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Faculty of Mechanical Engineering University of Niš



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## RAILWAY VEHICLE ACCESSIBILITY

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**Abstract** – Regarding to EU regulations today's public transportation systems must be accessible for everyone without any restrictions. The involved group does not include only disabled people, but also elderly, passengers with baby carriages, big sized luggage etc. i.e. all people with some kind of reduced mobility. Assure accessibility for all is an inevitable future obligation for the railway operators. The interface between platform and rail vehicle is one of the largest problems particularly for wheelchair users. For most of the railway vehicles special boarding devices are required. To advance the actual situation a project consortium (PubTrans4All) founded by the EU within the FP7 will develop a new boarding assistance system that can be used not only by wheelchair users, but by a larger number of mobility reduced people.

**Keywords** - accessibility, vehicle entrance, boarding assistance device, people with reduced mobility

### 1. INTRODUCTION

The process of boarding rail vehicles consists of several connected steps: passengers must get to the rail station; they must get to the platform; finally, they must get from the platform to the rail vehicle. Once on the rail vehicle they must have an appropriate space to ride and access to various facilities. The process of alighting follows the same steps in reverse. The PubTrans4all project - founded by the EU within the 7th frame programme - focuses on the problems of the people with reduced mobility by getting from the platform to the rail vehicle. Main goal of the project is a better boarding assistant system (BAS).

#### 1.1. Main problem - existing high floor vehicles

The main accessibility problem for rail transport operators is that many old trains, suburban or tramway lines have significant vertical differences (e.g. steps) and horizontal gaps between rolling stock and platform. This problem is accentuated by the fact that rail rolling stock and infrastructure has a very long life. This means that operators will be using 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.

#### 1.2. Difficulties - huge variety of platforms and vehicles

In all cases it is difficult to develop a fixed 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 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. EVALUATION CRITERIA

The following chapter shows an overview about all relevant parameters, the „must haves“ and „nice to haves“ that must be considered when designing a new boarding assistant system. The evaluation criteria catalogue is a summary of all relevant parameters, criteria and frames. All criteria are defined in three levels (see Table 1). Features rated as not important, are not shown herein.

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Table 1: importance of criteria including score

Score	Meaning
1	Very important („must have“)
2	important („nice to have“ – high benefit for customers and operators
3	less important („nice to have“ – benefit for user and operator does exist, but is merely important)

Table 2: evaluation criteria - overview

Main criteria	remark	importance
<b>User</b>		
<i>User with devices</i>	wheelchair, walking frame, baby prams	1-2
<i>Physical impaired</i>	Walking disabled, with crutch or sticks, elderly, diminutive people	2
<i>User with special needs</i>	Visual and hearing impaired	2-3
<i>General passengers</i>	Passengers with luggage, children, pregnant	2-3
<i>Operation without staff</i>	Operation by passengers themselves, automation	2
<b>Operator</b>		
<i>Reliability of BAS</i>	Prevention of Malfunction	1
<i>Operational quality</i>	Short dwell time, defect must not have influence on the train operation	1-2
<i>Operational effort</i>	Number of staff	1-2
<i>Failure management</i>	Problems easy to solve	1
<b>Manufacturing/ Implementation</b>		
<i>Universalism</i>	The system needs to be universal, retro-fitting allowed	1-2
<i>Costs</i>	Keeping costs as low as possible	1
<i>Manufacturing effort</i>	The manufacturing effort needs to be low – especially when retro-fitting	1-2
<b>Safety</b>		
<i>Safety risks</i>	No safety risks to be tolerated	1
<i>Safety features</i>	Optical and sonic signals	1-2
<b>Maintenance</b>		
<i>Maintenance effort</i>	Number of personnel required, special tool required	1
<i>Costs</i>		2
<i>Sustainability</i>	recyclability and energy consumption	3

**Aesthetics**

<b>Optical design</b>	Aesthetics is important for customer acceptance	2-3
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All regulations must be fulfilled (currently according to TSI-PRM) as a minimum standard. Some specifications in project PT4All had been set-up more severely.

Table 3 shows the most important technical and operational frame conditions which must be considered when designing a BAS.

Table 3: Technical and operational frame conditions

Frame condition	limit
<i>Total duration → preparation, use, stowing</i>	< 2 min
<i>Platform width</i>	> 130 cm
<i>Vertical gap platform - vehicle</i>	< 110 cm
<i>Access door width</i>	≥ 80 cm
<i>Access door resting height from the floor</i>	> 174cm
<i>Capacity (wheelchair)</i>	350kg
<i>Relative angle platform-vehicle*</i>	< 13,2% or 7,5°

\* Transverse gradient of platform and super-elevation of track

**3. IMPROVING ACCESSIBILITY**

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 manually 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 the wheelchair users is expected to stop.

Advantage of all vehicle-based devices is that they are at disposal always in time, at right place and in all stations, because they are placed in the vehicle adapted for wheelchair users. It makes possible the ride of the people with reduced mobility even without an announcement of the ride in advance. This is very important for both: users and "accessibility for all" policy of the railway operators.

The supporting personnel can be usual conducting personnel, which is for operators more convenient than in case of platform-based BAS.

For each BAS there are two main technologies: ramps or lifts (elevators); and, there are manually or electro-mechanically operated ramps/lifts.

The following chapters will give a short overview

about existing systems that are used for typically high floor vehicles. All existing systems for low floor vehicles - like gap bridging systems - are not part of this paper.

### 3.1. Ramps

Ramps are generally the simplest and least expensive BAS devices. However, they can only be used if the vertical difference vehicle floor-platform is not significant (i.e. high), since otherwise the ramp slope would be too great to use safely, or the ramp should be very long. Most ramps cannot be operated without the assistance of rail operator staff.

There are five different types of ramp based BAS solutions: platform-based manual ramps, vehicle-based manual ramps, vehicle-based electro-mechanical ramps, vehicle-based horizontal gap closure ramps and platform-based horizontal gap closure devices.

#### 3.1.1 Platform-based Manual Ramps

This consists of a movable ramp located on station platforms. They require staff assistance to operate.

Manual ramps must have an ergonomic design both for the wheelchair users' comfort, but also to ensure good operating conditions for the train staff (weight, manoeuvrability, etc.). If the boarding assistance devices are easy to handle, staff will be more willing to use them.

Several rail transport operators use manually deployed ramps also for high floor vehicles.



Fig. 1. Ramp used in Belgium and the Netherlands - ramp goes around the corner



Fig. 2. Two rail ramp used in Norway - difficulties

The figures 1, 2 and 3 show some examples of platform based ramps that are also used for larger vertical gaps.



Fig. 3. Ramp used in Germany

#### 3.1.2 Vehicle-based Manual Ramps

Vehicle-based manual ramps are ramps that are located on the vehicles. They also require the assistance of rail operating company staff to deploy and use. The advantage of vehicle-based ramps is that they provide accessibility to all stations from the trains that have them installed since they are on the train. The ramps may be permanently attached to the vehicle or simply stored on the vehicle.

The figures 4 and 5 show some examples of vehicle based ramps that are also used for larger vertical gaps.



Fig. 4. Ramp used in Austria



Fig. 5. Ramp used in Latvia

### 3.2. Lifts

Lifts are mechanical lifting devices either attached to the vehicle or mobile lifts placed on the platform. Lifts are used in cases where slopes are too great for ramps.

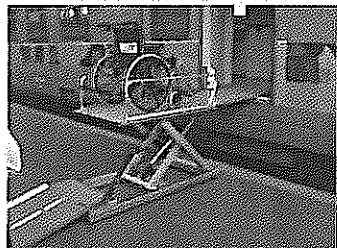
A key advantage of lifts is that they are very flexible. Platform-based lifts can adapt to almost all types of rolling stock and stations since they can be moved around on the platform and can bridge variable horizontal gaps and vertical changes. Similarly, vehicle-based lifts can adapt to many different platform heights.

### 3.2.1 Platform-based Lifts

These lifts are operated by the railway operator staff and are often pushed around the platform to the train door and then hand-cranked. Similar to manually deployed ramps, these lifts must be ergonomically designed, not only for the wheelchair user, but also for the staff who must move and operate the lift. The following figures show some examples of platform based lifts.



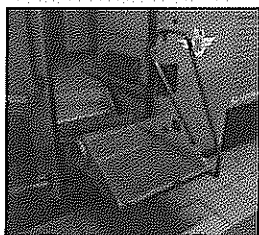
*Fig. 6. Platform based lift used in Germany*



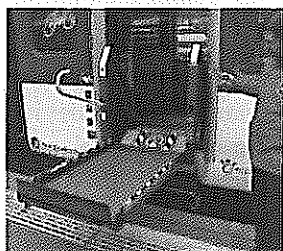
*Fig. 7. Platform based lift used in France*

### 3.3. Vehicle-based Mechanical Lifts

These consist of elevator platforms that extend from trains. They are normally operated by the railway operator staff.



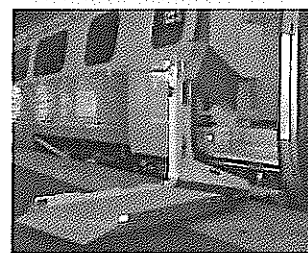
*Fig. 8. Vehicle based lift in Sweden*



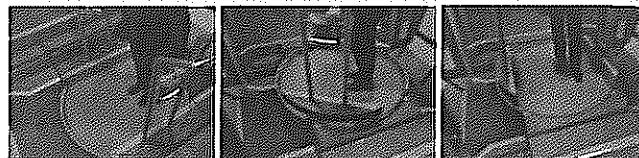
*Fig. 9. Vehicle based lift in Switzerland*

Like platform based lifts this BAS lets override difference in platform to vehicle floor heights of 1100mm or even more. 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 with parallel to train boarding and alighting exist also.



*Fig. 10. Vehicle based lift in Sweden*



*Fig. 11. Vehicle based lift in Sweden - Regina train*

With vehicle based mechanical lifts an additional advantage is the possibility to evacuate wheelchair users in extraordinary conditions even on the track without platform.

Vehicle-based mechanical lifts need a source of energy. Two devices, one per each side of the vehicle are necessary. Wheelchair platform of the lift must be a little bit narrower than the door width. Lifts occupy some place along entrance doors, which is most problematic in classical UIC wagons.

Figures 8, 9 and 10 show examples of the vehicle based lifts. Figure 11 shows an interesting example of a rotating lift inside of the vehicle.

## 4. CONCLUSIONS

With intention to develop an improved boarding assistance system and facilitate accessibility of railway vehicles, consortium of the EU FP7 project PubTrans4All started by building evaluation criteria for both, existing and new BAS.

A comprehensive research work across the Europe and the world in collecting the data about existing BAS and their evaluation was the next step.

The results of these steps shown in this paper illustrate complexity of different vehicle and platform conditions, which make difficult to find a universal and standardised solution of BAS.

The project will focus on the most difficult case of accessibility of the classical UIC wagons expecting that the solution for these vehicles will be most universal and usable on other rail vehicles too.

## REFERENCES

- [1] All shown data, figures and information has been collected by the consortium PubTrans4All per in situ visits and email-questionnaires.