Improving Railway Vehicle Accessibility for all Persons with Reduced Mobility

1. INTRODUCTION

EU regulations require that public transportation systems are accessible for everyone without any restrictions for People with Reduced Mobility. This does not only refer to disabled people, but also other groups of people with reduced mobility such as elderly people, passengers with baby prams, outsize and large luggage items etc. i.e. all people with some kind of reduced mobility, in order to assuring that accessibility for all is an inevitable future obligation for railway operators. The interface between the platform and rail vehicle itself is one of the largest railway challenges in terms of accessibility, particularly for wheelchair users.

The interface between platform and vehicle is one of the key areas of potential difficulties in regards to accessibility. Most of the existing boarding assistance devices are designed for wheelchair users, whereas a variety of many other groups of passengers do also have special needs and expectations regarding the boarding process on a train. In order to improve the existing situation, a project consortium approved by the European Commission within the 7th Framework Programme (PubTrans4All), will develop a new boarding assistance system that can be used by a larger number of mobility reduced persons than it is the case today.

The reseaerch methods which have been applied in this project had been performed through conducting personal interviews amongst experts throughout Europe by interviewers being experts themselves in the field of accessibility, interviewing the key-representatives of railway operators, e.g. ATOC Association of Train Operating companies U.K., as well as talking to representatives from user-groups and professional organisations such as the british Department for Transport in London and RSSB, UK Campanions of SNCF/RATP France as well as with representatives of the “Accès Plus” Accessibility Programme of SNCF. In order to find out about their professional experiences and personal views, in depht questions had been asked in regards to daily real-life experiences with the various boarding assistance systems being in use across Europe.

Also quantitative research methods had been applied, by conducting a survey amongst 5.000 train users for creating a better understanding for the basic needs of Persons with Reduced Mobility, and by including various European railway-regions and evaluating their experiences when facing different environmental conditions within the specific regional railway-environment, as well as doing a research on the daily use of various different types of Boarding Assistance Systems in Europe.

2. BOARDING SITUATIONS DURING THE BOARDING PROCESS

The difficulties that passengers face during the boarding process of a train within different boarding situations, such as different types of vehicles in combination with different platforms heights - can be categorised as follows:

2.1. Different platform high

Fig. 1 shows the variety of platform heights that do exist in Europe. The common standards within the EU member States is 550mm and 760mm. Many new vehicles, especially in local traffic, have got a vehicle floor height of about 550mm. This situation allows level boarding. Also double-deck trains offer level boarding for those platform heights. They can also be used for long distance InterCity-traffic. Platform heights of 760mm is typical for highspeed trains. Usually there are only two remaining steps. Some highspeed trains have got a lower vehicle floor, like the TGV or Spanish Talgo-trains, where passengers only do have to pass one step, or to are provided with a level boarding situation.

The huge variety of different platform heights in Europe causes most of the difficulties in regards to the standardisation of vehicles and boarding assistance systems. For example level boarding in a station in one country can potentiallyy mean one or two steps to be overcome in a station in another country.

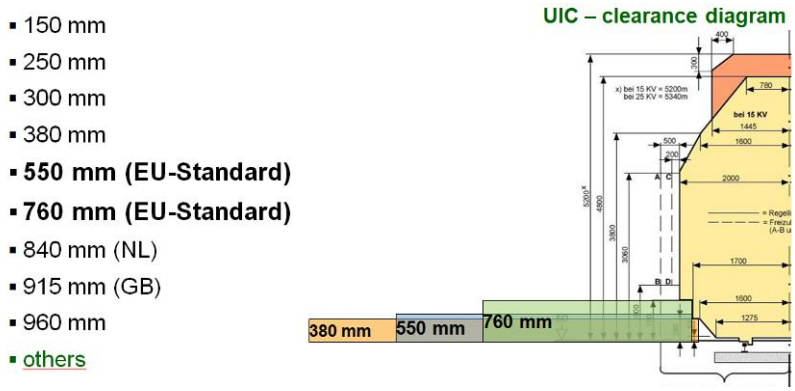

Fig.1. Variety of typical platform high in Europe – combined with the UIC clearance diagram

Source: Accessibility – Vehicle Manufacturer's Requirements,Helmut-Franz Wieder, Martin Kollmann Siemens AG Österreich – Engineering Metros & Coaches, Conference Public Transport – Accessibility for All, Vienna, May 2010

2.2. Difficulties for passengers during the boarding process – Access categories

Fig.2 to Fig.5 are showing combinations and the connection between parameters such as access type, luggage and passenger-age:

Cat 1: Level Boarding or one stair step to be overcome at the max.: travellers of all ages, with or without luggage, rarely have difficulties.

Cat 2: Access with two stairs, wide doors and stairs with flat angles: travellers with luggage independently from age do rarely have difficulties when accessing the vehicle. Nevertheless more than 10% of travellers with luggage do have severe and very severe difficulties, of which 7% do need assistance.

Cat 3: Access within UIC wagons and related trains (3 stairs from platform): Between 10-15% percent of travellers have difficulties or a lot of difficulties when accessing the train without luggage, and 25-30% when having luggage. Whereas only between 1% and 2% need assistance for themselves, more than 10% need assistance for their luggage.

Cat 4: Old-type vehicles, steep stairs (3-4 stairs from platform): 20-30% of travellers do have difficulties and severe difficulties without luggage, and 50% of travellers with luggage, this group includes up to 20% of passengers that have a lot of difficulties. Approximately 20% of travellers having luggage do need assistance. Approximately 8% amongst the group of 40 to 59 year old, and approximately 20% amongst the group of over 60 year-old, require personal assistance when accessing the vehicle.

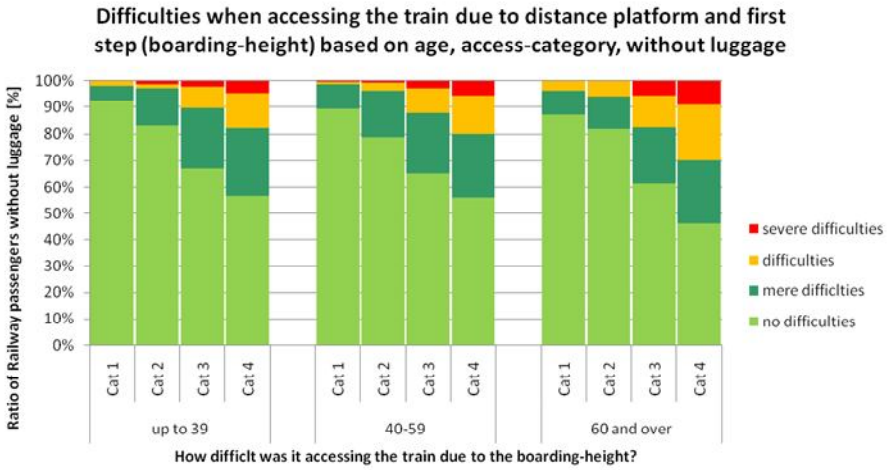

Fig.2. Difficulties of passengers WITHOUT luggage when accessing the train

Source: Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Boarding Assistance System Evaluation Criteria Report, Delliverable 2.1, June 2010. EU-FP7-Project Public Transportation – Accessibility for all

Fig.3. Difficulties of passengers WITH luggage when accessing the train

Source: Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Boarding Assistance System Evaluation Criteria Report, Delliverable 2.1, June 2010. EU-FP7-Project Public Transportation – Accessibility for all

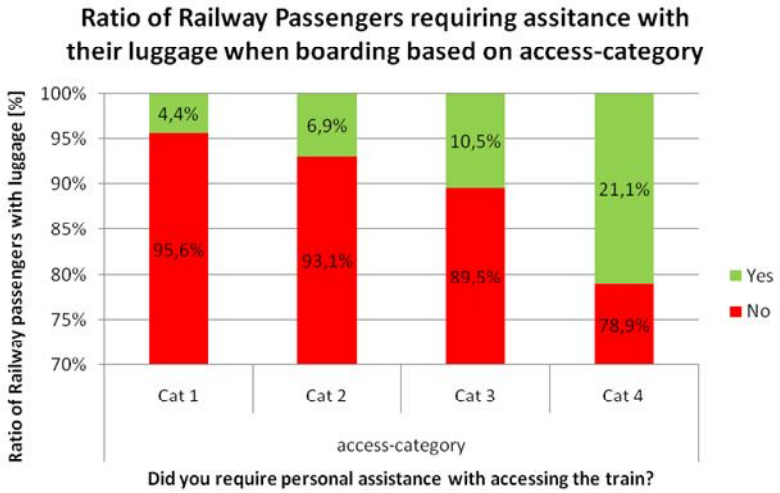

Fig.4. Required assistance when boarding with luggage based on different access-categories

Source: Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Boarding Assistance System Evaluation Criteria Report, Delliverable 2.1, June 2010. EU-FP7-Project Public Transportation – Accessibility for all

Fig.5. Required personnel assistance when boarding based on different access-categories and age

Source: Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Boarding Assistance System Evaluation Criteria Report, Delliverable 2.1, June 2010. EU-FP7-Project Public Transportation – Accessibility for all

The survey clearly shows that the great part of the travellers have no problem when using an access with no step or with even one step. In situations in which two steps need to be overcome in combination with luggage, the difficulties are growing rapidly.

2.3. Wish of technical assistance for the boarding process

For a better understanding of the difficulties that passengers face, it has also been asked if they prefered to get technical help to facilitate the boarding process, such as ramps or lifts.

In situations of level boarding and boarding situations with only one stair, almost no passenger would make use of a technical aid. Regardless the luggage situation, 14% of men would use a technical accessibility aid, and 17% of women would make use of it when using a classic train (see Fig.6).

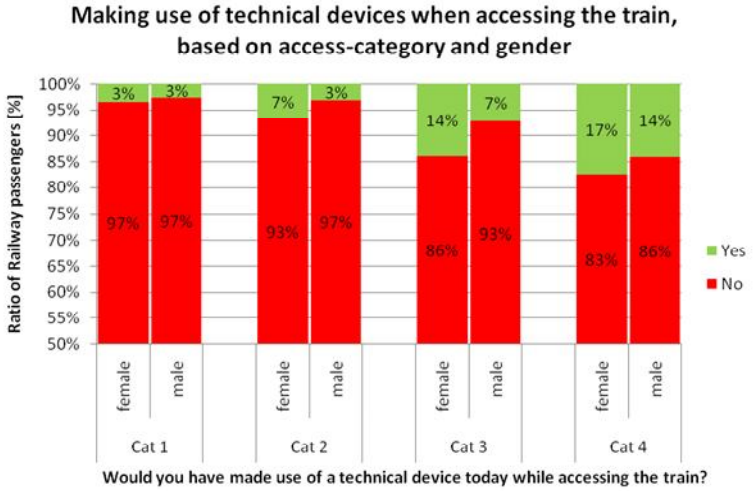

Fig.6. Wish of making use of a technical device, based on the access-categories and gender

Source: Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Boarding Assistance System Evaluation Criteria Report, Delliverable 2.1, June 2010. EU-FP7-Project Public Transportation – Accessibility for all

3. BOARDING ASSISTANCE

As shown above in fig.6 many passengers would prefer to get assistance when boarding a train. Most of the non-disabled passengers whishing help have problems with luggage. There are two ways of providing assistance. It can be either offered through personnel assistance, i.e. trained staff helping

passengers with their luggage, baby prams etc., or elderly people when boarding, or it can be offered by applying a technical device such as a boarding assistance system like a lift or ramp. In most cases personnel assistance can be prefered because it's much quicker compared to technical devices and can be offered to many more passengers. In some cases, especially for wheelchair users, or persons with severs walking disabilities a technical aid such as a boarding assistance system is essential.

3.1. Main challenge - existing high floor vehicles

The main accessibility problem for railway operators is that most old classic trains, e.g. UIC wagons, as well as some suburban or tramway lines have significant vertical differences, between one and very often three or four steps, as well as horizontal gaps between the vehicle and the platform. These difficulties within the infrastructure are accentuated by the fact that rail rolling stock and general railway infrastructure have a very long service life both. Railway operators will use their current rolling stock for many more years to come and therefore, temporary solutions must be found until the fleet will be replaced with modern fully accessible rolling stock.

3.2. Challenges for the railway infrastructure and rolling stock

The technical and operational environment of a boarding assistance system and its capabilities under which it needs to perform are considered within the PubTrans4All project, as well as the important role of an effective, universal retro-fit Boarding Assistance System. Both criteria are being evaluated from an operators´ and manufacturers´ perspective, e.g. environmental conditions, time and space required for the operation and installation of the boarding assistance system. The main focus is on conventional heavy rail high-floor vehicles of the exisitng rolling stock. Light rails and tramways within local traffic are less important in terms of the need of Boarding Assistance Systems, as they are usually "closed systems", providing the same platform height and same type of vehicles throughout the infrastructure which either offers level boarding or will do so in near future when the infrastructe is getting adapted accordingly. In most situations "simple" gap closing systems, from a technical point of view, lead to perfect boarding situations.

For heavy rail it is difficult to develop a standard "one-fits-all" boarding assistance system as a universal accessibility solution due to the huge variety of differences within rolling stock and platform heights. Even amongst one particular rail line several different types of rolling stock are sed quite often, 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 also need to consider a safety margin between the train and platform to account for train rocking etc. Finally, technical accessibility devices must work under all types of environmental conditions, e.g. rain, snow, frost, etc.

4. EVALUATION CRITERIA FOR BOARDING ASSISTANCE SYSTEMS

The PubTrans4All-Consortium developed an evaluation criteria catalogue of all relevant parameters that need consideration when designing a new boarding assistance system. The following tables give a summarised overview of the evaluation criteria. Features rated as not important, are not shown herein.

4.1. User related criteria

Table 1 shows the neccesity of having boarding assistance for different groups of passengers.

For wheelchair users, and also some groups of people with walking disabilities. like people being depended on walking-aids such as walking frames, technical boarding assistance systems are a must in order to be able to board a high-floor vehicle.

For most other passengers it would be a "nice to have" to make use of a Boarding Assistance System. These groups, i.e. passengers with luggage or baby prams, persons with walking disablities, which are the absolute majority of passengers. On one hand this leads to the fact that these groups also need be content when using a train, and especially while boarding, on the other hand it is not possible to offer technical devices which require a longer operational time, and do block the entrance for other passengers like lifting devices, normally being used for wheelchair users only.

For the big group of travellers explained before personnel assistance is ideal because only passengers needing help will call on it, as also staff can act flexible and quickly. The ultimate solution, as ideal for all passenger-groups, is a level boarding situation. Technical devices like automatica gap bridging systems, or occassionally also short ramps can also be used for all passengers without causing any train delay.

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

Table 1: Boarding assistance – for different user groups

Source: Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Boarding Assistance System Evaluation Criteria Report, Delliverable 2.1, June 2010. EU-FP7-Project Public Transportation – Accessibility for all

Another user-related criteria is automatisation. The possibility of operating boarding assistance systems automatically scores as “impotant”. Automatisation means that the system either works automatically in each and every station (e.g. folding steps or gap bridging systems), or can be operated by the users themselves. The difficulties of offering systems operated by the users are not due to technical reasons, but reasons for safety and legal issues.

4.2. Operator and manufacturer related criteria

Table 2 shows an overview of the importance of different criteria that a boarding assistance device must fulfill, e.g. technical features, from the operators’ point of view. Most criteria are evaluated as “very important” by the operators, especial a high level of reliability, operational quality, easy maintenance, low costs, and no safety risks are scoring high as very important.

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 TSI-PRM must be fulfilled as a minimum standard. Some specifications in project PT4All have been set higher and in more detail than the minimum requirements as	

specified in the current version of the TSI PRM.

Table 2: operator and manufacturer – evaluation criteria

Source: Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Boarding Assistance System Evaluation Criteria Report, Delliverable 2.1, June 2010. EU-FP7-Project Public Transportation – Accessibility for all

4.3. technical and operational requirements

Table 3 presents the most important technical and operational requirements that must be considered when designing a boarding assistance system.

Framework Requirements	limit
Total duration for use preparation, use, stowing	< 2 min
Platform width	> 130 cm
Vertical gap platform – vehicle, (more in case of a emergency evacuation outside a station)	< 110 cm
Access door width	≥ 80 cm
Access door clear height measured from floor-level	> 174cm
Capacity (wheelchair&occupant,), including state-of-the-art power-chairs	Max. 350kg
Relative angle platform-vehicle*	< 13.2% or 7.5°

* Transverse gradient of platform and super elevation of track

Table 3: boarding assistance system technical and operational requirements

Source: Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Boarding Assistance System Evaluation Criteria Report, Delliverable 2.1, June 2010. EU-FP7-Project Public Transportation – Accessibility for all

5. IMPROVING THE VEHICLE ACCESSIBILITY SITUATION ON ROLLING STOCK

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

Platform-based systems are usually manually operated devices being simple to apply. At least one device is needed at each station that is usually only suitable and designed according to wheelchair user's specifications and needs. One person per station should be available as boarding assistance system operator. Before the train arrives at the station, the boarding assistance system must be moved to the exact position on the platform where the adapted vehicle 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) as they are stored on the train-vehicle. This enables people with reduced mobility to travel even without making travel-arrangements in advance. This is very important for both the users and the accessibility policy of the railway operators.

The on-board conductors are trained to operate this kind of boarding equipment, which is more convenient for operators than the use of platform-based boarding assistance systems.

For each boarding assistance system there are two main technologies: ramps or lifts; and, two sources of powering them, manual or electro-mechanical.

A short overview of existing systems that are typically used for high floor vehicles is given in the following chapters. Existing systems for low floor vehicles, i.e.. gap bridging systems, are not part of this project.

5.1. Ramps as Boarding Assistance System

Ramps are generally the simplest and least expensive boarding assistance devices. However, they can only be used if the vertical difference between vehicle floor-platform is not significant, typically not more than 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.

There are five different types of ramp based boarding assistance systems solutions: platform-based manual ramps, vehicle-based manual ramps, vehicle-based electro-mechanical ramps, vehicle-based and platform-based gap-bridging devices to close horizontal gaps only.

5.1.1 Manual Ramps - platform-based applications

A movable ramp is usually located on the station platform and requires staff assistance to be operated.

Manual ramps must have an ergonomic design, both for the wheelchair users' comfort and also to ensure good operating conditions for the train-staff such as weight, manoeuvrability, etc. If a boarding assistance system is easy to handle, staff will be more willing to use it. Fig.7 shows an example of platform based ramps as used in Norway.

Fig.7 Platform based Ramp NSB, Norway

Source: Bernhard Rüger, Vienna University of Technology

Several railway transportation operators are using manually deployed ramps for high floor vehicles also, although ramps do have their technical limits.

5.1.2 Manual Ramps - vehicle-based applications

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.

Fig.8 shows the example of a vehicle based ramp used for bridging vertical gaps, and height differences where needed. Such short ramps can theoretically be used by all passengers. Some operators in Europe, and all operators in the UK, for example provide such easy to handle ramps in each station. The main advantage of manual, vehicle- or platform-based ramps,is that many passengers, other than PRMs, are using that particular entrance for their convenience, as the provided ramp is more comfortable than taking an entrance with a step, or more than one. The ramp as shown in Fig.8 can be stored on board but also on platforms.


Fig.8: Manual mobile Ramp (Port-a-Ramp, UK), bridging the gap between the train and the platform (South Eastern Trains, England)

Source: Bernhard Rüger, Vienna University of Technology

5.2. Lifts as Boarding Assistance System

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 but also on very narrow platforms on low floor vehicles if ramps are too long.

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.

5.2.1 Lifts - platform-based applications

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. Fig. 9 shows an example of platform-based lifts.


Fig.9. Platform based lift used in Switzerland (and many more countries)

Source: Bernhard Rüger, Vienna University of Technology

5.2.2 Mechanical Lifts - vehicle-based applications

They consist of elevator platforms that deploy and unfold from the train, and are operated by the railway operating staff only, due to a complex lift operation, and the operator´s legal responsibility in order to avoid potential injuries.

.This boarding assistance systems can be used to provide access for differences in platform to vehicle floor heights of 1100mm, which is more than a platform-based lifts can manage. Usually this type of

boarding assistance systems requires a sufficient width of the platform in order to provide enough space for entering the lift platform safely with the wheelchair, but less than platform based lifts. Exisitng vehicle-based lifts designed for a boarding and alighting process parallel to train are suitable for narrow platforms, which ultimately enhances passenger flow.

An additional advantage of most 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 must be provided, one on each side of the vehicle. The measurements 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 UIC wagons since space is at a premium. Fig.10 shows examples of vehicle based lifts.

Fig.10. Examples for vehicle based lifts in Norway, Switzerland, Sweden and Germany

Source: Bernhard Rüger, Vienna University of Technology, and MBB-Palfinger

A combination of results from the PubTrans4All research and relevant European projects was taken into consideration, as well as European or national regulations etc., in order to come up with a comprehensive overview on recommendations based on existing Boarding Assistance Systems. E.g., the analysis of the accessibility situation on UIC wagons shows that there are no existing boarding assistance systems solutions on passenger coaches with doors of 800mm width located at the end of the vehicle, which is a very common situation with existing UIC type coaches, and represents one of the technical restrictions and main design challenges ahead.

6. CONCLUSION

Today accessibility is a must for each railway operator – not only because of regulations. One special barrier is the link between the platform and the wagon. Two possibilities are state of the art – either level boarding which means accessibility and advantages for all passengers and the operator, i.e. shorter boarding time, or classical high-floor railway coaches fitted with steps, which represent boarding and alighting problems for mobility impaired people. The second case will be an ongoing situation within the next decades in the field of long-distance travelling, especially in high speed traffic. Here we need some kind of boarding assistance devices to make vehicles accessible, especially for wheelchair users. A variety of types of railway vehicles and the variety of platform heigths lead to the today's situation of having various different solutions for making boarding accessible. The PubTrans4All project tries to find a standardized boarding assistance device that can be implemented in as many coaches in Europe as possible and can be used at a variety of different platform highs. Additionally the project tries to find a technical solution for as many of the users as possible.

7. OUTLOOK

The goal of the PubTrans4All project is to develop an improved boarding assistance system, in order to facilitate the accessibility of railway vehicles. The project is being completed as part of the EU Commission's 7th Framework Programme.

The project's first step completed was the development of evaluation criteria for both existing and new boarding assistance system to be designed. The second step was the completion of a comprehensive

research study about existing boarding assistance systems across Europe and the world, and finally to evaluate these boarding assistance systems and apply those criteria accordingly.

The results of these activities illustrate the complexity of developing a universal and standardised boarding assistance system solution which shall work for as many types of vehicles and platform conditions as possible.

The project focuses on the most difficult scenarios of accessibility situations for classic UIC wagons, expecting an effective solution for these vehicles, being universal and covering most other types of rail vehicles as well.

By creating an “Existing Boarding Assistance System Evaluation Matrix Report”, the evaluation and assessment of existing solutions has been performed. Further steps included the definition of recommendations and requirements for new boarding assistance system for existing UIC type vehicles, provided and developed by a task-force, the “Prototype Development Group of the FP 7 PubTrans4All Project”, consisting of the Vienna University of Techology and University of Belgrade, industrial manufacturers such as MBB Palfinger as the developper of the Boarding Assistance System, Bombardier and Siemens for the train-vehicle side, BDŽ, the bulgarian passenger railway operator, and Rodlauer Consulting, project coordinator. A final Prototype Solution will be presented at the Innotrans 2012.

Authors:

Dr. Bernhard Rüger, Benjamin Petutschnig, Vienna University of Technology - Faculty for Zivil Engineering, Institute of Transportation - Research Center for Railway Engineering, Viennam Austria, bernhard.rueger@tuwien.ac.at; benjamin.petutschnig@tuwien.ac.at

Prof. Dr. Goran Simic, University of Belgrade - Faculty of Mechanical Engineering, Belgrade, Serbia, gsimic@beotel.net

REFERENCES

[1] Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Boarding Assistance System Evaluation Criteria Report, Delliverable 2.1, June 2010. EU-FP7-Project Public Transportation – Accessibility for all

[2] Rüger B, Tauschitz P, Vienna University of Technolgy; Petutschnig B - BP International Consulting, Existing Boarding Assistance System Evaluation Matrix Report, Deliverable 2.2, August 2010. EU-FP7-Project Public Transportation – Accessibility for all