Rail Car Accessibility – Boarding Technologies for Passengers Using Mobility Aids

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ABSTRACT

VIA Rail is an independent crown corporation offering inter-city passenger rail services in Canada. After a review of VIA's current boarding assistance system and related services provided to passengers using mobility aids, an investigation to identify a potential Boarding Assistance System that could be deployed to access intercity train services was initiated. A detailed survey of passengers using mobility aids was done to identify their needs and preferences for boarding and alighting services. The respondents indicated the need to improve upon the boarding assistance currently provided. A general conclusion of the present investigation is that provision of a safe, reliable, and comfortable vehicle-based lifts will reduce some of the present limitations for passengers using mobility aids to use inter-city passenger rail services. This improvement could be achieved by integrating vehicle-based lifts with VIA Rail's existing and future rail cars. A survey of VIA's operational and technical requirements in retrofitting their rail cars with vehicle-based lifts indicates that while it is considered feasible to retrofit the rail cars, some modification of commercially available Boarding Assistance Systems would be required.

Keywords: Accessibility; Reduced Mobility; Rail Transportation; Passenger Needs Survey; Boarding Assistance Systems

BACKGROUND

In recent years there has been an increasing focus on the transportation needs of people with reduced mobility. Wasfi, Levinson et. al (*1*) investigated the travel demands and activities (in terms of both actual behavior and unmet needs) of seniors residing or working in Hennepin County, Minnesota. Other researchers, such as Blais and El-Geneidy (*2*) have focused on trying to understand the relationship between access to transportation, well-being and type of disability. The above research shows that people with disabilities need equal access to transportation and that access to transportation has a significant positive effect on the well-being of the people with disabilities. "Public Transportation – Accessibility for All" (PubTrans4All) (*3*) was large, multi-year project on rail accessibility, particularly in regard to Boarding Assistance Systems, recently undertaken in Europe. A research paper by Rüger and Simic (*4*) presents some of the work done in the PubTrans4All project.

In 2014 a research and development project was initiated by Transport Canada to investigate, identify and test a potential technological solution that could be deployed to assist passengers using mobility aids to board trains where the station platform is not level with the car floor. The PubTrans4All project provided a guide to some of the potential issues for implementing BAS systems for Canadian users. Work was carried out by a Consortium led by Real-Time Engineering & Simulation Inc. in collaboration with VIA Rail Canada (an independent Crown corporation offering inter-city passenger rail services in Canada) and the Canadian Transportation Agency, and completed in December of 2015. This paper highlights the findings of that work.

INTRODUCTION

Accessibility of rail vehicles is particularly problematic, since rail vehicles have a service life of 40 years or longer. Many currently inaccessible vehicles will remain in service well into the future. Accessibility to VIA's passenger rail service is guided & regulated by the Canadian Transportation Agency (CTA) who's mandate includes ensuring that undue obstacles to the mobility of persons with disabilities are removed from the federal transportation system; specifically in respect of air, rail, and extra-provincial ferry and bus transportation. The CTA seeks to remove such obstacles by:

- developing regulations and codes of practice;
- communicating with the transportation industry and the community of persons with disabilities;
- resolving individual accessibility-related disputes; and
- ordering corrective measures as required.

The present project explored the best options for improved access while complying with the standards and regulations that already exist in Canada and the United States.

The project included:

a) Part 1: a review of Relevant Canadian and US Standards and Regulations for Accessibility of Rail Cars,

b) Part 2: a detailed survey of intercity rail travel and transportation needs of the Canadian population having some disability,

c) Part 3: consultations with VIA Rail regarding its technical and operational requirements in implementation of a Boarding Assistance System in its existing and future rail car fleets, and

d) Part 4: a survey of commercially available Boarding Assistance Systems that could potentially be integrated with the VIA Rail vehicles. Commercially available Boarding

Assistance Systems (BAS) for railway boarding are of two types: ramps and lifts (*4*, *5*). These devices could be platform-based or vehicle-based (integrated with the vehicle).

PART 1: RELEVANT CANADIAN AND US STANDARDS AND REGULATIONS FOR ACCESSIBILITY OF RAIL CARS

Canadian legislation contains very little regarding accessibility of rail transport for individuals with disabilities. The official document addressing the issue is the Canadian Transportation Agency's *Canadian Code of Practice: Passenger Rail Car Accessibility and Terms and Conditions of Carriage by Rail of Person With Disabilities* (*6*). The Code's purpose is to improve the accessibility of rail travel for persons with disabilities and presents minimum standards that rail carriers should meet to improve the accessibility of rail travel to persons with disabilities. It addresses the provision of services and the equipment used in rail transportation that should be provided. It also deals with features to make passenger rail cars more accessible. Both The Canada Transportation Act (*7*) and the Canadian Human Rights Act (*8*) provide mechanisms for enacting regulations.

1. The CTA – Code of Practice is the main document that defines the requirements for Passenger Rail Car Accessibility. This Code of Practice document refers to CSA Standard CAN/CSA-B651-95 *Barrier-free Design* (*9*), which has been replaced by CAN/CSA B651-12 *Accessible Design for the Built Environment* (*10*).

The Americans with Disabilities Act (ADA) of 1990 (*11*) prohibits discrimination and ensures equal opportunity and access for persons with disabilities. In regards to transportation issues, the act made accessible and usable transportation a qualified civil right. The Federal Transit Administration is in charge of investigations and compliance reviews related to the ADA. The ADA covers public and private transportation providers and services in all modes, regardless of funding sources.

PART 2: PASSENGER SURVEY

Methodology and Survey Description

To establish a traveller profile for passengers with reduced mobility, their preferences in terms of boarding devices, as well as to establish a profile of the mobility aids they use (wheelchairs, scooters, walkers, etc.) an online survey was conducted during October and November 2014.

The survey was designed and conducted by the Consortium in consultation with the Accessibility Advisory Committee of Canadian Transportation Agency (AAC-CTA). The target population was anyone that identified as having a physical disability or condition that limits one or more basic activity such as walking, climbing stairs, bending, lifting or carrying. The goal was to obtain a representative sample. The questionnaire could be answered in either French or English. Under the guidance of the AAC-CTA, the consortium contacted the "Council of Canadians with Disabilities," the "Confédération des organismes de personnes handicapées du Québec", the "Spinal Cord Injury of Canada," "Independent Living Canada," and "Regroupement des activistes Pour l'inclusion au Québec" for help identifying the population to survey. Through the representatives of member organizations of the AAC-CTA, emails were sent to people with disabilities. In all, 93 responses were obtained, of which 60 were complete and 33 were partially complete. It is impossible to determine a response rate as it is not known how many emails were sent and how many people with disabilities were actually reached through the emailing process. The representatives were encouraged to disseminate the survey to

as many members of their organisations as possible, in order to obtain the greatest survey size as practical.

A series of socio-demographic questions to help in better understanding the study sample were contained in the survey. These questions included information on sex, age, income, activity level, driving license, etc. The survey concluded with a series of open-ended questions where respondents could provide suggestions as well as other approaches that VIA Rail should consider in relation to accessing upgrades.

Results and Analysis

Table 1 presents a general summary of the respondents who submitted completed surveys. Among those who provided an answer to the socio-demographic questions, 42% of respondents were female, while 35% were male. Respondents' ages ranged from 20 to 70. The majority of respondents are employed, retired or completing their studies.

TABLE 1 General Characteristics of Survey Respondents

Category	Criteria	Score
Gender	Female	42%
	Male	35%
	Prefer not to answer	2%
Status	Student	8%
	Retired	23%
	Employed, full-time	22%
	Employed, part-time	10%
	Unemployed	10%
	Prefer not to answer	7%
Income	Less than $20,000	15%
	Between $20,001 - $40,000	13%
	Between $40,001 - $60,000	12%
	Between $60,001 - $80,000	7%
	Between $80,001 - $100,000	2%
	Between $100,001 - $120,000	3%
	More than $120,000	7%
	Prefer not to answer	22%
Driver's license	Yes	53%
	No	28%
Age	Age 18 -30	7%
	Age 31-45	23%
	Age 46-65	40%
	Age > 65	8%
	Prefer not to answer	22%

The survey also showed that about 40% of participants live in British Columbia, with 20% in both Quebec and Nova Scotia. Only 8% live in Ontario, and 5% or less in each of Alberta, PEI and Saskatchewan.

Disabilities and Type of Mobility Assistance Device

The first part of the survey asked respondents to describe the type of disabilities they have and which type of mobility assistance device they use, such as walking aids, manual and electric wheelchairs, or electric mobility scooters. Pictures were used to identify each mobility assistance device.

In the summary of the survey respondents' disabilities (Figure 1), it should be noted that respondents could identify themselves in more than one category. Most respondents have a physical disability or a condition that limits one or more basic physical activity such as walking, climbing stairs, bending, lifting or carrying. Fewer indicated blindness or vision impairment, learning disability or other disabilities such as long-standing illness. Only a few of participants indicated deafness or hearing impairment and intellectual disability.

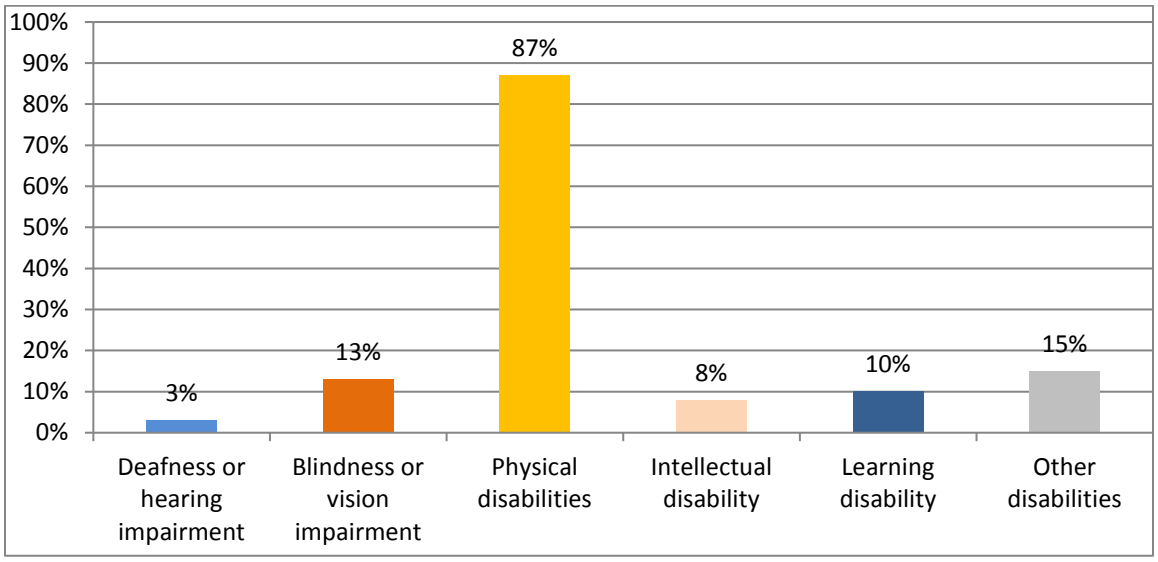

FIGURE 1 Do you identify as having any of the following disabilities or did you in the past identify yourself as having any of the following disabilities?

About 87% of respondents indicated that they use a mobility aid device to assist them in their daily activities in order to improve their mobility, whether a type of *manual* wheelchair (Figure 2), *power* wheelchair (Figure 3) or *scooter* (Figure 4). Participants were able to select more than one type of device. The majority of respondents using a manual wheelchair are using a custom-made or a standard wheelchair (Figure 3). Very few respondents are using lightweight manual wheelchairs or sport wheelchairs.

There is a nearly even split between respondents using a *basic* power wheelchair and a *mid-wheel drive* power wheelchair (Figure 3). About 10% of respondents use others types of power wheelchairs, including *heavy-duty* power wheelchair, *rear drive* power wheelchair and front drive power wheelchair. None of the respondents used a *standing power* wheelchair.

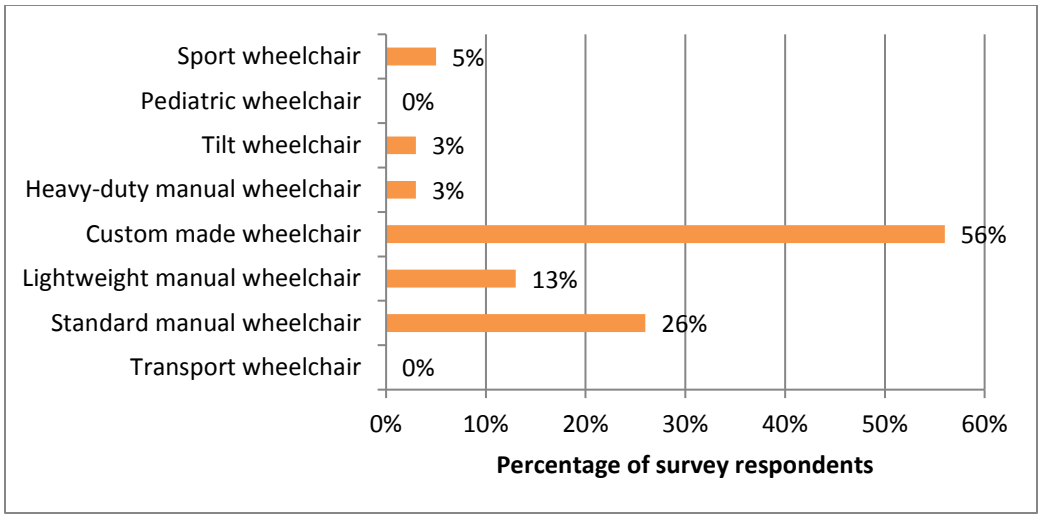

FIGURE 2 Which types of manually propelled wheelchair do you or did you use?

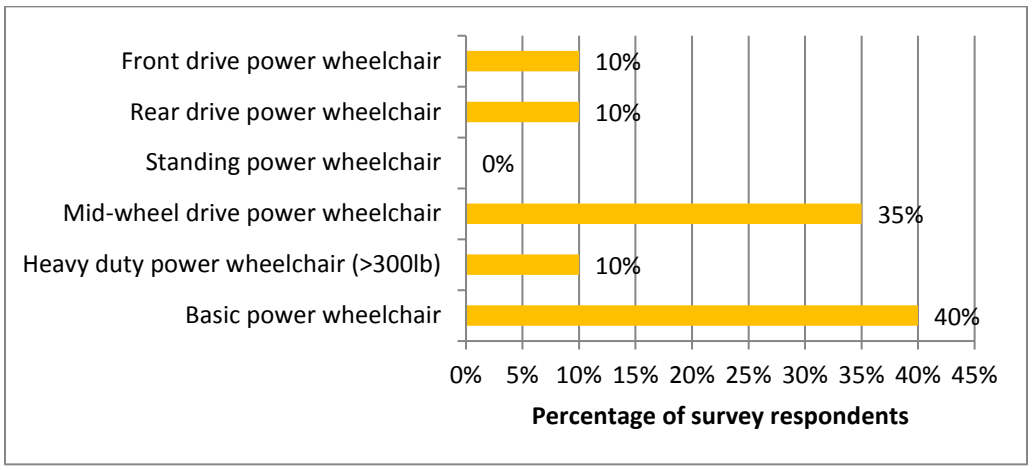

FIGURE 3 Which types of electric powered wheelchair do you or did you use?

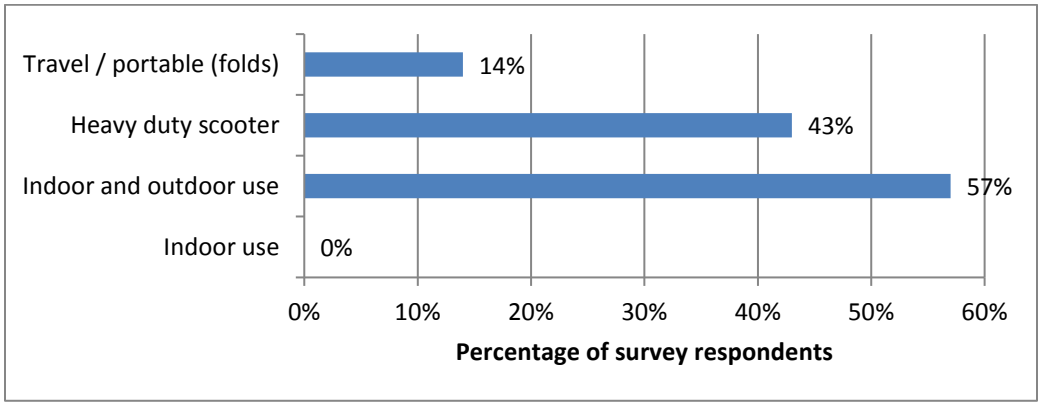

FIGURE 4 Which types of electric mobility scooter do you or did you use?

Difficulties and Challenges

The second part of the survey focused on current and past difficulties or challenges encountered by people with mobility impairments in long distance travel. This section included questions on the number of long distance trips they made during the last year, frequency of their trips, reasons preventing them from using rail services and difficulties or obstacles they encountered to board or alight VIA Rail trains. The population surveyed also rated VIA Rail staff assistance based on their courtesy, availability, technical skills and overall assistance.

About 78% of respondents have done at least one long-distance trip during the last year, using any mode of transportation, not just rail (Figure 5). The survey also asked participants to indicate if there were any essential long-distance trips they wanted to make but could not. More than half of respondents indicated "yes" (Figure 6). Lack of accessible travel mode options was the primary reason preventing people with physical disabilities from making those long distance trips.

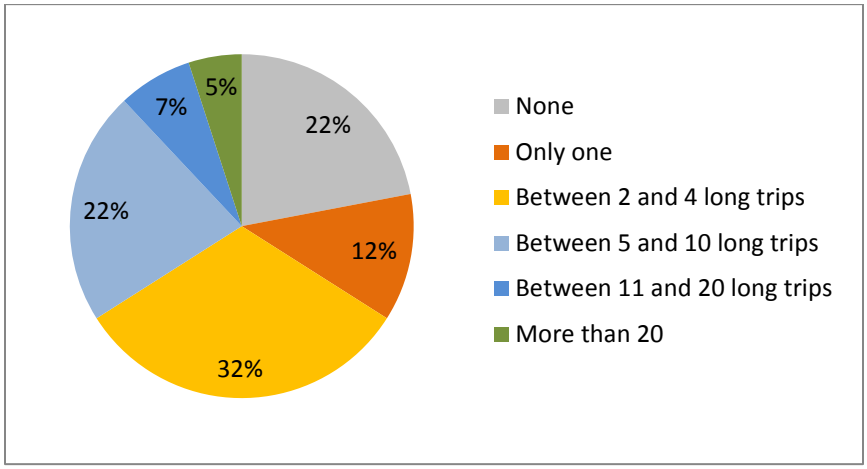

FIGURE 5 In the past year how many long distance trips have you made?

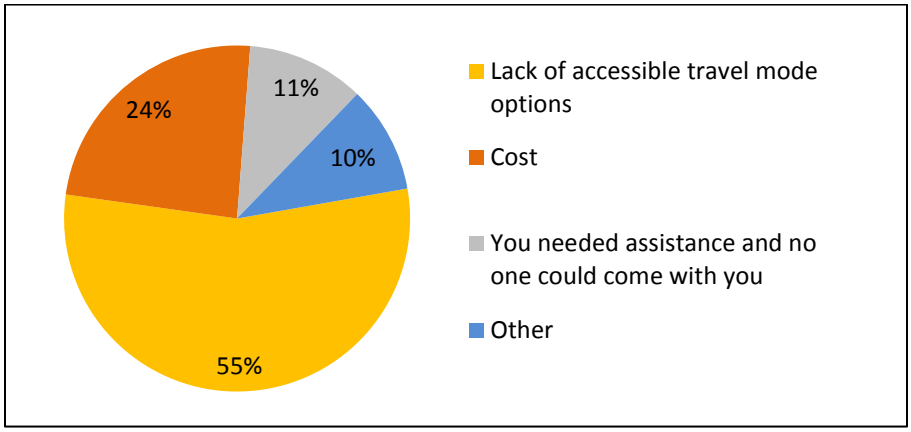

FIGURE 6 What was the primary reason preventing you from making long distance trips?

Preferences and Perceptions

The third section of the survey asked questions related to respondents' preference and perception for various BAS for rail vehicles. Pictures were provided to illustrate the use of each device. Participants were asked to evaluate the perceived safety, comfort and ease of using five different boarding devices and to identify their preferences between boarding devices operated by them or assisted and operated by staff. These devices include mobile platform-based ramp, manual and electric platform-based lifts, and vehicle-based lifts operated by staff and by users.

In addition, several questions were asked to identify whether lift or ramp systems are preferred and whether these devices should be fixed or not to the rail car. The survey suggests vehicle-based lifts operated by staff are perceived as the most reliable device in terms of safety, comfort and ease of use (Figure 7). The mobile platform-based ramp comes next in terms of safety, comfort and ease of use.

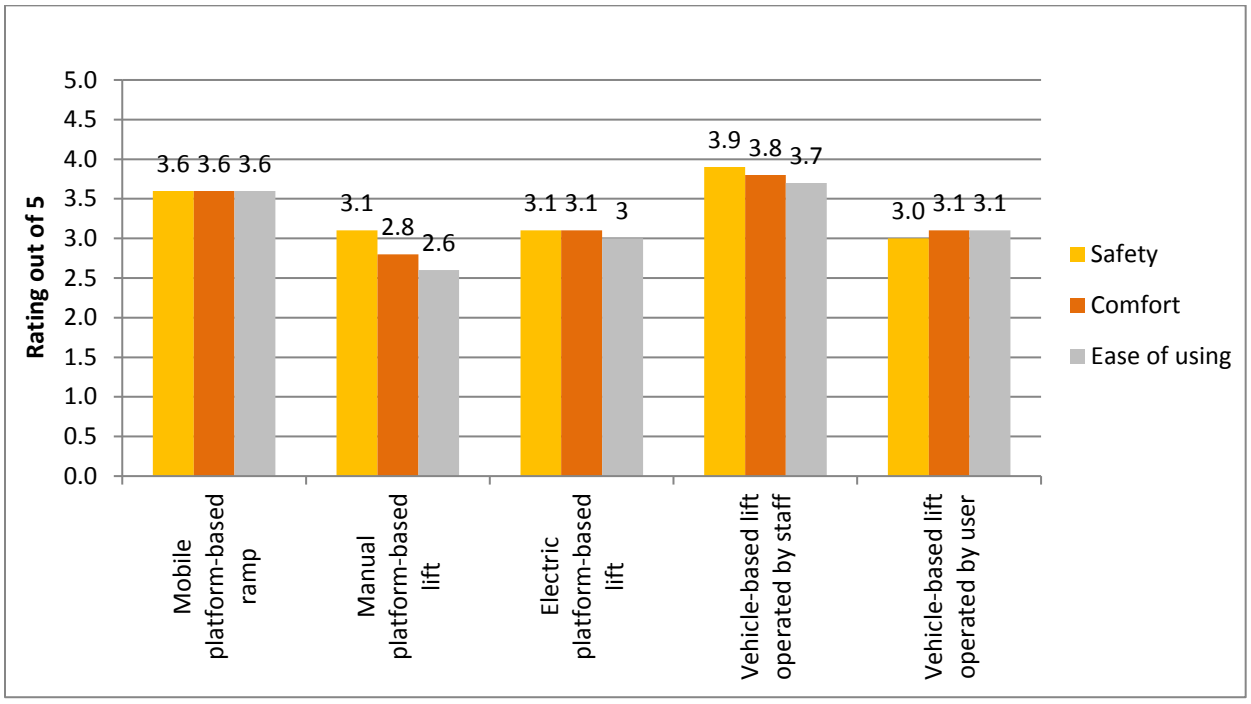

FIGURE 7 Evaluation of the safety, comfort and ease of use of the various boarding devices to get on high floor trains.

This section also requested respondents rank in order of importance five evaluation criteria of boarding devices (safety, comfort, ease to use, time to operate and the autonomy of the person with mobility impairment). Survey respondents indicated "Safety" as the most important. "Comfort" and "Ease of Use" came second and third (Figure 8). The ranking of "Safety" as the most important evaluation criterion may explain why vehicle-based lifts operated by staff are favoured by people with mobility impairment, since these devices are considered as the safest according to the sample (Figure 7). In addition, other survey questions confirmed the previous results and indicated that users generally prefer lift systems over ramp systems in terms of safety and comfort.

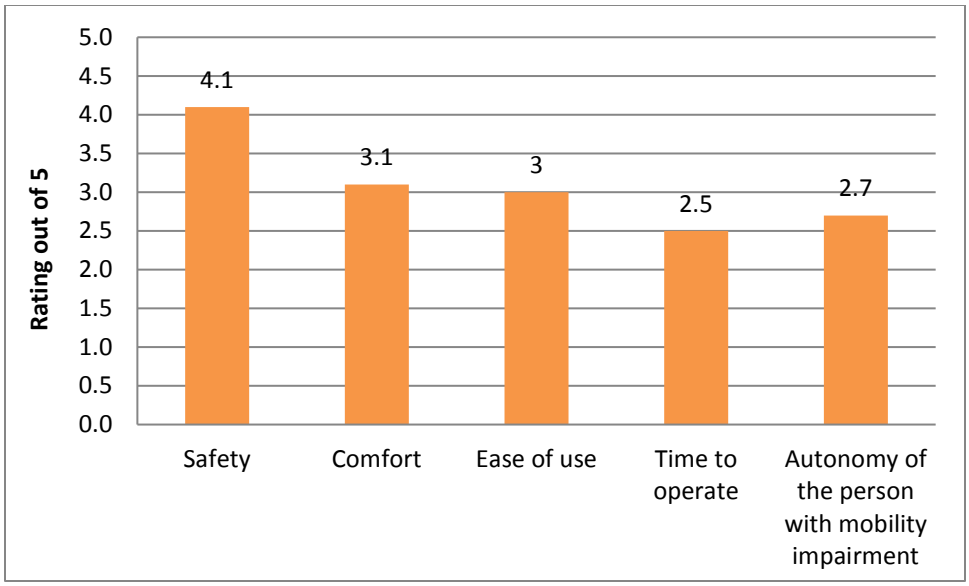

FIGURE 8 Ranking criteria, in order of importance, for evaluating boarding devices.

Discussion of Survey's Findings

Generally, survey participants ranked the vehicle-based lift operated by staff as the most reliable device in terms of safety, comfort and ease of use. When considering the type of mobility aid device used by the respondents, three main groups of users were identified: manual wheelchair users, power wheelchair users and scooter/walking aid users. All three groups ranked vehicle-based lifts operated by staff as the most reliable device in terms of safety, comfort and ease for use.

Scooter/walking aid users indicated mobile platform-based lift systems and vehicle-based lift operated by users tied for second. This generally shows that scooter/walking aid users prefer lift systems over ramp systems. For all the wheelchair users, mobile platform-based ramps came next after vehicle-based lifts operated by staff. Therefore, if it is impossible to equip vehicles with vehicle-based lifts operated by staff, train operators should prioritize the use of mobile platform-based ramps where the vertical gaps between the vehicle and the station platform permits.

All of the three groups of users indicated accessibility as the main issue preventing people with reduced mobility from using VIA Rail.

General Concerns

The previous section indicates and recognises accessibility as the main reason survey respondents gave for not using VIA Rail more often. Among those who answered the question, about 59% of the survey respondents indicated the gap between the platform and the vehicle floor more important than between the station entrance and the platform (Figure 9). Therefore, strategies and policies that address the horizontal and/or vertical gap between the platform and rail cars should be prioritized.

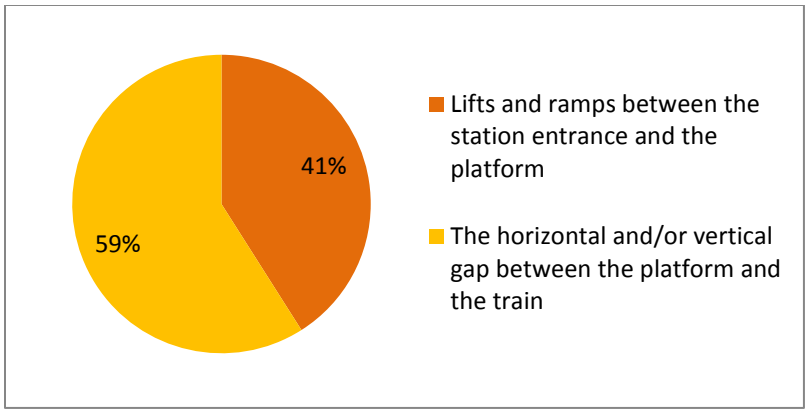

FIGURE 9 Which issue is most important to you today regarding accessibility to VIA Rail services?

Survey Conclusions and Recommendations

Improving accessibility means either creating level boarding by adjusting platform height to the vehicle floor height or providing Boarding Assistance Systems that enable mobility-impaired passengers to reach rail car floor levels from platforms. Since the current Canadian rail cars will last for many more years, the Consortium recommended the second option in order to improve accessibility.

This survey also helped identify preferred technological solutions that could be deployed to assist passengers using mobility aids to board trains. Among the five devices used in the survey, the respondents identified vehicle-based lifts operated by staff as the preferred boarding assistance device. The assistance of someone during the boarding process seems to have a strong positive effect on the perceived security of the device.

Regarding the findings from this survey, the following recommendations are suggested:

1. Testing staff-operated vehicle-based lifts on every train.
2. Using lift systems, especially when the vertical gap between the vehicle and the platform is considerable. At the stations where the platform is such that the vertical gap between the station platform and the vehicle floor is less than 400 mm a ramp system with safety barrier can be used.
3. Improving staff training to assist people with disabilities when boarding or alighting trains. For people with mobility impairment, the safety, comfort, and ease of use are more important criteria than the time to operate and the autonomy of the passengers when considering a new boarding assistance device.
4. Promoting services provided by VIA Rail to encourage people with physical disabilities to board trains and access platforms.

PART 3: CONSULTATIONS WITH VIA RAIL

Although in some respects passenger rail travel has fewer constraints than air travel, in a large country like Canada it has its own unique accessibility challenges. Passenger rail serves large cities such as Montreal and Toronto, but also serves less populated areas of the country and as such, passengers may have access to level boarding in an urban center, but disembark at an unstaffed station where access to a level platform and assistance is unavailable. This may be

particularly difficult for a passenger with a mobility disability, given that to date few Canadian rail cars are equipped with boarding devices.

Boarding System Technical and Operational Requirements Survey

As part of the project, the Consortium team prepared a survey questionnaire on boarding systems' technical and operational requirements to be completed by VIA Rail staff. The results show the importance of various criteria that a boarding assistance device must fulfil from the operators' point of view. The operators evaluated most criteria as "very important," especially high level of reliability, operational quality, easy maintenance, low costs and no safety risks (Table 2).

TABLE 2 Operator and Manufacturer – Evaluation Criteria

Score	Criteria
Very important ("must have")	*Reliability of boarding assistance system:* Prevention of malfunction
	Operational quality: Short dwell time
	Failure management: Problems easy to solve
	Costs: Costs as low as possible
	Safety risks: No safety risks to be tolerated
	Maintenance effort: Number of personnel required? Special tool required?
Important high benefit for operators ("nice to have")	*Operational quality:* malfunctions must not influence train operations
	Manufacturing effort: The manufacturing/installation effort needs to be low – especially when retro-fitted on vehicles
All regulations according to the Code of Practice: 'CTA - Passenger Rail Car Accessibility and Terms and Conditions of Carriage by Rail of Persons with Disabilities' must be fulfilled as a minimum standard.	

The survey also highlighted the most important technical and operational requirements that must be considered when designing a boarding assistance system. According to the VIA Rail personnel surveyed, total duration for preparation, use, and stowing needs to be kept below 5 minutes. Platform width exceeds 1060mm, while the vertical gap between vehicle and platform can be as much as 1300mm, or more in the case of an emergency evacuation outside a station. Access door width needs to be equal to 810mm or greater, while the maximum capacity for a wheelchair and occupant (including state-of-the-art power-chairs) is 300-350kg. The relative angle (platform-vehicle) must be less than 6% or 3.4^{o}. Transverse gradient of platform and super elevation of track (super elevation 50mm, platform gradient 2.5%)

Existing Station Accessibility

Although 80% of VIA Rail business is in the Corridor route, VIA currently serves about 380 stations throughout Canada. These stations have strongly varying infrastructure and service patterns. Some stations are served by many trains per day while others are only serviced every several days.

VIA Rail has developed platform-based lift systems for higher volume rail terminals. These are lifts similar to those used by regional air carriers at lower-volume air terminals. Information obtained from the operators survey and in meetings suggests that these platform-

based lifts are not optimal. Forty-seven stations along VIA Rail's network are equipped with these devices. These lifts are powered by a manual crank and have a payload capacity of 272 kg. Considering the trend of larger and heavier wheelchairs and scooters, a larger payload capacity must be considered. VIA Rail has reported that these lifts require a significant amount of physical force by the operator, especially as the height of the rail car floor above the station platform could be up to 1300 mm. Due to their difficult operation, their use can cause unnecessary delays and physical strain on operators.

The remaining stations on VIA Rail's network include 35 staffed stations and up to 300 stations that are unstaffed.

Based upon the findings of the Passenger Survey and Consultations with VIA Rail it was concluded that:

1. Ramps are not a viable option as these devices work only up to a vertical distance of 400 mm between rail car floor and the station platform and this distance could be up to 1300 mm in VIA Rail network.
2. Vehicle-based or platform-based lifts could be used, though it would be preferable to use vehicle-based lifts.

COMMERCIALLY AVAILABLE BOARDING ASSISTANCE SYSTEMS

Information about vehicle-based lifts and platform-based lifts was collected from a number of suppliers and evaluated. As vehicle-based lifts are the preferred solution, information about the platform-based lifts was not evaluated in depth. A typical vehicle-based lift in stowed position is shown in Figure10.

FIGURE 10 Vehicle-based lift

3D computer modeling was used to assess the feasibility of retrofitting a typical commercially available lift into a standard North American passenger rail car. This modeling technique revealed that a significant amount of modifications of the rail car structure would be required.

Recommendations for Boarding Assistance Solutions for Existing Passenger Rail Cars

Based on the results of the investigation of BAS the following solutions are proposed:

1. Work with vehicle-based lift suppliers to modify their standard lift design for retrofitting in existing vehicles without requiring a major modification of the vehicle structure.
2. Rail cars with a 900 mm door width can be provided with modified commercially available vehicle-based lifts. For the cars that have a door width of about 800 mm some of the commercially available lift designs need to be further modified. For door widths of less than 800 mm, it may not be possible to provide a commercially available vehicle-based lift.

NEXT STEPS

A follow-up project to continue the investigations presented here has been planned. The follow-up project is entitled, 'Accessible Rail Vehicles - Development For Overseas' (RailAccess4Overseas). The goal of the follow-up project is to complete a feasibility study on retrofitting a wheelchair lift into existing Canadian railway vehicles and to develop specific requirements and implementation plans for developing and installing such lifts. The project will be undertaken during a one year period starting in September 2016 and will be funded by the Austrian Ministry of Science, Research and Economy.

CONCLUSIONS AND RECOMMENDATIONS

This investigation has identified railway Boarding Assistance Systems that could be deployed to assist passengers using mobility aids to access inter-city train service offered by VIA Rail, and by extension, passenger rail operators in North America. From the findings of the Passenger Survey part of this investigation, the vehicle-based lift operated by staff is ranked as the most reliable device in terms of safety, comfort, and ease of use. Passengers using mobility aids indicated accessibility as the main issue preventing people with mobility impairment from using inter-city rail service.

Based upon the findings of this investigation it is recommended that:

1. Passenger rail operators should investigate development of a vehicle-based lift that could be installed on all appropriate types of passenger rail cars. This should lead to the adoption of a uniform approach to providing accessibility throughout the entire network.
2. Vehicle-based lifts should be integrated with sufficient number of existing and future rail cars so that each train would include a lift-equipped rail car.
3. In the short term, until vehicle-based lifts have been installed, mobile platform-based lifts should be provided at all the stations where station staff is available to help operate the lift.
4. Passenger rail operators should promote services to encourage people with physical disabilities or with a condition that limits one or more basic physical activity to board trains and access platform.

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