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IMPROVING RAILWAY BOARDING ACCESSIBILITY

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Abstract. *Regarding the EU regulations, the present public transportation systems must be accessible for everyone without any restrictions. The relevant question is: how can trains be accessible to everyone? A huge variety of different vehicles and different platforms does not allow level boarding everywhere, but only in the so-called "closed" systems. In all other situations some technical aids for the people with reduced mobility are needed. The paper gives an overview of the requirements for new boarding assistance systems as well as of the recent results in development of the lift system for UIC-coaches within the EU-cofounded project Public Transportation Accessibility for All (PubTrans4All).*

Key Words: *Accessibility, Rail Vehicles, Barding As, Wheelchairs*

1. INTRODUCTION

The public rail systems accessibility requires accessible infrastructure and accessible vehicles. Still, this is not enough since the platform heights at stations served by one vehicle can be very different thus presenting a severe boarding or alighting problem for people with reduced mobility (PRM).

Usually it is only the closed rail systems such as, for example, metros, that can offer complete level boarding which is the best accessibility solution for all categories of the people with reduced mobility; it also offers the quickest exchange of travelers. In all other cases, especially for wheelchair users, the boarding assistance systems (BAS) like ramps or lifts are needed. Research within PubTrans4All-project reveal that the worse accessibility is in older railway rolling stock and, within them, in coaches built according to the

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regulations of the International Union of Railways (so called UIC[1] coaches). Therefore, the main project goal is to build a prototype of the BAS for this type of vehicles.

2. General Requirements for a New Boarding Assistance System

In order to identify all relevant parameters, build evaluation criteria and stipulate general requirements that must be considered when designing a new boarding assistance system different methods are used, namely: survey and assessment of the existing BAS [1], international student competition for new BAS ideas, a survey amongst 5.000 train users in seven European countries, organization of an accessibility expert conference as well as personal interviews with accessibility associations and railway operators throughout Europe.

Table 1 BAS evaluation criteria - overview

Criteria	Remark	Importance
	User	
User with devices	Wheelchair, walking frame, baby prams	1-2
Physically impaired	Walking disabled, with crutch or sticks, elderly, diminutive people	2
User with special needs	Visual and hearing impaired	2-3
General passengers	Passengers with luggage, children, pregnant	2-3
Operation without staff	Operation by passengers themselves, automation	2
	Operator	
Reliability	Prevention of Malfunction	1
Operational quality	Short dwell time, malfunctions must not influence train operations	1-2
Operational effort	Number of staff	1-2
Failure management	Problems easy to solve	1
	Manufacturing/ Implementation	
Universalism	The system needs to be universal, retro-fitting allowed	1-2
Costs	Costs as low as possible	1
Manufacturing effort	The manufacturing and retro-fitting effort needs to be low	1-2
	Safety	
Safety risks	No safety risks to be tolerated	1
Safety features	Optical and audio signals, foot entrapment protection, anti slip surfaces,…	1-2
	Maintenance	
Maintenance effort	Number of personnel required, special tools required	1
Costs		2
	Aesthetics	
Optical design	Important for customer acceptance	2-3
All regulations must be fulfilled (currently according to TSI-PRM[2] as minimum standard)		

[1] UIC-Union Internationale des Chemins de Fer

[2] Technical Specifications for Interoperability for People with Reduced Mobility - adopted by the European Commission resolution

A short overview of the most important evaluation criteria that result from these activities is presented in Table 1. The importance scores of different requirements are used in order to rank the evaluation criteria. Features rated as unimportant are not shown herein. In column "importance" the notes mean:

1 – Very important – critical to successful operation ("must have")

2 – Important – high benefit for users and operators ("nice to have")

3 – Less important – some benefit for users and operators, but not absolutely necessary

The best practice recommendations for improvement of the existing BAS usage as well as for building or acquiring of new BAS systems are also important results of the project [2].

3. DECISION MAKING PROCESS

At the beginning of the project the project consortium consciously set the bar very high with the aim to find a technical solution for accessibility for all passengers in all boarding situations.

After a long research and discussion process, the consortium concluded that many restrictions are necessary and the all-in-one solution is not possible.

For all local systems (including tramways, metros, urban and suburban railway traffic) a newly developed BAS is neither necessary nor meaningful. All these systems can be seen as so called "closed systems". Here the operators provide vehicles which correspond to the existing platform height or plan to adapt the platforms and/or their vehicles to achieve level boarding. The remaining horizontal gap between the vehicle and the platform is bridged by relatively simple technical aids.

High speed, long distance and international railway traffic will not be able to offer level boarding. The first reason is a higher floor. The lowest floor height in high speed trains is offered in Talgo-trains (760mm). All other vehicles have got higher floors.

The second reason comes from TSI regulations in which two different platform heights are defined as European standard (550mm and 760mm). The consequence is that for the next decades all international trains will have to stop at both levels!

The investigation has also shown that within the next decades a huge number of high floor vehicles will run in European countries in long distance traffic. Due to the long life cycle of railway vehicles they cannot be changed in a short or medium term.

So the decision is to develop a BAS for all types of high floor vehicles. In general there are four possibilities – ramps or lifts, platform or vehicle based.

The operators' surveys clearly show that operators strongly wish to have vehicle-based BAS systems. Two reasons can be identified for that. Firstly, operators want to be independent of the infrastructure and want to offer the possibility of accessible boarding everywhere. Secondly, it is very difficult to provide for a platform-based device at all (!) platforms in a railway network.

By comparing the advantages and the disadvantages of the ramps and the lifts it becomes clear that for high floor vehicles the ramps should be very long and it is not possible to find a technical solution for installing such a ramp into existing vehicles. Only different types of lifts are left in focus.

For the next steps of development two decisions are necessary, namely, it is essential to define the user and to decide which vehicles are relevant.

The investigations show that for all types of high floor trains with an entrance door width of at least 900mm, different lift systems already exist.

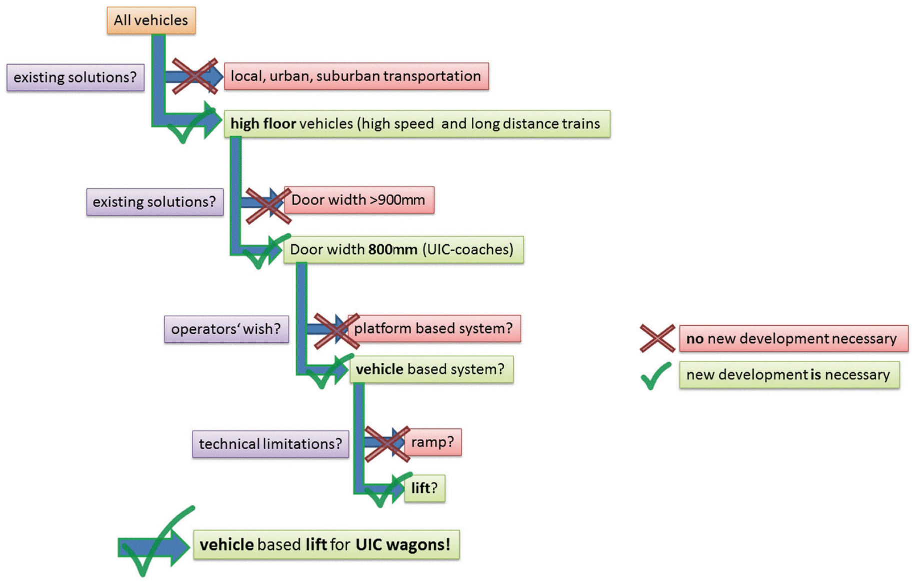

Fig. 1 Decision making process

But there is one very big group of high floor railway vehicles in Europe, the so called UIC-coaches. They will be running in many European countries for some decades more and in many countries form the backbone of the long distance railway traffic, especially in eastern European countries. UIC coaches have small doors with a width of only 800 mm with limited space in the entrance area. At the moment there is no vehicle based BAS for UIC coaches and only platform-based lifts can be used for boarding/alighting of wheelchair users. Therefore, the consortium has come to the decision that the most important step to offer accessibility to all is to focus on UIC-coaches.

With regard to the user requirements, the wheelchair users are the only passengers for whom a technical solution is an absolute must. For many other groups it would be very nice to have some technical devices. But if it is not feasible, then other solutions like special services at entrance door well established in some European countries are acceptable and can be further improved.

At the end of the decision process, it has turned out that the most important case is to develop a vehicle-based lift for UIC-coaches. Since there are many restrictions because of the vehicle design, it is necessary to define some compromise design solutions

4. Technical Requirements for a Lift for UIC Wagons

A large number of technical requirements for the lift implementation into UIC coaches has been identified during the project research. A short list of most important of them is shown in Table 2.

Table 2 Technical requirements for lift

Characteristic	Value	Comment
Carrying capacity	300kg	Covers 99% of wheelchair users
Minimum clear width of lift platform	720mm	Covers 96% of wheelchair users
Minimum platform length	1200mm	
Maximum working height difference vehicle floor-platform	1300mm	
Boarding/alighting parallel to the vehicle (required for narrow platforms)	recommended	Alternatively, exit sideways through lay down of the side fenders
Handrail bound to the platform on one side, should be at the height of	650 to 1100mm from platform level	
Finger pressure for activation of control buttons	≤ 5N	
Manual force to operate the lift by staff	≤ 200N	For example for emergency mechanical activation.
Manual force to operate the lift by staff at movement start	≤ 250N	Allowed only for short period at the start. For example for emergency mechanical activation.
Vertical speed in the operation	≤ 0.15 m/s	Movement should be smooth
Speed of any point of BAS without load	≤ 0.2 m/s	Up to 0,6m/s allowed by EN 1756-2. TSI PRM: maximum speed without load less than 0,3m/s is recommended.
Acceleration during operation with load in any direction and at any point of the lift platform	≤0.3 g	
Tilting speed of the lift platform	≤ 4o/s	In case of automatic adaptation to the relative angle between vehicle and platform, for example at superelevated track by platforms in curves.
Automatic roll-off protection height	≥100mm	The barrier in front and at rear side of the wheelchair lift platform should be automatically erected during lift operation.
Lateral side guards height:	≥25mm min ≥50mm preferred	Prevention of the wheelchair side roll-off from the lift platform
End of travel mechanical limitation devices	yes	
Overload protection of the main power electrical circuit	yes	Fuse, an overload cut-out or similar

Table 2 Technical requirements for lift (continuation)

Characteristic	Value	Comment
Mechanical securing devices against uncontrolled displacements in stowed position should be dimensioned according to the accelerations:	$a_{longitud.}$=5g $a_{lateral}$=1.5g $a_{vertical}$=1g	These accelerations can arise in the exceptional case of occasionally buffing impact at coach staying in yard (without passenger) (UIC 566)
Activation possible only at:	V = 0 km/h.	
Activation of the BAS should introduce activation of the coach brake system.	yes	Movement of the train during BAS usage must be prevented
The lift platform surface should be smooth and must have slip-resistant surface	yes	Slip resistance according to EN ISO 14122-2.
Minimum safety coefficient against yield strength	2.1	
The warning features should be fitted at edges that can come in contact with persons or injure passengers or personnel.	Yes	light / reflective stripes / reflective markings, visible at night also
The operation control should be of type hold-to-run.	yes	Lift shall stop moving and remain motionless after the control is released.
In any case of breakdown, it is acceptable that platform may decrease with controlled speed:	≤ 0,165 m/s	For example in case of the hose or pipe failure by hydraulic systems or similar.
Controls shall be designed to avoid unintentional lift actions.	Yes	Recessed or covered buttons, etc.
A stop in overload protection should be present at overload more than	25%	
An emergency stop button within reach of the user should be present	yes	Release of the emergency stop button should only be possible by the personnel
Additional protecting measures like obstacle detector, foot entrapment protection etc.	Recommended	Although control of hold-to-run principle is used additional measures are recommended
Other technical details not covered in this table should be based on:	TSI PRM, EN 1756-2, RVAR	

5. Design and Testing

Since there are many restrictions because of the vehicle design, it is necessary to make compromise solutions for few stipulated requirements.

The UIC coaches have doors located at the ends. Because of the folding or sliding steps, vicinity of the buffers as well as other constraints, there is no space under the steps for the installation of a BAS. The space at the entrance is occupied by mechanisms of the head doors leading to the next coach, some electrical and pneumatic components, handbrake, firefighting equipment, etc. Typical for these coaches is that the passageway is in majority cases on one side outside the longitudinal center line of the vehicle because of the neighboring toilet cabins.

After analyzing several lift types the only feasible solution is a swivel lift. This lift type used in some other applications of consortial partner and lift manufacturer MBB has recently been designed to meet the limited space conditions in entrance area of UIC coaches. The design width in the stowed position is reduced to the required aisle widths inside the car needed for free passage of wheelchair. The swivel mechanism has to be redesigned for the lift to pass through doors of 800mm in width. The lift sliding pillar geometry is adapted to allow for the lift to pass the foldable step in its opened position.

The UIC coach of the Bulgarian State Railways provided for lift prototype installation has also to be adapted. The rod as a mechanical connection between the door mechanism and the foldable step should be removed and replaced by pneumatic drive for the foldable step in order to leave enough space for lift mechanism. Appropriate new wiring is necessary, too. The outer part of the double wall between the side corridor and the toilet should be removed to create a corridor sufficiently wide for the wheelchairs passage. The end wall has to be moved about 40mm toward the end of the coach to avoid interference with the lift during unfolding. Installation of the lift attaching plates at three positions near entrance door is necessary. The door pillar is reinforced in accordance with FME strength analyses under different load cases, Fig.2.

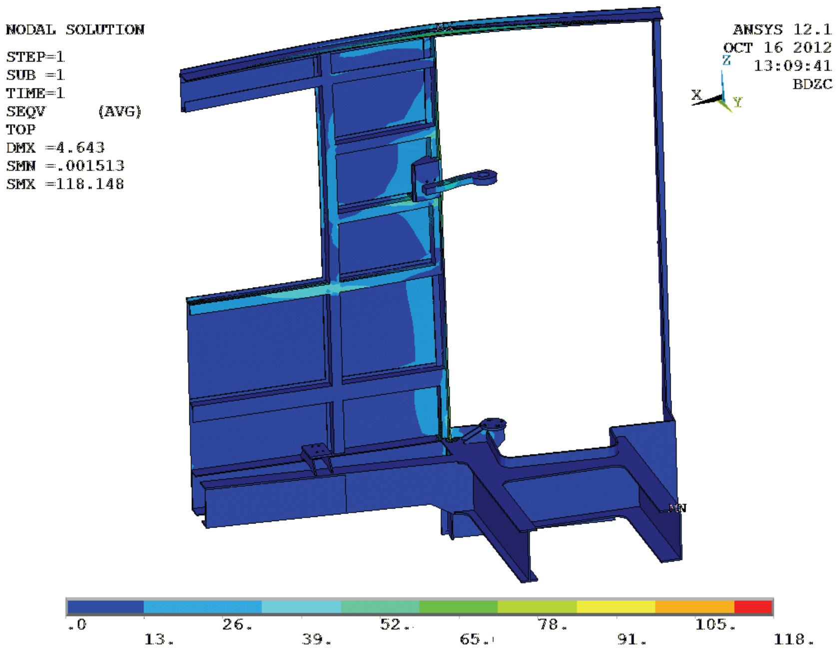

Fig. 2 Stresses in coach structure near door under maximum lift service load

The installation of the adapted lift is simulated using virtual reality equipment of Siemens Transportation, Vienna (Fig. 3) before the installation in the mock-up. To test the space and usability of the system and the installation, a mock-up of Bulgarian State

Railways UIC-coach entrance area is constructed by the Bombardier Transportation, Berlin. The tests of the mock-up are performed along with required measurements, including the test of 300 kg load capacity (Fig. 4), overloading, etc.

To test the prototype performances in real conditions of the platform and track characteristics the installation of the lift prototype in the existing UIC coach is made by the Bulgarian State Railways.

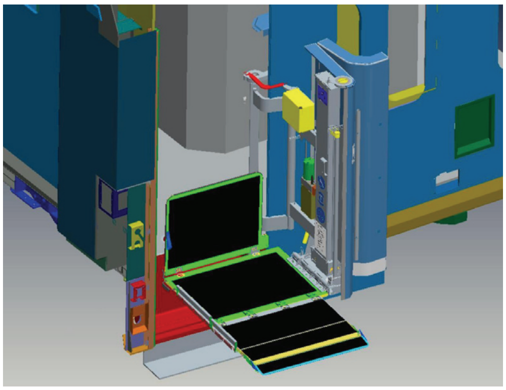

Fig. 3 Virtual reality lift examination

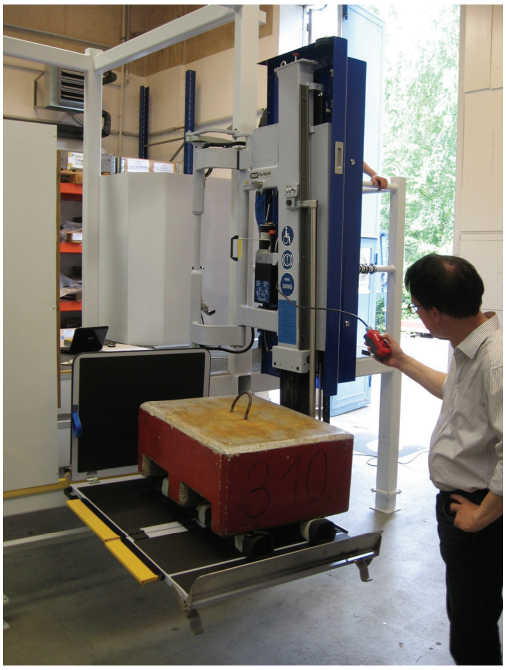

Fig. 4 Lift tests in mock-up

During the rides on the main line route from Sofia to Pleven the boarding and alighting of the wheelchair users were successful tested (Fig. 5). Stations with different platform heights and widths covered all possible boarding situations. Some of them were in curves with different radii and track cants.

Fig. 5 Tests in real service conditions

The tests have shown that the lift can be used on platforms heights down to 160 mm. For platforms in curves, there are some limitations due to superelevation of the track. The boarding is possible with a side roll-off and roll-on at the platforms which are no more than 1,4m wide in the case of the hand driven wheelchairs. For motor driven wheelchairs a little bit larger platforms are needed.

From the perspective of the operator, the complete usage cycle lasts in average about 2 minutes (a half minutes more on very low platforms).

Both the mock-up and the on the line tests represent a good opportunity to make a list of small possible improvements that can make lift even more user friendly in serial production.

6. CONCLUSIONS

The main goal of the EU PubTrans4All project to choose appropriate solution, design, build and test the prototype of BAS for demanding conditions of UIC coaches is successfully completed. The coach with the lift for wheelchair users was presented to the public at Innotrans fair in September 2012. This lift represents the first vehicle-based BAS solution that can be installed in the existing high floor vehicles with door width of only 800mm.

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POBOLJŠANJE PRISTUPAČNOSTI ŽELEZNIČKIH VOZILA ZA OSOBE SA TEŠKOĆAMA PRI KRETANJU

Propisi Evropske unije zahtevaju da javni transportni sistemi moraju bit pristupačni za sve ljude bez ograničenja. Stoga se postavlja pitanje: kako obezbediti da šinska vozila budu pristupačna za sve. Ulaz u nivou, kao jedino kompletno rešenje tog problema, je moguć samo u takozvanim zatvorenim šinskim sistemima kao što su na primer metro-sistemi. Velika raznolikost različitih vozila i različitih perona u najvećem broju šinskih sistema onemogućava takvo rešenje i zahteva odgovarajuća tehnička pomoćna sredstava za osobe sa teškoćama pri kretanju. U ovom radu je dat pregled zahteva za jedan novi uređaj za pomoć putnicima pri ulasku u šinska vozila. Prikazani su rezultati projekta "Public Transportation Accessibiliy for All" sufinansiranog od strane Evropske unije u kome je razvijen prototip novog lifta za osobe u invalidskim kolicima za železničke UIC vagone.

Ključne reči: *pristupačnost, šinska vozila, invalidska kolica, lift*