Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia - Social and Behavioral Sciences 48 (2012) 341 – 349

Procedia
Social and Behavioral Sciences

Transport Research Arena– Europe 2012

PubTrans4All – Public Transportation Accessibility for All

Mag. Barbara Birkenmeyer[a,*], Dr. Bernhard Rüger[b], Dr. Goran Simic[c], Dennis Behnken[d]

[a]*Rodlauer Consulting e.U. Hertha-Firnberg-Straße 10/4-1-2, 1100 Vienna, Austria*
[b]*Technical University of Vienna, Research Center for Railway Engineering, Karlsplatz 13/230-2, 1040 Vienna, Austria*
[c]*University of Belgrade, Faculty of Mechanical Engineering, Ktaljice Marije 16, Belgrade, Serbia*
[d]*MBB Palfinger GmbH, Fockestraße 53, 27777 Ganderkesee, Germany*

Abstract

The EU-funded project "Public Transportation – Accessibility for All" (PubTrans4All) will develop a prototype vehicle-based boarding assistance system that can be built into new rail vehicles or retrofitted into existing rail vehicles to improve accessibility for all persons – not only for handicapped people but also for people with huge luggage, parents with baby carriages or elderly. Accessibility for all is essential for creating an equitable, effective and efficient transport system. Therefore the PubTrans4All project will help building a fully accessible rail network.

Keywords: Public Transportation; Railway sector; Accessibility; Persons with reduced mobility (PRM); Boarding assistance systems; Prototype

1. The project PubTrans4All

The project PubTrans4All funded under the European Community's Seventh Framework Programme (FP7/2007-2013) has started in September 2009 with a project duration of 39 months. The project's objective is to develop a standard boarding assistance system (BAS) that can be built into new rail vehicles or retrofitted into existing rail vehicles to improve accessibility especially for persons with reduced mobility (PRM) – disabled persons, elderly, persons with prams, persons with heavy luggage etc. The boarding assistance system will not simply be a device, but rather include contributing elements that

* Corresponding author. Tel.: +43 1 29 84 400 104; fax: +43 1 29 84 400 444.
E-mail address: barbara.birkenmeyer@rodlauer.com

1877-0428 © 2012 Published by Elsevier Ltd. Selection and/or peer review under responsibility of the Programme Committee of the Transport Research Arena 2012
doi:10.1016/j.sbspro.2012.06.1014

make it possible to effectively use the device to access rail vehicles. Accessibility for rail vehicles is particularly problematic since rail vehicles have a long service life (30 years or longer) and many currently inaccessible vehicles will remain in service well into the future.

Therefore, the PubTrans4All project pursues three main objectives:

- Survey existing practices for the use of vehicle and platform based boarding assistance systems (BAS) and develop best practice recommendations for their design and use
- Develop a prototype for a standard BAS that can be retrofitted into all types of existing rail vehicles or installed on all types of platforms
- Disseminate information about the project findings and recommendations widely

The multi-disciplinary consortium consists of 13 project partners from seven different European countries and includes users, public transport operators, academic researchers and manufacturers.

2. Main problem - existing high floor vehicles

The main accessibility problem for rail transport operators is that many old trains have significant vertical differences (e.g. steps) and horizontal gaps between the vehicle and the platform. This problem is accentuated by the fact that rail rolling stock and infrastructure has a very long service life. Railway operators will use their current rolling stock for many more years and therefore, temporary solutions must be found until the fleet can be replaced with modern fully accessible rolling stock.

It is difficult to develop a standard accessibility solution because of the huge variety in rolling stock and platform heights. Even on a single rail line several different types of rolling stock are often used and platforms may have different heights and profiles. Moreover, the exact physical dimensions of rolling stock (e.g. height) can also vary depending on its occupancy and wear. Designers must also consider a safety margin between the train and platform to account for train rocking etc. Finally, accessibility devices must work under all types of environmental conditions (e.g. rain, snow, etc.).

2.1. Evaluation criteria

This section presents an overview of all relevant parameters that must be considered when designing a new boarding assistance system. Table 1 presents the importance of a boarding assistance system for different user groups, fully described in Deliverable 2.1 “Boarding Assistance System Evaluation Criteria Report” (Rüger, Tauschitz, & Petutschnig, 2010) and Table 2 summarizes the evaluation criteria. For generating the following ranking many experts from whole over Europe particularly from railway operators, representatives from handicap and from passenger associations, from Universities and from the railway industry have been asked to give their opinion on the importance of the several criteria.

Table 1: Boarding assistance – for different user groups

Score	Users
Very important (“must have”)	Wheelchair, walking frame
Important high benefit for users & operators (“nice to have”)	walking disabled, with crutch or sticks elderly, diminutive people baby prams, passengers with luggage
Less important (“nice to have” - but not absolutely necessary)	children pregnant visual and hearing impaired

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 Operational effort: Number of required staff Failure management: Problems easy to solve Costs: Costs as low as possible Safety risks: No safety risks to be tolerated Safety/Alert features: Visual , e.g. flash-light, contrast etc., and audio signals 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 Universalism: The system needs to be universal and allow retro-fitting Manufacturing effort: The manufacturing/installation effort needs to be low – especially when retro-fitted on vehicles
All regulations according to the Technical Specification for Interoperability, Accessibility for Persons with Reduced Mobility (TSI-PRM) must be fulfilled as a minimum standard. Some specifications in project PubTrans4All have been set higher and in more detail than the minimum requirements as specified in the current version of the TSI-PRM.	

3. Improving accessibility – examples for boarding assistance systems

Improving accessibility means either creating level-boarding by adjusting platform height to the vehicle floor height or providing boarding assistance systems (BAS) that enable mobility impaired passengers to reach rolling stock floor levels from platforms at a different level. There are two main types of boarding assistance systems: platform-based and vehicle-based.

Platform-based systems are usually simple manual operated devices. At least one device is needed at each station that is suitable for wheelchair users, and one person per station should be available as BAS operator. Before each train arrives the BAS must be moved at the place where the vehicle adapted for wheelchair users is expected to stop.

The advantage of all vehicle-based devices is that they are always available (i.e. at the right time and place and in all stations), because they are placed in vehicles adapted for wheelchair users. This makes it possible for people with reduced mobility to ride even without making arrangements for travel in advance. This is very important for both the users and the "accessibility for all" policy of the railway operators. The on-board conductors can operate this equipment, which is more convenient for operators than the case of platform-based BAS. For each BAS there are two main technologies: ramps or lifts (elevators); and, two sources of power manual or electro-mechanical. More detailed information can be found in Deliverable 2.2 "Existing Boarding Assistance System Evaluation Criteria Matrix Report" (Rüger, Tauschitz, & Petutschnig, 2010).

3.1. Ramps as Boarding Assistance System (BAS)

Ramps are generally the simplest and least expensive BAS devices. However, they can only be used if the vertical difference between vehicle floor-platform is not significant (typically one step), since otherwise the ramp gradient would be too steep in order to use the device safely, otherwise the ramp-platform would be too long to be used on narrow platforms. Most ramps cannot be operated without the assistance of rail operating staff.

Fig. 1. Vehicle-based ramp as used on UK South Eastern Trains, King´s Cross St. Pancras Station, London

Source: Petutschnig B. Vienna University of Technology

Vehicle-based manual ramps are ramps that are located on the train vehicle. They also require the assistance of the rail operating company staff to be deployed and used. The advantage of vehicle-based ramps is that they provide accessibility to all stations from the train since they are stored on board. The ramps may be permanently attached to the vehicle or simply stored on the vehicle.
Figure 1 shows the example of a vehicle based ramp used for bridging vertical gaps, and height differences where needed.

3.2. Lifts - platform-based applications

Lifts are mechanical lifting devices either installed on the vehicle, or mobile lifts placed on the platform. Lifts are the preferred solution over ramps in situations of great height differences, usually more than one step, where slopes are too steep for the application of ramps. Figure 2 shows four examples of a vehicle based lift used in Norway (a), in Switzerland (b), in Sweden (c) and in Germany (d).

Fig. 2. (a) Example for vehicle based lift in Norway; (b) in Switzerland; (c) in Sweden; (d) in Germany

Source: Rüger B. Vienna University of Technology and MBB-Palfinger

A key advantage of lifts is their vast flexibility. Platform-based lifts can be adapted to almost all types of rolling stock and stations since they can be moved around on the platform and can bridge variable horizontal gaps and vertical changes. Similarly, vehicle-based lifts can be adapted to many different platform heights accordingly. These lifts are operated by train-operating staff and are usually pushed on the platform to the train door and then manually operated. Similar to manually deployed ramps, these lifts require ergonomic design, not only to be used for the wheelchair users, but also for the staff who moves and operates the lift. Vehicle based lifts can be used to provide access for differences in platform to vehicle floor heights of 1100 mm or more as a platform-based lift does. Usually this type of BAS requires a sufficient width of the platform in order to provide enough space for safe wheelchair roll on/roll off, but a little bit less than platform/based lifts. Lifts for boarding and alighting parallel to train do also exist.

An additional advantage of vehicle based mechanical lifts is the possibility to evacuate wheelchair users under extraordinary conditions in case of an emergency, even without platforms in-between stations, as lifts can usually manage greater floor-to-ground distances than ramps. Vehicle-based mechanical lifts require an energy source. Two devices per vehicle must be provided, one on each side. The dimensions of the lift platform in a folded stowing-position needs to be narrower then door width. Lifts occupy space at the entrance doors and behind inside the wagon, which is a difficult situation in classic wagons since space is at a premium.

4. Best practice recommendations

The project PubTrans4All, among other goals, tries to provide ideas for improving accessibility to rail vehicles using the existing BAS. On the one hand, recommendations are based on research results of the project, such as: analysis of existing BAS in use on rail systems, established criteria for BAS assessment, evaluation of existing BAS according to defined criteria and interviews with railway operators, manufacturers and users performed in 21 countries. On the other hand, recommendations are based on analyses of existing European or national norms like TSI-PRM, Rail Vehicle Accessibility Regulations (RVAR), Union Internationale des Chemins de Fer (UIC), documents prepared by some international bodies or organizations like European Cooperation in the field of Scientific and Technical Research (COST), and International Association of Public Transport (UITP), as well as results of some EU Projects dealing with accessibility of rail vehicles.

First, general recommendations that can be applied to all types of BAS and include mainly the organizational measures that can improve the usage of the existing BAS, were summed up like:

- Information for persons with reduced mobility (PRM) before ride (internet, call services, written and oral information on the information's desks, download on mobile phones etc.)
- Information at stations: visual, audible information, information on the platform about exact location of the BAS within the train, well visible signage on the vehicle with BAS
- PRM assistance services from home to the station, at the station and in the train
- Positioning of the BAS on the platforms or in the trains,
- BAS operation

Second, the groups of the recommendations address specifications of four typical boarding/alighting situations:

- Level boarding/alighting
- One or two steps upwards boarding and downwards alighting
- Step down boarding and upwards alighting
- Boarding/alighting in case of a height difference of more than approximately 400 mm

There are included recommendations for BAS types that are suitable for every typical situation, limiting and desirable values of the technical parameters and features that should be achieved. The complete set of recommendations can be found in Deliverable 3.1 “Recommendations for Improving Boarding Assistance systems“ (Simic et al. 2010).

5. Design recommendations for improved BAS

The main goal of the PubTrans4All project is the development and building of a prototype of a new, improved BAS. The consortium decided to develop a BAS solution for the UIC wagons which are the most demanding because of their poky entrance area. At the moment no BAS for that type of wagon exists. UIC wagons, like the example in Figure 3, are defined by the UIC in order to facilitate railway operators to use them in service all over Europe. They have unified main geometrical and other characteristics. As they are high floor vehicles, the consortium focused on the applicability of various lift types.

Fig. 3. Example of an UIC wagon

Source: Simic G. University of Belgrade

The analysis of the existing BAS in earlier project phases showed that there are no existing BAS solutions on passenger wagons with doors of 800 mm width, positioned in the front area, directly behind the buffers, which is a very common situation in existing UIC wagons. Therefore, the first step was to consider in detail the entrance areas recognizing technical constraints that must be respected for the BAS fitting. The standard position of the buffers, main electrical line sockets and connecting cables, as well as necessary rails for door guiding below the stairs make an application of a cassette type lift (stowed below the floor) impossible. According to international norms, the upper edge of the door opening should be at minimum 1750 mm over floor level. Almost all UIC wagons do not offer more than this minimum because the space over the door area is used for upper door guidance. Due to the small clear door height it is practically impossible to implement a BAS design with upper guiding rails in UIC wagons. Closer consideration of the available space in the entrance area revealed that there is no space behind or parallel to the end wall, as there must be left some space for sliding of the end door during opening. On the side vis-à-vis the end wall the space for lift stowing can be created only if neither the toilette door nor hand brake wheel or some other equipment remains there. Some covers for inspection of the installations behind the wall can be tolerated supposing that after the BAS installing they can be accessed at least in maintenance facilities. On the opposite wagon longitudinal side there is often not the transverse wall but the side corridor. In this case, the only available place for stowing the BAS is parallel to the side wall, supposing an enough large side corridor for wheelchair passage.

It can be concluded that there are demanding boundary conditions and constraints that prevent many of the common BAS solutions to be applied in this type of vehicle. The analysis leads to minimum design recommendations for the new BAS for UIC wagons. Recommendations contain some restrictions in comparison to new vehicles with wider doors, vehicles without buffers or vehicles with doors located further away from the buffer area. The complete list of dimensions, technical parameters, security measures and other features that will be taken into consideration when building the new BAS prototype can be found in Deliverable 3.1 “Recommendations for Improving Boarding Assistance systems“ (Simic et al., 2010).

6. Preliminary design recommendations and results for a new BAS

Following the evaluation of existing Boarding Access Systems (BAS) and the development of recommendations for improving BAS, the development of preliminary design recommendations for a prototype of the vehicle-based boarding assistance system was done by a special Product Development Group (PDG) within the PubTrans4All consortium. For achieving the best possible results, the interdisciplinary PDG consists of the big vehicle manufacturers Siemens and Bombardier, the railway departments of the TU Vienna and the University of Belgrade, the railway company BDZ from Bulgaria, the BAS manufacturer MBB Palfinger and the consultant company Rodlauer Consulting specialized in accessibility. The different design concepts that derived from two idea workshops of the TU Vienna and brainstorming and discussions in the consortium have been reviewed with the result that three concepts (parallel ramp, convertible step lift and elevator lift) should be verified by the Prototype Development Group more in detail. The PDG compared and evaluated the results of the technical feasibility studies of the three different variants and the technical conditions and constraints of common UIC wagons and modern wagons. The technical analysis of the PDG provided the result that a parallel ramp solution is not applicable for a height difference of more than 400 mm which is the case for classical UIC wagons and all other high floor trains. In accordance to the TSI-PRM the slope of a ramp should not exceed the maximum of 10.2 degrees (18%) due to the high force that is necessary to get into the train and the risk to fall over by alighting the train. Therefore a ramp for a train with a floor height of app. 1250 mm would require a length of more than 7 m. A ramp with a length of more than 7 m will be very complex to handle and to operate. Additionally, such a ramp would be very heavy in weight which makes manual or powered operation nearly impossible. As the ramp in case of operation should be used by all passengers or PRM it is possible that approx. up to ten persons could stand on the platform at the same time which potentially could cause a capacity problem for the system (> 1t). To allow a usage as described the design of the ramp must be very solid and therefore will be very heavy. After a detailed technical analysis the PDG came to the conclusion that a convertible step lift solution is also not applicable for classical UIC wagons and all other high floor trains due to the missing installation space under the steps in the entrance area of these trains. Usually this space is blocked by several other systems like the buffers, door guiding or electrical wiring (UIC wagons) or folding steps and coupling systems in high speed trains (HST). Furthermore, the installation of step lifts is only possible by cutting a hole in the car body under frame structure. This is usually impossible due to the high longitudinal tension force. Additionally a cut-out would weaken the strength of the car body structure which makes the installation of these lifts impossible in commuter or high speed trains. Moreover high efforts need to be spent for fulfilling the air pressure tightness requirements especially for HST. For the elevator lift the technical analysis of the PDG provided the result that such a solution is not applicable for the very narrow doors (width and height) which are used in classical UIC-coaches and all other high floor trains. Due to the linear movement and the height of the doors, the height in the elevator cabin will be less than 1600 mm so that it only can be used by wheelchair users or maybe sitting persons. Furthermore the system will constrain the interior design and the gangway of the wagon. Moreover the installation of an elevator lift will cause a considerable reduction of the usable door width so that the passenger flow will be disturbed and current standards (TSI) could not be fulfilled. Additionally, there is no possible space to stow the elevator lift in the entrance area or underneath the roof of classical UIC wagons and all other high floor trains. The floor and the roof area are usually used and needed by other technical installations. The detailed technical analysis of the PDG showed that all first three variants (parallel ramp, elevator lift and convertible step lift) are not applicable in classical UIC wagons as well as modern high speed trains.

Therefore new design solutions were derived from the results of the evaluation of existing BAS, the results of the students contest held by the TU Vienna and internal developments. All PDG participants concluded that for three new concepts (sloping mast lift, hinge lift and moveable twin pillar linear lift) feasibility test in a UIC coach should be done. During this phase the decision was made to concentrate on a solution for UIC coaches and therefore to adapt the design recommendations regarding platform width, capacity and other parameters. The outcome of the technical analysis of the PDG provided again the result that neither the sloping mast lift solution nor the hinge lift nor the moveable twin pillar linear lift is applicable for classical UIC wagons due to the missing installation space in the entrance area of these vehicles. An installation of one of these lift types would cause a considerable reduction of the door width so that the passenger flow would be disturbed and current standards (TSI) could not be fulfilled. However, the results of the detailed technical analyses illustrated that the layout of older UIC wagons and modern high speed trains that are designed for wheelchair users and other PRMs is nearly identical. Both of them have small doors with (800 to 900 mm) positioned at the end of the wagons. Because of the folding or sliding steps as well as other constraints there is no space under the door area for the installation of a BAS. Additionally, the space at the wagon end is occupied by mechanisms of the fire safety doors or other electrical components. Typical for these wagons is also that the passageway is at one side outside the longitudinal centre line of the wagon because of the toilet and cabins adapted for people with reduced mobility. Finally, there are only two potential positions left which could be used for stowing the BAS. These two positions can be seen in Figure 4 and are marked in green colour.

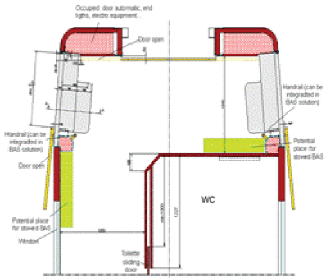

Fig. 4. Entrance area of a UIC wagon with possible installation space for BAS (green)

Source: Simic G. University of Belgrade

Due to the recommended space for a BAS it was decided to check the option of the installation of a swivel lift with a possible swivel radius of 180° and 270°. Although there were some technical constraints that had to be considered in detail, the PubTrans4All consortium voted for the 180/270° swivel lift solution as the best promising design concept for a prototype of a boarding assistance system for a UIC wagon and other high speed trains. Swivel lifts usually consist of a solid steel frame with a swivel arm and a vertical lift column like the example in Figure 5. The upstroke is generated by a hydraulic cylinder or an electrical spindle drive located within this column. The multi-piece lift platform is attached to the column and usually manually operated. The lifts are operated and supervised by a trained operator. The turning radius of the lift is adaptable to the individual requirements (e.g. 180°/270°) of the vehicle.

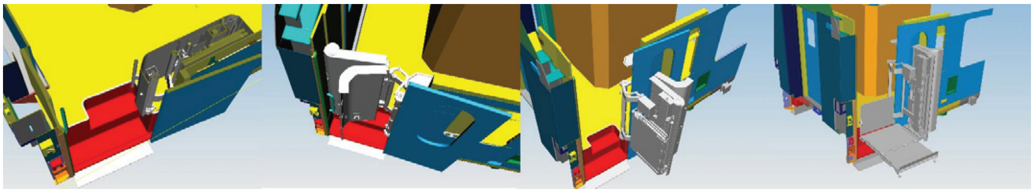

Fig. 5. Swivel lift operation 270°: parking position – swing-out – operating position (grey)

Source: MBB Palfinger GmbH

Furthermore, it is possible to board and alight the lift platform from the side which is helpful on very width limited platforms. Swivel lifts can be used in very narrow doors due to the very slim bracket which minimizes the door width only marginally. For more detailed information see also Deliverable 4.2 "Vehicle-Based BAS Preliminary Design Recommendations" (Behnken 2010). The installation of swivel lifts will usually not cause a reduction of the clear passage width (TSI requirement) so if the system is not used the passenger flow will not be influenced. Swivel lifts allow lifting heights of more than 1200 mm which will enable evacuation if the train is not situated in station (lifting from vehicle floor to rail track level). The lifts can be installed in nearly all standard doors avoiding the need for an extra door for PRMs and thus saves additional costs. The installation of swivel lifts in older or used vehicles is possible but may require adjustments that result in one-off-costs. Due to the installation in the entrance area of the train the design of the cover in stored position could be adapted according to the special design requirements of the vehicle manufacturer and/or operator. Although the decisions for the swivel lift design had been made by the consortium there are still many complex technical difficulties that need to be solved during the ongoing design and construction phase. The first difficulty is the optimisation of the dimensions (height, depth, width) including the optimisation of the weight. Another challenge is the opportunity to position the platform parallel to the train. Furthermore, the usability for all PRMs (not only wheelchair user but also persons with prams or walking sticks, elderly etc.), the automation (using the lift with less manual operation) and the avoidance of interference with the door mechanism must be considered and optimized for the prototype that should be presented to the public at the InnoTrans 2012.

References

Behnken D. (2010). "Vehicle-Based BAS Preliminary Design Recommendations". *Report for European Commission. Deliverable D 4.2*. Available from: http://www.pubtrans4all.eu/en/project69-downloads.html.

Rüger B., Tauschitz P., Petutschnig B. (2010). "Boarding Assistance System Evaluation Criteria Report". *Report for European Commission. Deliverable D 2.1.* 2010. Available from: http://www.pubtrans4all.eu/en/project69-downloads.html.

Rüger B., Tauschitz P., Petutschnig B. (2010). "Existing Boarding Assistance System Evaluation Matrix Report". *Report for European Commission. Deliverable D 2.2.* Available from: http://www.pubtrans4all.eu/en/project69-downloads.html.

Simic G. et al. (2010). "Recommendations for Improving Boarding Assistance systems". *Report for European Commission. Deliverable D 3.1.* Available from: http://www.pubtrans4all.eu/en/project69-downloads.html.