avant que l'on puisse passer à l'étape de la mise en oeuvre. La bande audio ou vidéo descriptive et les cartons en braille et en caractères tactiles peuvent servir de précieux compléments aux personnes handicapées qui ont reçu un breffage pré-embarquement. Pour les personnes aveugles ou malvoyantes munies d'un baladeur, la mise en service de bandes audio descriptives ne devrait pas poser de difficulté.

Les systèmes de communication par rayonnement infrarouge qui diffusent dans la cabine de l'avion et dans les toilettes peuvent constituer un outil de communication intéressant pour les personnes dures d'oreille. Des essais s'imposent pour écarter tout risque de perturbations électromagnétiques pouvant nuire aux instruments d'avionique, comme l'exige la réglementation de Transports Canada. Il convient en outre de revoir les incidences sur la sécurité de la masse que représentent les récepteurs individuels et leur rangement, lorsque survient une situation d'urgence.

Pour les passagers sourds et malentendants, la présentation des consignes de sécurité devrait être appuyée par la projection sur écran de bandes vidéo avec sous-titrage non codé. Il y a lieu toutefois de mener des essais supplémentaires de la technique de sous-titrage, afin d'en vérifier la lisibilité, c.-à-d. la taille et l'emplacement des caractères sur l'écran. Cette technologie peut aussi s'avérer utile aux personnes atteintes d'un handicap cognitif.

Pour les passagers ayant un trouble de la parole, il n'y a pas lieu, présentement, de recommander l'utilisation d'un synthétiseur texte-parole portable. D'autres essais devraient être menés avec le personnel de bord.

Cette étude n'a pas abordé la question des personnes multihandicapées, par exemple des personnes qui sont à la fois sourdes et aveugles. Des essais s'imposent pour mieux cerner leurs besoins d'information touchant le service de bord, les consignes de sécurité et les procédures en cas d'urgence. Les besoins des personnes âgées n'ont pas, non plus, été expressément examinés. Certains ont suggéré de mettre à leur disposition des bandes audio descriptives en complément des démonstrations de sécurité. Peu de personnes âgées portent un baladeur, mais des essais devraient tout de même être menés pour déterminer l'utilité et la commodité de cette technique pour elles. Il pourrait également être utile de compléter les présentations de sécurité d'un sous-titrage non codé et d'une transmission par rayonnement infrarouge, à l'intention des personnes âgées.

La réglementation exige que les consignes de sécurité soient communiquées individuellement aux passagers ayant une incapacité sensorielle. D'où l'importance pour les personnes dont le handicap n'est pas visible de s'identifier et de faire connaître leurs besoins.

Les pratiques en vigueur concernant les breffages individuels n'ont pas été évaluées dans la présente étude. Tous reconnaissent qu'aucune technologie ne peut remplacer un breffage individuel. Il est donc fortement recommandé de mener des recherches sur ce sujet. On peut penser, par exemple, à des initiatives de sensibilisation et de formation du personnel, et des études visant à améliorer le contenu et la clarté de l'information transmise lors de ces breffages.

Le coût des technologies importe autant au passager qu'au transporteur. Il serait bon de comparer à cet égard les technologies proposées et les solutions existantes (p. ex., papier-crayon, cartes braille, breffage individuel, systèmes de sonorisation, langage des signes).

Référence

Turnbull, A., *Persons with Disabilities: Air Travel in Canada*, Centre de développement des transports, 1996.

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1 BACKGROUND

During a flight, all passengers must be able to receive information provided over the public address (PA) system, through headphones, on screen, or in person by a flight attendant. To ensure safety, all passengers must receive and comprehend messages and follow instructions. Information must reach those in cabin areas as well as in washrooms, on a one-to-one basis (e.g. between flight attendant and individual passenger), and on a one-to-many basis (e.g. from flight attendant/captain to all passengers).

Access to communication and information any time during flight is vital. Without effective communication, individuals will miss important clues in their environment as well as instructions in the case of emergencies.

According to research carried out for the Transportation Development Centre (TDC) of Transport Canada, an estimated 756,000 persons in Canada have hearing, sight, speech, or cognitive disabilities. Approximately 308,000 air travellers have hearing impairments, 56,000 have speech impairments, 210,000 have visual impairments, and 182,000 have cognitive disorders (Turnbull, 1996).

In a study (Arnold et al.,1993) conducted for TDC, several recommendations were presented.

- PA announcements should conform with human factors principles;
- safety demonstrations should be improved;
- aircraft information systems should be standardized;
- captioning should be provided on video screens; and
- real-time captioning should be provided.

2 PROBLEMS AND ISSUES

During a flight, all passengers must be able to receive information provided over the public address system, through armrest-headphones, on screen, or in person by a flight attendant. To ensure safety, all passengers must be able to receive and comprehend messages and follow instructions. Information must reach those in cabin areas as well as in washrooms, on a one-to-one and one-to-many basis (Geehan, 1996).

At present, passengers with hearing and cognitive impairments have difficulties receiving real-time or pre-recorded audio messages given over the PA and armrest-headphone system. Passengers with sight impairments are unable to receive visual messages on monitors although safety information transmitted via an aircraft monitor is accompanied by an audio description. Travellers who are speech impaired cannot converse/talk or speak with an agent, and travellers who are cognitively impaired cannot always follow the message pace or comprehend the content. These situations can create significant safety problems.

2.1 One-to-one communication

One-to-one communication refers to a dialogue between a flight attendant, or any other person, and an individual passenger.

For passengers with visual impairments, the individual safety briefing required by Transport Canada regulations consists of detailed information on, (and hands-on familiarisation with) equipment such as oxygen masks and life vests, as well as placement of service animals and storage of canes. It includes information about the number of rows to the closest exit and a tactile familiarization with the exit. Braille or tactile cards, tactile maps, and hand spell may be used to facilitate communication (Canadian Transportation Agency, 1996).

For passengers with hearing impairments, attendants are required to point out the emergency exits and alternative exits using the safety features card, and to demonstrate any other equipment that the person may be required to use (Canadian Transportation Agency, 1997). Pencil and paper or sign language may be used to facilitate communication.

For passengers with cognitive impairments, briefing by a flight attendant should include an explanation of the safety features card, as well as demonstration of the location of emergency exits and alternative exits, and of any equipment the person may be required to use. The message may need to be delivered at a slower than usual pace or repeated for better comprehension. Pencil and paper may also be used to facilitate communication.

Transport Canada regulations require that briefing on safety instructions be provided to the above groups, and to anyone who requests it. Short gate times, lack of self identification, and invisibility of disabilities mean that this is not always possible.

2.2 One-to-many communication

One-to-many communication refers to information provided by flight attendants and the captain to all passengers. Three systems are currently in use:

- Pre-recorded video is shown on monitors accompanied by voice received over speakers and via headphones. The display includes safety instructions, movies, and advertising. Without captioning, this system is not accessible to passengers with hearing impairments, who require a text display of the audio information. For passengers who are blind and visually impaired only the audio portion of the video can be heard.

- Pre-recorded voice track is transmitted over the public address system in aircraft with no video monitors. Safety instructions are demonstrated by flight attendants, along with a voice track. For passengers with hearing impairments, the voice mode is not entirely satisfactory. Passengers who are blind or visually impaired cannot see these demonstrations.

- Real-time voice information is provided by a flight attendant, flight officer, or the captain, and transmitted over the public address system. This can cover the following subjects: preparation for take-off and landing; customs information; weather conditions; flight path information; emergencies; and evacuation. Again, for passengers with hearing impairments, the voice mode is not entirely satisfactory.

3 OBJECTIVES AND SCOPE

3.1 Objectives

The overall objective of Transport Canada is to make aircraft information accessible for passengers with sensory and cognitive disabilities or limitations.

The specific objectives of this exploratory study were to:

- collect data with respect to on-board information and communication systems;
- review potential on-board constraints;
- develop assessment criteria;
- demonstrate and evaluate aircraft information technologies; and
- develop recommendations based on a synthesis of the results.

3.2 Scope

The study's scope was exploratory and limited to a small sample of test participants. No detailed costing was provided except for estimated figures.

4 TARGET GROUP OF AIR TRAVELLERS

The target group of interest for this project included individuals with sensory disabilities: persons with visual, auditory, cognitive, or speech impairments.

Hearing
Limited ability to hear what is being said in conversation with one other person, or two or more persons, even when wearing a hearing aid.

Visual
Limited ability to read ordinary newsprint or to see someone from four meters (12 feet), even when wearing glasses.

Cognitive
Limited because of a learning disability, emotional or psychiatric disability, or developmental delay.

Speech
Limited because of an inability to speak and be understood; functionally limited in communication with others.

4.1 Persons with hearing disabilities

4.1.1 Persons who are hard of hearing
A hearing impairment can mean any degree and type of auditory disorder. Hearing loss ranges from mild, where some speech sounds are difficult to hear, to profound, where speech or other sounds can only be heard with amplification. A hearing loss can occur in one or both ears. A hearing loss may be improved through the use of hearing aids. While hearing loss can be found in all age groups, the loss of hearing acuity is part of the natural ageing process. Some degree of hearing loss is found in approximately 50% of people over the age of 65.

Functional limitations

- reduced ability to hear high and/or low frequencies;
- reduced ability to differentiate between tones; and
- reduced ability to understand speech in noisy situations.

4.1.2 Persons who are deaf
Deafness means an extreme inability to hear. Deafness means that for all practical purposes these persons rely more on vision rather than hearing for processing information. A person is considered deaf when sound must reach at least 90 decibels (5 to 10 times louder than normal speech), and even when amplified speech cannot be heard. Typically persons who are deaf rely for communication on speech reading or text display. Sign language is the main language for

persons who are deaf. American Sign Language (ASL) is used by most North Americans, except for Quebec, where Quebec Sign Language (Langage des signes québecois, or LSQ) is used.

Functional limitations

- inability to hear other person in a conversation;
- inability to carry out conversation over regular public phone;
- inability to hear auditory emergency messages; and
- inability to hear sounds.

4.2 Persons with visual disabilities

According to the Health and Activity Limitation Survey (HALS, 1990), persons with visual disabilities account for 18.2 percent of all Canadians with disabilities. Of these, about 10.2 percent are legally blind, defined as either: less than 10 percent (20/200-20 feet/200 feet; 6/60-6 m/60 m) vision after correction in the best eye; or vision limited to a field of 20 degrees or less.

Blind and visually impaired people experience different degrees of vision loss as a result of their particular impairment and, therefore have widely different needs. People who are born blind (congenital) need to learn concepts that would otherwise have been acquired through sight. People who have become blind or visually impaired through an accident or disease (adventitious) often have visual memory, but they need to master a new set of coping strategies to deal with the world safely and effectively in a non-visual way.

Differences between people with visual impairments also exist in terms of the way they see. Some can distinguish only the difference between light and darkness; others see as if through mist. Still others have only peripheral sight while others have pinhole sight. A significant number of blind and visually impaired persons also have additional limiting disabilities.

The vast majority of blind people who need assistive devices for mobility, use canes that are specifically designed for them and are designed for use with certain techniques. Far fewer individuals use service animals. Less than 10 percent of blind persons can read Braille, a system using raised dots representing letters read by passing a fingertip over them.

Functional limitations - visual impairments

Persons with visual impairments or those who are blind can have difficulties or inability with the following functions:

- interpreting visual static signage: printed text and or/pictograms, and displays: electronic display, computer terminals and kiosks, and visual emergency warning signals;
- using controls or devises where vision and/or hand-eye co-ordination is required: mouse on computer terminals, controls on kiosks, controls on phones;
- reading printed non-tactile material;
- perceiving colour-coded signage; and
- interpreting a three-dimensional product unknown to person, e.g. life vest, oxygen mask.

4.3 Persons with cognitive disabilities

Cognitive problems are complex and can vary widely. They are often invisible and have no distinctive characteristics or appearances. Cognitive disabilities can be categorized as: learning related, memory related, perception related, and conception related and can include mental illness. Cognitive disability may also include psychological, emotional, and communication disorders.

Functional limitations

- problems perceiving and/or discriminating particular situations;
- difficulties recognizing and remembering persons, places, and events;
- increased difficulty in differentiating messages;
- slower pace perceiving and conveying information; and
- reduced memory for complex information.

4.4 Persons with speech disabilities

Persons with speech disabilities are defined by HALS as those persons who have difficulties speaking and being understood by others in a conversation.

Functional limitations

The primary functional limitation is conveying spoken message(s) to conversation partner(s) in an understandable format.

5 SELECTION OF TECHNOLOGIES

The criteria for the selection of technologies included:

- usefulness and usability by the passenger;
- feasibility of implementation in an aircraft; and
- availability of the equipment for testing.

5.1 Technology for persons who are hard of hearing

A person who is hard-of-hearing can receive messages with improved fidelity through sound reinforcement or through technologies that can bypass the acoustical space between the sound source and the listener (Access Disability Awareness, 1997).

Technologies designed to improve fidelity are known as assistive listening devices (ALDs). They include infrared systems, FM radio systems, and audio induction loops. For in-cabin application, an infrared system was chosen. An infrared system typically comprises a transmitter and a receiver. The source sound is invisibly carried by infrared light through the environment to the person’s receiver. It can be heard via a neck loop and a hearing aid, headphone, or earphone.

Figure 1 Participant who is hard of hearing using infrared system

5.2 Technology for persons who are deaf

Persons who are deaf cannot hear sound at all. They typically depend on lip reading, written communication, or sign language. Other technologies available include paper and pencil, electronic readerboards, and personal communicators.

In an aircraft cabin, announcements are usually made in audio or a combination of audio and visual mode. Some modern aircraft are equipped with monitors that show safety videos, as well as providing entertainment and other information. The safety demonstration is one of the most important information sources for all passengers. When provided in both the audio mode and captioned text, it is most likely to meet the needs of persons with hearing impairments.

Open captioning of the safety video was chosen for the test scenario. The message was displayed at the lower part of the screen and was visible at all times. This technology could be easily applied and could also benefit other passengers as well, especially when the quality of the aircraft's public address system is inadequate. It can also be shown in different languages. The only proviso would be not to obstruct the visual portion of the screen with too many text messages.

Figure 2 Open captions shown on safety video

5.3 Technology for persons who are blind or visually impaired

A person who is blind relies on touch, smell, vibration, and audio messages to compensate for the loss of visual information. Technologies for persons who are blind include Braille and tactile cards and maps, descriptive video, descriptive audio tapes, and vibrating pagers.

At the suggestion of the Canadian National Institute for the Blind (CNIB) representative, a descriptive audio tape was chosen to provide safety information for passengers who are blind. Supplied by the CNIB for the tests, the tape describes in greater detail the key features shown in the safety video, emphasizing how these components feel, their size, material, location, etc. Inexperienced travellers often know little about oxygen masks, life vests, and washroom and exit locations. The audio tape was provided to each subject with a portable tape player and a headphone.

Figure 3 Participant who is blind using a portable tape player with audio tape

5.4 Technology for persons who are cognitively impaired

Cognitive impairments vary greatly, ranging from learning disabilities, reading dyslexia, and short memory and attention spans, to anxiety and slow communication. Several technologies are available that may meet their requirements e.g., paper and pencil, printed pages, audio visual displays, portable communicators, or audio tapes. No single technology can satisfy all needs. Open captioning on screen was chosen as one method of reinforcing the audio message given in the safety video.

5.5 Technology for persons who are speech impaired

Persons who are speech impaired can read and hear, but cannot speak. Although speech impairment is not considered a sensory impairment, it results in communication difficulties for those affected, who often have hearing impairment as well. Therefore, it was decided that this group should be included in the test.

Technologies applicable in the in-cabin environment for this group include personal communicators, paper and pencil, printed media, and laptop text-to-speech computers. A laptop computer capable of converting text to speech was chosen for the tests because of its portability and performance. The user types in a text message, which is displayed on a small screen, with voice output from a built-in speaker. The voice output can be chosen from the voices of a male, a female, a child, a young person, or an older person. The message can be repeated and the volume can be controlled. Like any other computer equipment, it cannot be used during take-off, landing, turbulence, during an emergency or when directed by flight crew members.

Figure 4 Participant who is speech impaired using the text-to-speech portable unit

6 TEST METHODOLOGY

The tests were carried out in a Canadian Airline's cabin simulator, in a hangar at Vancouver International Airport.

The methodology was divided in two parts: the human factor trials and the technical evaluation of the technologies.

In the human factor trials, each group of subjects performed two trials: one without the technology (no technology trial), and one with the technology specific to their disability (technology trial). To randomize the effect of the tests, the first group of subjects completed the "no technology trials" first, and the second group completed the "technology trials" first. After the trials, the subjects completed a written questionnaire and were interviewed by the researchers, to determine their reactions. Ten subjects, each of whom was hard-of-hearing, deaf, blind, or cognitively impaired, took part in the trials. Two subjects with no sensory disabilities were also included.

The technical evaluation of the technologies was undertaken by the researchers and a specialist in aircraft avionics. It was based on the following criteria: interference with on-board electronic systems; power requirements; applicability in the aircraft cabin and in the washrooms; on-board storage requirements; technical and operational constraints; and estimated cost for the carrier and the passenger.

For the test set-up, the light emitting panel of the infrared system was mounted on a tripod at the door to the flight deck in front of the aircraft, at a height of about 7 feet (2.13 m), with the diodes directed towards the cabin; the safety demonstration video was displayed on a regular 19 inch (48.2 cm) TV monitor positioned at the front of the aircraft, at a height of about 5 ft (1.52 m), facing the passenger cabin; researchers provided the portable laptop computer; the audio tape was placed in a portable tape player with a headset and given to the subjects.

The researcher who administered the tests posed as a flight attendant, delivering in-service information and emergency instructions. The standard briefing on safety instructions required by law was intentionally omitted, to create a "worst case" scenario.

6.1 Human factors trials

The purpose of the trials was to test human factors aspects of specific information and communication technologies with a target group of subjects, in a realistic environment, to determine the suitability of the technology in meeting the needs of travellers with sensory disabilities onboard aircraft. The tests were carried out in a simulator of Canadian Airlines International in Vancouver Airport.

6.1.1 Technologies and Equipment

Four different assistive technologies were tested during the trials: open captioning of the in-flight safety video, the infrared transmission system, a descriptive audio tape of the in-flight safety video, and the text-to-speech communication system. Table 1 describes the way the technologies were presented and their intended users.

Table 1 Technologies used in trials

Technology	Intended user	Information	Comments
Open captioning	Deaf	The in-flight safety video was open captioned	The captioning provided a written version of the sound track
Infrared transmission	Hard of hearing	All announcements made over the public address system as well as information on the in-flight safety video	Participants were fitted with the appropriate receiving device
Descriptive audio tape	Blind and visually impaired	Information from the in-flight safety video was transcribed into a descriptive audio tape by the CNIB	Participants were given a portable tape player
Text-to-speech laptop	Speech impaired	One to one communication between traveller and “flight attendant”	This technology was not incorporated into the scenarios and was tested after the trials

The cabin simulator was in all of the trials. Announcements were made using the public address system. Call button lights and bells, "fasten your seat belt" signs and bells, cabin lighting, and the "flight attendant call buttons" were all operable by the researchers from a concealed booth with one-way mirror at the front of the cabin. Life vests were placed under the passenger seats prior to the trials, and oxygen masks could be remotely released from overhead panels by the researcher. Aircraft noise and simulated sounds of emergency scenarios were played over the in-cabin speaker system.

Figure 5 Participants at Canadian Airlines' simulator in Vancouver

The infrared transmission system was installed in the cabin simulator. Subjects who are hard of hearing were provided with the accompanying neck loop prior to the trials. A portable audio tape player containing the descriptive audio tape was placed on the seat to be occupied by the traveller who is blind after a briefing. A VCR and monitor were placed at the front of the cabin in view of all passengers. Two safety demonstration videos were shown, one with open captioning and one without. A safety card was provided in the seat backs in front of each passenger. Selected seat backs were pushed down after passengers were seated in order to improve sight lines for analysis.

<u>6.1.2 Participants</u>

Ten participants took part in the trials. Persons who were deaf and speech-impaired were represented by two participants who were deaf, the other three groups of interest were represented by two participants each. The participants who were blind were legally blind. In addition, two participants represented able-bodied travellers. Table 2 provides a description of the participants. The criteria for participation included:

- little travel experience (less than three trips by aircraft in the last two years);
- between 18 and 60 years of age;
- moderate to severe degree of disability, with no multiple disabilities; and
- no mobility impairment.

Table 2 Trial participants

Disability	Gender	Age	Travel experience
Blind	F	40-50	About once per year with companion
Blind	F	20-30	Twice before with companion
Deaf	M	20-30	About once per year
Deaf	M	20-30	Less than once per year
Hard of hearing	M	30-40	Less than once per year
Hard of hearing	M	50-60	Frequent flyer*
Cognitive	F	50-60	Less than once per year
Cognitive	M	20-30	Three times before
Able-bodied	F	30-40	About twice per year
Able-bodied	F	30-40	About twice per year

* This participant was part of the research team. He took the place of the scheduled participant who was unable to attend.

Participants were recruited through the CNIB, the Canadian Council for the Blind (CCB), the Western Institute for the Deaf and Hard of Hearing (WIDHH), and the Adults with Learning Disabilities Association (ALDA). None of the participants had taken part in similar trials. All participants received a nominal remuneration following the trials. Interpreters were provided for participant who were deaf.

Figure 6 Participants during trial in simulator

6.1.3 Procedure

Upon arrival at the simulator, participants were greeted, informed of the purpose and procedure for the trials, and asked to sign an informed consent. Before each trial participants were briefed regarding the operation of the specific technology being tested.

A between-trials study design was used to evaluate the technologies. The ten subjects were tested in two groups consisting of a representative from each disability group, as well as one participant who is able-bodied to act as a "control" for comparison of results. The first group had six participants (two participants who were deaf) since interpreters for participants who were deaf were only available for the first trials.

Each group of subjects performed two trials: one without any assistive technology ("no technology trial"), and one with the technology specific to their disability ("technology trial"). To balance the effect of order of trials, the first group of subjects completed the "no technology trials" first, and the second group completed the "technology trial" first.

Specific scenarios were designed to assess the type and amount of information perceived for general requirements, such as gate changes and emergency situations. The intent was not to provide an exact scenario, but to test the ability of passengers to perceive and retain critical information. There was no flight attendant during the simulations to provide information over and above that provided in the safety videos or tape and public address announcements. There was also no "pre-boarding briefing", which is required by law. The reason that these were not included is that the researchers wanted to force out the design deficiencies of the technology in a "worst case" scenario to ensure that the technology would be appropriate and useful.

Prior to the trials, the simulator was prepared by ensuring that the correct video tape was played, the technologies were operating, and the public address system, call buttons, lights, life vests, and oxygen masks were functioning.

The subjects were taken into the simulator and asked to sit in their pre-assigned seats. Once seated, the safety video was played. After the safety video was completed, an announcement was made over the public address system asking specific passengers to identify themselves. Note was made of whether the passenger responded or not. Following the safety video, a questionnaire was administered to assess the amount of information perceived by the passengers.

A specific scenario was then followed depending on whether the trial was the "no technology trial" or the "technology trial". During the "no technology trial", a decompression emergency was simulated. A tape was played of decompression noise, followed by an announcement asking passengers to return to their seats. Oxygen masks were released from the overhead compartment and passengers were told to put them on. Note was made as to whether this was completed. Passengers were then informed that the masks could be removed. The scenario continued with a safe landing. After landing, the participants were told that the exit doors were blocked and were asked over the public address system to move to the forward exit. Once all the passengers had completed this task, they were told that the trial was over. Following the trial, a questionnaire was administered to gather information about the amount and quality of information that was perceived during the trial.

During the "technology trial", a water landing was simulated. After an uneventful flight, passengers were asked to prepare for a standard landing. During the landing, a tape with the sound of a failed engine was played and passengers were told (over the public address system) that the aircraft had landed on water. They were told to put on their life vests and to evacuate through the forward exit. Once all the participants had moved to the exit they were told that the trial was over. Following the trial, another questionnaire was administered to gather information about the amount, and type of information that was perceived during the trial.

Following both trials the subjects were asked to fill out a final questionnaire and were interviewed about their opinions of the two trials. The total time for both trials and the subsequent interview was about 2 to 2.5 hours.

The text-to-speech technology was tested using the participants who were deaf/speech impaired following both trials. They were briefed in operating procedures by the researchers and then asked to communicate to the researcher, via laptop specified, questions regarding a delayed flight, possibilities for hotel accommodation and ground transport and times for new flights. The researchers made notes of difficulties and informally questioned the two participants about the technology.

6.1.4 Measures used in the evaluation

Performance measures and subjective measures were taken during the trials.

Performance Measures

The trials were videotaped from two angles, so that the performance of each participant could be viewed and later analysed. Performance of several tasks was recorded to determine whether the participant perceived and understood the information provided. Performance was recorded as "yes" if performed correctly and timely, "no" if not performed at all or performed incorrectly, or "delayed" if the participant performed the task correctly, but took longer than expected. The following is a list of the tasks for which performance was recorded.

During "no technology trial" participants

- identified themselves to "flight attendant" when asked to do so;
- donned oxygen mask when asked to do so;
- removed oxygen mask when asked to do so; and
- moved to front exit.

During “technology trial” the participants

- identified themselves to “flight attendant” when asked to do so;
- located life vest;
- donned life vest correctly; and
- moved to front exit.

Subjective measures

Subjective measures were taken during and after the trials using self-administered questionnaires and interviews. A self-administered questionnaire was completed following the viewing (or listening to the descriptive audio tape) of the safety video during both the “no technology trial” and the “technology trial”. Participants had to answer specific questions which were referred to on the video and the responses were later marked as being correct or incorrect. Different questions were asked for each of the two trials. Participants were also asked to indicate the amount of information which they felt they received during the safety video.

Following each trial, participants were asked to fill out a “post-scenario” questionnaire which asked how easy or difficult it was for participants to perceive or understand that specific tasks were required, or how they should be carried out. A copy of the “post-scenario” questionnaire for both trials is provided in Appendix B.

After both trials, a final questionnaire asked participants to compare the amount of information they perceived and understood between the two trials. Specific questions were asked about the technology. An interview was also conducted by the researchers. Its purpose was to clarify responses on the questionnaires and to probe the reasoning behind the participant’s actions during the trials.

Results from the performance measures, questionnaires, and interviews were tabulated following the trials.

6.2 Technical Evaluation

A theoretical technical evaluation was carried out by Stewart Muirhead, a retired avionics engineer, formerly with Air Canada. Mr. Muirhead was provided with the project’s terms of reference and technical product information regarding the infrared transmission system, the portable audio player, and the laptop computer. He was asked to analyse two major aspects. One, which technical problems could these new technologies face in an aircraft environment, specifically with interference of present on-board electronic systems, and two, which are the problems of implementing new equipment. In addition, the possibility of a real-time speech to monitor display and key-in to monitor display systems was explored for emergency purposes. The following are excerpts from Mr. Muirhead’s evaluation.

Infrared transmission system
There is no technical reason why an infrared system could not be adapted to an aircraft environment. A string of light emitting diodes could be installed on the ceiling and in the washrooms. Problems could be encountered with the receiving system. Infrared diodes can be desensitized by other light sources (daylight or strong fluorescent or incandescent lighting). Infrared signals are of such short wavelength that there should be no possibility that the signals could interfere with existing aircraft systems. The Audex system uses a 95 KHz carrier, which is a low radio frequency. This represents a potential interference source. Tests would have to be conducted to ensure there was no interference from this signal. Aircraft electrical power is 115 Volt 400 cycle AC and 28 Volt DC. The Audex system uses 24 Volt DC to power the infrared emitter. Some kind of power converter would have to be developed to convert the aircraft power to 24 Volt DC. This is not a major problem, but tests would have to be conducted to demonstrate that the power converter would not interfere with aircraft systems.

Audio descriptive tape
Certain airlines already provide first and business class passengers with Sony Video Walkman units. It would not be impractical for an airline to store and hand out walkman type units.

Text-to-speech laptop computer
This product should not present any serious technical, operational, or regulatory problems if used on board an aircraft. Use of portable computers is restricted during take-off and landing. These restrictions would apply to this unit as well.

Emergency communication
According to Cabin Safety, Transport Canada, operators currently do not use monitors to convey information during an emergency for the following reasons. Monitors and electronic equipment are stowed and secured in a prepared emergency as one of the first steps to secure the cabin. Monitors installed in aircraft ceiling, when in the "in use" position, protrude into the aisle, reducing the amount of clearance between aisle and ceiling. These monitors are retracted when not in use, during take-off, landing, and turbulence to prevent occupants from injuring themselves. Should evacuation be required, monitors could cause head injuries. As each emergency situation is different and is influenced by unpredictable variables, it is not viable to convey emergency instructions on a monitor.

Several technical problems must also be considered. The input device would probably be a portable PC, a digital device. However, most passenger entertainment devices are based on analogue technology. Digital-to-analogue conversions would be involved. TV receivers and monitors have been used as computer displays. However, at present, flip-up monitors under the overhead bins will be stowed and secured in a prepared emergency situation.

As far as speech-to-text systems are concerned, there are speech recognition software programs, which convert the spoken word into text. They run on multimedia equipped PCs. These software programs are surprisingly low priced and apparently work well. The computer must be "trained" to recognize the speaker's voice characteristics to accurately display text. The "voice file" is customized to that voice pattern. Training could be simplified if a limited vocabulary were displayed.

7 FINDINGS AND RESULTS

7.1 Human factors test results

The following section provides the results of the test carried out by individuals representing the target groups.

7.1.1 Performance Measures

The performance measures were based on whether or not participants were able to carry out specific tasks based on the information provided. In Tables 3-12, the number of participants from each group able to perform the task is identified (yes), as well as those who did not meet the criteria (no), and those who were delayed in performing the task (delay).

Participants who are blind

Table 3: "No technology trial" performance results for passengers who are blind

	Self identify to flight attendant	Don oxygen mask	Remove oxygen mask	Move to exit
Yes	2	0	1	2
No	0	2	1	0
Delay	0	0	0	0

Table 4: "Technology trial" performance results for passengers who are blind

	Self identify to flight attendant	Locate life vest	Don life vest	Move to exit
Yes	2	0	0	2
No	0	0	2	0
Delay	0	2	0	0

Both participants who were blind were unable to don the oxygen masks in the "no technology" trial. For one participant, the masks fell too far in front of her. Since she couldn't feel the masks, she was unable to tell where they were. The other participant expected one mask to be there, not three, and was unable to determine what to do.

The use of the descriptive audio service did not help the participants in locating or donning the life vest during the "technology trial". Neither of the participants who were blind was able to complete these tasks successfully.

Participants who are deaf

Table 5: "No Technology trial" performance results for passengers who are deaf

	Self identify to flight attendant	Don oxygen mask	Remove oxygen mask	Move to exit
Yes	0	2	0	0
No	2	0	0	0
Delay	0	0	2	2

Table 6: "Technology trial" performance results for passengers who are deaf

	Self identify to flight attendant	Locate life vest	Don life vest	Move to exit
Yes	0	0	0	0
No	2	1	0	0
Delay	0	1	2	2

As expected, the participants who were deaf were unable to respond to a request for identification in either trial. During both trials, they relied on watching other passengers for cues about when to remove oxygen masks and move to exit doors, and as result, were delayed in completing these tasks. During the "technology trial" both passengers who were deaf had difficulty locating and donning the life vests. The open captioning technology did not help.

Participants who are hard of hearing

Table 7: "No technology trial" performance results for passengers who are hearing-impaired

	Self identify to flight attendant	Don oxygen mask	Remove oxygen mask	Move to exit
Yes	1	2	2	2
No	1*	0	0	0
Delay	0	0	0	0

* This participant was part of the research team

Table 8: “Technology trial” performance results for passengers who are hearing-impaired

	Self identify to flight attendant	Locate life vest	Don life vest	Move to exit
Yes	2	2	2	2
No	0	0	0	0
Delay	0	0	0	0

The participants who were hard of hearing had difficulties with some of the announcements over the PA system. Without technology, one participant, a member of the research team, was unable to perceive a request for identification, or determine that a gate change was required. By using the infrared transmission technology however, both participants were able to perform these tasks successfully. Neither participant had difficulties with any of the other tasks in either of the trials.

Participants who are cognitively-impaired

Table 9: “No technology trial” performance results for passengers who are cognitively-impaired

	Self identify to flight attendant	Don oxygen mask	Remove oxygen mask	Move to exit
Yes	2	1	2	2
No	0	0	0	0
Delay	0	1	0	0

Table 10: “Technology Trial” performance results for passengers who are cognitively-impaired

	Self identify to flight attendant	Locate life vest	Don life vest	Move to exit
Yes	2	2	0	2
No	0	0	1	0
Delay	0	0	1	0

The group who was cognitively-impaired did not have difficulties perceiving information in either of the trials; however, both had difficulties with tasks requiring more cognitive processing. One participant had difficulty donning the oxygen mask during the “no technology trial” and the other participant was unable to correctly don the life vest on during the “technology trial”.

Participants who are able-bodied

Table 11: “No technology trial” performance results for passengers who are able-bodied

	Self identify to flight attendant	Don oxygen mask	Remove oxygen mask	Move to exit
Yes	2	2	2	2
No	0	0	0	0
Delay	0	0	0	0

Table 12: “Technology trial” performance results for passengers who are able-bodied

	Self identify to flight attendant	Locate life vest	Don life vest	Move to exit
Yes	2	2	2	2
No	0	0	0	0
Delay	0	0	0	0

The only group who met the performance criteria in both trials was the group who was able-bodied.

7.1.2 Subjective Measures

This section describes the human factors results of the individuals regarding the technology they had used.

Most participants felt that it was important to receive information during a flight. The mean response was 4.4 (1 - very unimportant, 5 - very important). Two participants (one who was blind and one who was cognitively impaired) responded that it was neither unimportant nor important; however, they indicated that it was important not to receive too much information, thereby preventing information overload.

Participants who are blind

The descriptive audio tape did not increase the amount of information participants who are blind felt they received from the safety demonstration. One participant found no difference in the amount of information she thought she received when using the audio descriptive service compared to the safety video (100% received for both). The other participant perceived a large decrease in information with the descriptive audio tape (70% to 40% received). This participant felt that it was “easy” to perceive information from the safety video, but “difficult” to perceive information from the descriptive audio service. The other participant felt that information from both the video tape and descriptive audio tape were “neither difficult nor easy” to perceive.

To measure the accuracy of information received from the safety video and descriptive audio tape, participants were asked to answer two questions in each trial. Participants responded incorrectly to three of four questions (pooled responses) when asked from the descriptive audio tape during the “technology trial”, whereas they responded incorrectly to only one of four questions from the “no technology trial”.

When asked to rate their perceived level of stress, both participants who are blind reported increased stress when using the descriptive audio tape (“very stressed”) than with the standard videotape (“neither stressed nor relaxed” and “stressed”).

Both participants who are blind thought it was “easy” or “very easy” to notice that the flight attendant called their name, to determine that a gate change was required, and to determine that an emergency evacuation was required from announcements over the PA system. They found it “very difficult” to determine where to find and put on the life vests and to put on the oxygen masks.

Participants who are deaf

The open captioning increased the amount of information that the participants who are deaf felt they received. During the “no technology trial” with the non-captioned safety video, they felt that 40% and 60% of the information was received. During the “technology trial” with the open captioning, 70% and 100% of the information was received. Both participants who were deaf reported that it was “very difficult” to perceive information from the non-captioned video, and it was “easy”, or “very easy” with open captioning.

Without the open captioning, both participants who were deaf were unable to answer one of the two questions asked correctly. With the open captioning, both participants were able to answer all of the questions correctly. Both participants who were deaf felt that the open captioning positively or very positively affected the amount of information they received.

They both reported feeling less stressed during the “no technology trial” (“relaxed”) than the “technology trial” (“stressed”) as a result of having information from the open captioning. They both felt it was easy to use and that the open captioning could be helpful onboard aircraft.

The participants who were deaf found it “very difficult” to perceive information provided over the public address system in either of the trials such as: noticing that the flight attendant called their name, determining that a gate change was required, and determining that an emergency evacuation was required.

They found it “very easy” to put on the oxygen masks and to locate the life vests. They found it “difficult” to determine that oxygen masks were required during the “no technology trial”, and to put on the life vests during the “technology trial”. They found it “very difficult” to communicate with the flight attendant in both trials.

Participants who are hard of hearing
Participants who are hard of hearing had the advantage of both the infrared transmission technology and the open captioning on the safety video. Both technologies were tested since the open captioning would potentially assist with safety and general information provided on the video, whereas the infrared technology would potentially assist with announcements during the flight. Both participants reported an increase in the amount of information they felt they received as a result of using these technologies (from 60% and 50% without technology to 100% and 80% with technology). Without the technology, participants who are hard of hearing answered one of four questions incorrectly (pooled responses). With the infrared transmission technology, all the responses were answered correctly.

Participants rated perceiving information from the safety video, (noticing that flight attendant called their name, determining that a gate change was required, and determining that an emergency evacuation was required) as being “very difficult “ or “difficult” without the infrared transmission technology and being “easy” or “very easy” with the technology. For one participant who was part of the research team there was also a similar improvement in determining where the nearest emergency exit was located. For the other participant, who was not part of the research team, this task was “very easy” with or without the technology.

Both participants reported a slight improvement in the ease of communicating with the flight attendant when using the infrared transmission system (from “neither difficult nor easy” to “easy”). One participant reported feeling less stressed as a result of using the infrared transmission technology.

Neither participant who is hard of hearing thought that determining that an oxygen mask was required or determining how to put it on were difficult. One participant felt it was “difficult” to locate the life vest and to put it on. The other participant found these tasks “easy”. Both felt the infrared transmission system “very positively” or “positively” affected the amount of information they received. They both felt it was very easy to use and that it could be helpful on board an aircraft.

Participants who are cognitively-impaired
The cognitively impaired group reported a slight drop in the amount of information received as a result of seeing the open captioning on the safety video. Participants reported they received 90% and 100% of the information without the technology and 70% and 90% with the technology. However, both participants answered all the questions correctly during both the “no technology” trials and the “technology trials”. When asked how the open captioning affected the amount of information they received, both responded “neither negatively, nor positively”.

Both participants who were cognitively impaired reported that all the tasks in both trials were either “easy” or “very easy”, except for determining how to put on the life vest, which was rated as “difficult”. The open captioning did not change their rating of ease of perceiving information from the safety video, or determining where the nearest emergency exit was located, compared to the non-captioned video. They both thought the open captioning was easy to use and could be helpful on board an aircraft, particularly to persons who are cognitively impaired and who have difficulty understanding verbal or audio instructions.

Participants who are able-bodied

The able-bodied group felt that they received all the information in both trials. Both participants rated all the tasks in the “no technology trial” (open captioning presentation) as being “easy” or “very easy”, except one participant who rated determining that an emergency evacuation was required as “neither difficult nor easy”. All tasks in the “technology trial” were rated as “easy” or very easy” by both participants, except for one participant, who rated finding the life vest and putting it on as “very difficult”.

Both participants answered all the questions correctly during both trials. One participant said that the open captioning positively affected the amount of information received; the other participant responded “neither negatively, nor positively”. Nevertheless, both participants felt that the open captioning could be helpful to other able-bodied passengers on board all aircraft that are equipped with monitors.

Discussion

The human factors results indicate that the technologies all have the potential to improve communication on board an aircraft. However, the study did not find that all of the technologies provided for the specific group of participants improved the participant’s ability to perceive and understand information to the same degree. The results clearly indicate specific concerns with some technologies, which need to be addressed before they can be useful on board aircraft.

The results should not be interpreted as reflecting what might happen in a real emergency situation. Readers must remember that in the scenarios there were no flight attendants, nor was a “pre-boarding briefing” provided. Rather, the intent was to test the ability of passengers to receive and retain certain critical information in the worst case scenario, and to measure, using performance criteria and subjective assessment, how well this was done without the specific technology compared to using the technology.

The results from the participants who were able-bodied provide a benchmark for comparison of the performance and responses from the other groups of interest. This group had no difficulty in perceiving information and carrying out the standard tasks measured. The one exceptional task was “determining how to put on the life vest”. Participants who are able-bodied found this task “very difficult”, even though they were able to don the life vest correctly. In reviewing the results from all the participants in the study, it is clear that participants did not necessarily have difficulty with this task because of lack of information, but rather as a result of inherent design problems. Regardless of the amount and quality of information provided about how to use the life vest, participants would have had difficulty donning the life vest in an appropriate time frame. Poor performance in this task, therefore, cannot be considered a result of lack of information, which can be improved with the provision of assistive technology. Performance and subjective assessment from all the other tasks measured in the study, however, provide a good measure of the amount of information perceived.

7.1.3 Technology interface results

Descriptive audio tape

The results from participants who are blind regarding the descriptive audio tape technology are mixed. Despite poor performance results and subjective responses indicating dissatisfaction with the technology, participants who are blind thought that the technology could be helpful on board aircraft. This indicates a serious need for increased information about safety procedures for this group of travellers.

Participants who are blind felt that the descriptive audio tape had potential, but major improvements to the content should be made. The descriptive audio tape used during the trials did not provide adequate information about safety features onboard, particularly the configuration of the oxygen masks, or procedures to follow should the mask not descend directly in front of the passenger. More detailed description of these devices is required.

Study results clearly showed that comprehension and retention of information from the descriptive audio tape were poor, since participants were unable to answer basic questions from the tape. Participants felt that this was because too much superfluous information was provided. If this technology were to be used it should provide more detailed information about features (e.g. safety devices). Information about features which are inaccessible to travellers who are totally blind, such as flashing lights to indicate exits, are nevertheless important to the large percentage of visually impaired travellers.

Some of the negative results regarding the audio descriptive tape can be accounted for by the way the technology was presented in the study. Participants were only allowed to listen to the audio tape once (as they would the audio track on the safety video), and they had to listen to the tape at the same time that the safety video was being played. If this technology were used on board aircraft, the traveller should have the ability to rewind and play sections of the audio tape at their own pace, and should be able to hear the audio track of the safety video as well as the information on the safety video. The technology was tested in the “worst case scenario” (one-time use) in the study to reveal needed improvements in design features.

It was clear that if this technology were ever to be used on board aircraft, it should not replace a hands-on demonstration of the safety features. This was particularly true for the use of life vests. The participants who are blind had insurmountable difficulties figuring out how the life vest was to be put on. The trials reinforced the understanding that the ability to feel the safety devices and to walk through the configuration of the aircraft can not be replaced by any technology.

Figure 7   Participant who is blind trying to use life vest

Open captioning

Both participants who are deaf performed the “no technology trial” before the “technology trial” because of the availability of interpreters. Hence, the results from the trials may be influenced by some learning between the first and second trials. A review of the results indicates that seeing the video for a second time was a much smaller factor than the ability to verify what was being said in the safety video via the open captioning.

The subjective and performance results from the participants who are deaf clearly indicated that open captioning greatly improves the amount of information perceived by travellers who are deaf. They were able to answer simple questions about safety procedures with the help of open captioning, whereas they were unable to do so without the technology. They were less stressed during the “flight” and they felt that it made the flight easier.

Open captioning was limited to pre-recorded information from the safety video during the study. Participants who are deaf had difficulties in determining what was happening during the emergency scenarios and relied on visual contact with other passengers to carry out procedures. Their responses on the questionnaires and during the interviews indicated that they felt that real-time open captioning of information provided over the PA system would be ideal; however, there were questions about the practicalities in providing this service. In a real situation, participants who are deaf indicated that they would rely on communication with the flight attendant wherever possible.

Before the study, there was a question as to whether the open captioning technology would be beneficial to travellers who are cognitively-impaired, or whether it would be a hindrance. The results show that it was neither. Performance measures were unchanged between the trials and most subjective measures where unchanged. There was a slight drop in the amount of information participants felt they received from the safety video when there was open captioning (10 to 20%), however, this is likely an insignificant change given that all the other measures showed no differences.

Both participants who were cognitively-impaired considered the open captioning a positive feature, and although it didn't necessarily assist them, it would be an asset to other travellers who are cognitively-impaired with more difficulty understanding verbal instructions. The consensus was that the more forms (e.g. auditory, visual, tactile) in which the information could be provided, the better. It appears from the study results that the concern of interference from too many sources of information is minor for the traveller who is cognitively-impaired, compared to the advantage of having an alternative mode of receiving the information.

An unexpected result from the study was that the passengers who were able-bodied reported the open captioning improved their understanding of the information provided, and felt that all safety videos should include open captioning.

During the interviews, some recommendations regarding the design of the open captioning were made, including:

- The lettering should be larger and with high contrast;
- The writing should be in the centre of the screen, flush left;
- Different language options should be available;
- Information should be written at a level of English that is easier to understand; and
- If real-time open captioning could be provided, there should be displays in other parts of the aircraft such as washrooms.

Infrared transmission

The infrared transmission system was tested by two people with moderate to severe hearing loss. Due to one scheduled participant's inability to attend, a member of the research team with moderate hearing loss acted as a participant. Although this participant had more experience with the infrared transmission technology, the results from his trials can be considered valuable, particularly as they only confirm the results from the other participant who is hard of hearing.

Both the performance and subjective measures point to the infrared transmission technology as having good potential for improving the amount and quality of information perceived and understood by travellers who are hard of hearing.

All of the information provided over the public address system was much better perceived and understood when using the infrared transmission technology. During the interview, participants identified general concerns about public announcements, such as the need for repetition of announcements, clarity in pronunciation, and separation of double digit numbers such as “fifty-five” to “five”, “five”.

In general, the information provided during the safety video was better perceived using the infrared transmission technology; however, one participant who sat very close to the monitor, experienced significant signal interference which was very annoying. One participant recommended that the safety video be presented in a standard frequency with a consistent, moderate speech rate. Despite the interference, participants were able to answer all the questions about the safety video when using the infrared transmission system. They were unable to answer all of them without the technology.

Both participants thought the technology could be helpful on board aircraft, but expressed concerns about availability and instructions about its use without a briefing.

As was the case with all the other participants and the assistive technology they tested, the infrared transmission technology did not assist the passengers who were hard of hearing in putting on their life vests. Both participants reported difficulties. As stated earlier, this is due more to the design of the life vest than the instructions.

Text-to-speech laptop

The text-to-speech technology was tested with two participants who were deaf instead of those who were speech-impaired. People with a speech impairment, without any other accompanying disability which would not confound results (e.g. deafness, physical impairments, cognitive impairments), proved too difficult to find. People with speech impairments clearly have similar but different needs to those who are deaf (e.g. they can hear a response during a conversation). The results from the text-to-speech technology trial should therefore be considered preliminary.

The participants who were deaf were somewhat mixed in their response to the technology. For those who can type, and read and write English well, communication was very fast. It was much slower for the participant who could not. Both participants were unsure whether the technology was better than using pen and paper. In consideration of people who might not be able to type well (a significant portion of the population, particularly elderly), participants felt that pen and paper would let them perform the same task equally well. This response may partly be due to the inability of the participant who is deaf to make use of the synthesized speech feature on the technology. It is unclear whether the response would be different for strictly speech-impaired users.

Participants indicated that the technology might be difficult to use when the plane was “bumpy” and if the passenger was in the window seat. Despite these concerns, both participants felt that the technology could be helpful on board aircraft.

7.2 Technical evaluation results

7.2.1 Transport Canada regulations

Implementation of any equipment requires the certification by Transport Canada, Safety and Security.

There is a possibility that passengers who use or wear equipment, e.g. personal receivers, portable tape players, neck loops, may be asked to remove them if an emergency is anticipated. This is an issue to be reviewed.

7.2.2 Infrared system

Infrared transmission system could be adapted for implementation into the cabin and washrooms of an aircraft, pending test regarding carrier frequency interference and power conversion. Television monitors using cathode ray tubes can generate electromagnetic interference (EMI). The test seem to indicate that the TV monitor was interfering with the infrared receiver. Most likely the TV monitor was interfering with the infrared system 95 KHz carrier. A number of aircraft still use cathode ray type monitors. They likely have better EMI shielding than the one used in test. It is unlikely that flat screen monitors would interfere but the possibility cannot be ruled out. In addition, any equipment would require testing for interference with the aircraft’s navigational systems.

7.2.3 Descriptive audio tape

The use of a descriptive audio tape with a portable tape player and headphones does not present any technical problems. It can present an operational and logistics problem for the carrier to store and maintain the units. Another possibility is to play the audio information over a movie channel, for instance. But this may confuse other passengers listening to the same channel, and create another problem, and would not allow for rewinding and reviewing information. The controls for channel, volume, and agent call are often very small, located at different places on the armrest, depending on the aircraft type and might be difficult to detect and operate for blind and elderly persons.

7.2.4 Video captioning

Captioning on monitors does not present a technical problem. It is done at the time of the safety video production. Human factor aspects should be addressed: no scrolling of the text; the text to be in large letters; capitals and lower cases; not more than two lines on the lower part of the screen; and letters to be displayed on a separate background (e.g. white letters on dark background), not using the video's background. Detailed guidelines are provided in Appendix C.

7.2.5 Text-to-speech laptop computers

Portable palmtop computers do not present any other problem to the aircraft other than that they cannot be used during take-off, landing, turbulence, during an emergency and when directed not to be used by a crew member. Their volume output can be controlled and the voice type can be changed. A flight attendant may have some difficulty with the sounds coming from the small speaker due to high engine noise in some aircraft. It would help if cabin crew had prior knowledge of the device.

7.2.6 Real-time audio-to-text (not tested)

For emergencies and evacuations messages are provided over the PA system or in person by the agent and typically do not reach the person who is deaf. Could a flight attendant in such situation key in words that would be displayed on the monitors, or speak and have it displayed as text?

Technical problems would be significant. This could work if the various emergency messages are pre-recorded and stored and quickly selected by the agent to be shown on the monitor. Other difficulties in an emergency situation might include malfunctioning monitors or visibility problems due to smoke.

7.3 Summary of results

Table 13 sums up the results of the human factors (Criteria 1, 2, 3) and technical (Criteria 4, 5, 6, and 7) evaluations.

Table 13. Summary of human factors and technical evaluation of selected technologies

Criteria	Infrared transmission	Captioned video	Descriptive audio tape	Text-to-speech laptop
1. Effectiveness for passenger	high	high	med.	med.
2. Ease of use for passenger	high	high	high	med./low
3. Ease of use for flight attendant	NA	NA	high	med.
4. Ease of operation for carrier	med.	high	med.	med.
5. Feasibility of implementation in aircraft	med.	high	med.	NA
6. Estimated cost to passenger (in Cdn$)	$70 for receiver	NA	$40 for portable tape recorder	$3,000 for laptop
7. Estimated cost to carrier (in Cdn$)	$2,000 for transmitter	$500 for video master	$40 for portable tape recorder; $1,000 for tape master	NA

The infrared transmission system for passengers who are hearing impaired proved to have good potential. All information provided over the PA system was much better received and understood with the system than without. Some interference was experienced, which may have been caused by the proximity of a regular TV monitor to the infrared transmitter panel. Technical testing is required to confirm this assumption. Testing in accordance with Transport Canada regulations must also be carried out for implementation on board.

The subjective and performance results from the tests with participants who are deaf clearly indicated that open captioning on the video greatly improved the amount of information they received. With the help of open captioning, participants were able to answer simple questions about safety procedures after the safety demonstration, whereas they were unable to do so without it. Both participants with cognitive impairments felt that open captioning was a positive feature. Although their own comprehension of the safety instructions had not been enhanced, they considered it to be an asset for other travellers who are cognitively impaired and who might have more difficulty understanding verbal or audio instructions.

Observers without sensory disabilities suggested that open captioning on video would benefit all passengers, especially when the audio quality of the public address system is poor or when the environmental noise level is high. Open captioning can also be presented in several languages, to address the difficulties experienced by foreign passengers.

The tests illustrated the pros and cons of the text-to-speech laptop computer. For those with good typing skills, this is a good communication tool. For the less skilled, it is not the right answer.

The tests with participants who are blind using descriptive audio tape showed that this technology requires improvements for its use on board. Both participants felt that the descriptive audio tape has potential, but requires major improvements to its content. The performance of passengers who are blind and who were unfamiliar with air travel did not improve with the added information on the descriptive tape. The tape could be improved with more descriptive information on safety features, e.g., where the oxygen masks fall, what size they are, how they feel, etc. If the tape and player were available on board and could be replayed by passengers at their leisure, it is expected that the results would improve.

8 CONCLUSIONS

The following conclusions were reached based on the exploratory nature of this study:

Passengers who are blind or visually impaired
- Pre-briefing for passengers who are sensory disabled cannot be replaced by technologies.
- Descriptive audio tape should not be placed on board aircraft yet.
- Pre-flight briefing could be supplemented by Braille card and descriptive audio tape.

Passengers who are hard of hearing
- Infrared transmission system could be made available in cabin and washrooms pending interference tests.
- Safety implications must be reviewed for individuals wearing a neck loop receiver in anticipated emergency situations.

Passengers who are deaf
- Open captioning could be used on board aircraft using monitors for safety briefing.
- Caution should be exercised concerning size of screen, letter size, space for messages, and use of different languages.
- For aircraft not equipped with monitors and unable to provide captioning, an individual briefing is still required.

Passengers who are cognitively impaired
- Open captioning could be used on board aircraft using monitors for safety briefing.
- Caution should be exercised concerning size of screen, letter size, content, and space for messages and use of different languages.

Benefits to general public
- Open captioning for safety briefing, especially if the PA system's quality is inadequate.
- Caution should be exercised concerning size of screen, letter size, content, and space for messages and use of different languages.

Passengers who are speech-impaired
- The laptop computer is not recommended yet for use on board an aircraft.

Life vests
- Current life vests comply with TSO-C13 standards.
- Several subjects experienced great difficulties with their use.

9 RECOMMENDATIONS

The following recommendations are made based on the findings of the study and suggestions provided by steering committee members:

Passengers who are blind and visually impaired

- The descriptive audio tape requires further content refinement and should be tested with subjects.
- Operating and safety implications, such as use during an emergency, for weight and storage of equipment worn by passengers require further testing.
- A descriptive video should be designed, tested, and evaluated, as recommended by the CNIB.
- The needs of passengers who are deaf/blind should be addressed in future studies.

Passengers who are hard of hearing

- Infrared transmission systems must be tested for interference with the aircraft's navigational equipment as per aircraft certification requirements according to Transport Canada regulations.
- Safety implications concerning the weight and storage of personal receivers during emergency situations should be reviewed.

Passengers who are deaf

- Open captioning should be tested for scenarios other than safety demo, e.g. entertainment, service information.
- Tests should be carried out on legibility, comprehension, letter size, and placement of messages on the monitor screen.

Passengers who are cognitively impaired

- Open captioning for applicability for this group should be tested, as well as descriptive videos and tactile cards.

Passengers who are speech impaired

- If it is to be used on board, the laptop text-to-speech computer requires further testing, with the participation of flight attendants and subjects.

Elderly passengers

- Tests should be carried out with seniors for the effectiveness and operation of the descriptive audio tape.

General

- Regulations require that passengers with sensory impairments receive individual safety briefings. Persons with invisible disabilities must identify themselves and make their needs known.

- Current individual briefing practices were not addressed in this study. It is recognized that personal briefing cannot be replaced by technologies and therefore it is highly recommended that research and testing be carried out in this area. This would include such issues as personal sensitization and training as well as the content and clarity of the briefing information.
- The cost-effectiveness of technologies is important for both the passenger and the carrier. Comparisons of proposed technologies against existing solutions (e.g. pen and pencil, Braille cards, personal briefing, public address systems, and hand spell) should be carried out.

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APPENDIX A

Transport Canada safety regulations

CTA Recommendations

PROCEDURAL SAFETY REGULATIONS

Safety on board an aircraft is the responsibility of the Department of Transport.

According to the *Commercial Air Service Standards,* an air operator shall ensure that passengers shall be given a safety briefing.

Section 725.43 details such briefings for the general public as well as for persons with sensory impairments. The following are excerpts from the section:

1. Standard Safety Briefing

The standard safety briefing shall consist of an oral briefing provided by a crew member or by audio or audio-visual means in both languages which includes the following information as applicable to the aeroplane, equipment, and operation:

a) prior to take-off

- *i) when, where, why and how carry-on baggage is required to be stowed;*
- *ii) the fastening, unfastening, adjusting and general use of safety belts or safety harnesses;*
- *iii) when seat backs must be secured in the upright position and chair tables must be stowed;*
- *iv) the location of emergency exits, and for persons seated next to that exit, how that exit operates;*
- *v) the Floor Proximity Emergency Escape Path lighting system;*
- *vi) the location, purpose of, and advisability of reading the safety features card;*
- *vii) the regulatory requirement to obey crew instructions regarding safety belts and no smoking or* Fasten Seat Belt *signs and* No Smoking *signs and the location of these signs;*
- *viii) where flight attendants are not required, the location of any emergency equipment the passenger may have a need for an emergency situation such as the ELT, fire extinguisher, survival equipment (including the means to access if in a locked compartment), first aid kits, and life rafts;*
- *ix) the use of passenger operated portable electronic devices;*
- *x) the location, and operation of the fixed passenger oxygen system, including the location and presentation of the masks; the actions to be performed by the passenger in order to obtain the mask, activate the flow of oxygen and correctly don and secure the mask. This will include the demonstration of their location, methods of donning including the use of elastic band, and operation, and instruction on the priority for persons assisting others. This briefing may be completed after take-off but prior to reaching 25,000 feet;*
- *xi) the location, and use of life preservers, including how to remove from stowage/packaging and a demonstration of their location, method of donning and inflation, and when to inflate preservers. This briefing may be completed after take-off prior to the over water portion of the flight;*

b) after take-off
  - *i) that smoking is prohibited;*
  - *ii) the advisability of using safety-belts or safety harnesses during flight;*

c) in flight when the fasten seat belt sign has been turned on for reasons of turbulence
  - *i) when the use of seat belts is required; and*
  - *ii) the requirements to stow carry-on baggage;*

d) prior to landing
  - *i) carry-on baggage stowage requirements;*
  - *ii) correct seat back and chair table positioning;*
  - *iii) on flights scheduled for four hours duration or more, the location of emergency exits;*
  - *iv) the seat belt requirement;*

e) prior to passenger disembarkment, the no-smoking requirement, the safest direction and most hazard-free route for passenger movement away from the aeroplane following disembarkment; and any dangers associated with the aeroplane type such as pitot tube locations, propellers, or engine intakes.

The safety message of the briefing may not be diluted by the inclusion of any service information or advertising that would affect the integrity of the safety briefing.

*2. **Individual Safety Briefing***

The individual safety briefing shall include:

a) any information contained in the standard safety briefing and the safety features card that the passenger would not be able to receive during the normal conduct of that safety briefing; and

b) additional information applicable to the needs of that person as follows:
  - *i) the most appropriate brace position for that passenger in consideration of his/her condition, injury, stature, and/or seat orientation and pitch;*
  - *ii) the location to place any service animal that accompanies the passenger;*
  - *iii) for a mobility restricted passenger who needs assistance in moving expeditiously to an exit during an emergency:*
  - *A) a determination of what assistance the person would require to get to an exit;*
  - *B) the route to the most appropriate exit;*
  - *C) the most appropriate time to begin moving to that exit; and*
  - *D) a determination of the most appropriate manner of assisting the passenger;*

  - *iv) for a visually impaired person:*

  - *A) detailed information of and facilitating a tactile familiarisation with the equipment that he/she may be required to use*
  - *B) advising the person where to stow his/her cane if applicable;*
  - *C) the number of rows of seats between his/her seat and his/her closest exit and alternate exit;*

D) an explanation of the features of the exits, and
E) if requested, a tactile familiarisation of the exit;

v) for a comprehension restricted person:
A) while using the safety features card, pointing out the emergency exits and alternate exits to use, and any equipment that he/she may be required to use;

vi) for persons with a hearing impairment:

A) while using the safety features card, pint out the emergency exits and alternate exits to use, and any other equipment that the person may be required to use;
B) communicating detail information by pointing, face-to-face communication permitting speech reading, pen and paper, through an interpreter or through their attendant.

vii) for a passenger who is responsible for another person on board, information pertinent to the needs of the other person as applicable:

A) in the case of an infant
(I) seat belt instructions
(II) method of holding infant for take-off and landing
(III) instructions pertaining to the use of a child restraint system;
(IV) oxygen mask donning instructions;
(V) recommended brace position; and
(VI) location and use of life preservers, as required

B) in the case of any other person:
(I) oxygen mask donning instructions;
(II) instructions pertaining to the use of a child restraint system; and
(III) evacuation responsibilities.

viii) for an unaccompanied minor, instructions to pay close attention to the normal safety briefing and to follow all instructions.

A passenger that has been provided with an individual safety briefing need not be re-briefed following a change in crew if the crew member that provided the individual safety briefing has advised a member of the new crew of the contents of that briefing including any information respecting the special needs of that passenger. A passenger may decline an individual safety briefing.

CTA Recommendations

For air carriers in Canada (fixed wing aircraft with 30 or more passenger seats), the Canadian Transportation Agency has developed recommendations. The purpose is to improve the accessibility of air travel for persons with disabilities. Among the recommendations for sensory impaired passengers are: signage, lighting, handrails, seats with floor space to accommodate a service animal, tactile row markers, supplementary briefing cards in large print and Braille, communication of announcements.
In 1997 the Canadian Transportation Agency published a report entitled " Communication Barriers - A Look at Barriers to Communication Facing Persons with Disabilities Who Travel by Air".

The following are excerpts from recommendations in the report.

For travellers with disabilities, the agency recommends:
- that a guide for travellers with disabilities be produced

For air carriers and airports the agency recommends:
- that all air carriers and airport operators outline a clear and concise Alternative Format Policy

For personal help, the agency recommends:
- that the industry continue to provide personal services currently offered travellers with disabilities
- that the industry establish quality control measures to ensure that consistent, reliable service is provided to travellers with disabilities
- that when preparing refresher training, emphasis be placed on the importance of personnel having a working knowledge of services and policies offered by air carriers or terminal operators to travellers with disabilities, including communication of information issues
- that persons with disabilities be involved in refresher training sessions

For the elimination of the "No-Man's Land", the agency recommends:
- that airport and air carrier personnel work together to close the gap between the terminal's entrance and the carrier's ticket counter

For the new developments/ technological changes, the agency recommends:
- that the needs of persons with disabilities be addressed to facilitate accessibility
- that air carries and airport operators formally involve persons with disabilities when developing services or finding solutions to better serve persons with disabilities

For physical accessibility of airports, the agency recommends:
- that no new flight information monitors be installed which are above eye-level and which do not have significant colour contrast, large print or use audio-echo technology

For general announcements and individual communications, the agency recommends:

- that at every point of contact between the terminal employee and the public be equipped with dedicated pen and paper to ensure that communication is facilitated with travellers who are deaf or hard of hearing
- that public address announcements be improved by speaking more clearly, more slowly and repeating the message
- that any announcement about airport services also include a description of the service location

For terminal information, the agency recommends:
- that airport operators provide advance information about terminal lay-outs and that this information be available in alternative formats

For TTYs and volume-controlled phones, the agency recommends:
- that airport operators ensure that an adequate number of public TTYs and volume-controlled phones are available, in both the public area and arrival and departure are, 24-hours a day
- that personnel be fully aware of the location of such TTYs and volume-controlled phones, and that these phones be properly indicated by appropriate signage

For self-identification, the agency recommends:
- that air carriers actively promote understanding among travellers with disabilities of what services are available for persons with disabilities, as well as the benefits of self-identification

For itineraries in alternative formats, the agency recommends:
- that air carriers start providing itineraries or individual travel information in plain language with minimal use of codes and acronyms
- that itineraries and individual travel information be made available in the appropriate alternative formats

For general announcements and individual communications, the agency recommends:
- that, if passengers request it, air carriers use well-contrasted markers to write down the boarding gate number in large characters for those who have difficulties reading the information on boarding passes or else use a tactile mark, to facilitate their identification

For security, the agency recommends:
- that security personnel use both audio and visual means to indicate whether or not travellers can proceed to their boarding area after passing through the magnetometer

For reserved seating at boarding gates, the agency recommends:
- that air carriers designate reserved seating at boarding gates for passengers with disabilities

For Aircraft physical accessibility features, the agency recommends:
- that, when a carrier makes announcements to passengers, such as announcements concerning stops, delays, schedule changes, connections, on-board services and claiming baggage, the

carrier should have the means within the aircraft of visually and verbally providing these announcements to persons with disabilities
- that tactile markers to indicate row numbers should be placed on overhead bins or on passenger aisle seats

For orientation within the aircraft, the agency recommends:
- that upon request, air crews verbally give information about the operational features of the aircraft to passengers with disabilities, supplemented with written information where possible
- that the Air Transport Association of Canada sponsor an industry focus group to discuss customer service issues of concern to travellers who are deaf-blind

APPENDIX B

Test protocol and questionnaires

(Not available in electronic format/
Non disponible en format électronique)

APPENDIX C

Human factors guidelines for technologies

(Not available in electronic format/
Non disponible en format électronique)