PubTrans4All

Public Transportation - Accessibility for All

Deliverable 5.4
Final Report on Project Results

Grant agreement no.: 233701
Project acronym: PubTrans4all
Project title: Public Transportation – Accessibility for All
Filename: PT4A_D5.4_evaluation report_20121128.doc
Title of the Deliverable: Deliverable 5.4 Final Report on Project Results
Report Version: 0.1
Dissemination Level:

PU	Public	
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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Workpackage contributing to the deliverable: WP 5
Delivery Date: 2012/11/31
Due Date: 2012/11/28

Disclaimer

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 233701.

Table of Versions

Version	Date	Authors	Description	Date of Approval
0.2		Simic/Petutschnig	Addtl. Input and technical comments Petutschnig	
			Translation Petutschnig	

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1. Executive Summary

The PubTrans4All project's main objective is to develop a prototype of a vehicle-based boarding assistance system (BAS) that can be installed into new rail vehicles but also retrofitted into existing rail vehicles and can be used on many different types of rolling stock and infrastructures.

Accessibility of rail vehicles for people with reduced mobility (PRM) is particularly problematic since rail vehicles have a long service life (40 years or longer) which means that many currently inaccessible vehicles in the meaning of TSI PRM will remain in service well into the future.

At the beginning of the project the consortium consciously set the bar very high in order to get the best possible results. The primary defined goal of the project was to find a technical solution to provide accessibility to all passengers in all boarding situations.

As a part of developing a new prototype of a BAS, the consortium surveyed at the beginning of the project state of the art accessibility devices and made recommendations for best practices of use and operation of these devices. Furthermore an international student contest was held in spring 2010 finding new ideas and innovative solutions for a new BAS. Any new idea improving the interface between platform and vehicle was accepted. The consortium believed that students don't have the detailed knowledge about railway vehicles and therefor they are more independent in their thoughts. Experts usually have a tunnel vision because they think too much about reasons why something cannot work. In total 38 students from Austria, Hungary, Serbia, Croatia and Bulgaria participated at the contest and submitted their ideas.

There is one very big group of high floor railway vehicles in Europe, the so called UIC-wagons. The consortium came to the decision that the most important step to offer accessibility to all is to focus on UIC-wagons.

Installation investigations and technical calculations led to the adoption of the swivel lift concept as the best suitable design concept for the restricted space conditions in classical UIC-wagons.

After finalizing the building phase, the prototype was first factory tested at the site of our consortium partner and lift manufacturer MBB Palfinger. Therefore a test bench (welded steel construction) was built displaying all technical restrictions of a classical UIC-wagon for testing purposes. Next, the prototype of a BAS has been sent to our project partner BDZ in Bulgaria and was installed into a UIC-wagon of the Bulgarian State Railways. During the summer, the prototype was tested on the railway network in Bulgaria. In September, the new BAS prototype installed into a UIC-wagon of BDZ was presented to the interested public at the InnoTrans 2012 in Berlin.

2. Introduction

This Deliverable includes a report about the ideas for lift design, the decision making process and how it came to the final prototype.

The Deliverable contains a statement about the existing conditions of boarding assistance systems in public transportation. Also it contains the general requirements for a boarding assistance system as much as the specific users' requirements, the specific operators' requirements and the technical and operational requirements in detail for a BAS for UIC wagons.

The Deliverable contains the evaluation results of the factory test in the test bench from our project partner MBB Palfinger. The test bench, a welded steel construction, was specially made for testing the lift. Also there are evaluation results of the test of our prototype on the railway network in Bulgaria by our project partner BDZ where the lift was installed into a UIC-wagon of the Bulgarian State Railways.

In this Deliverable you can also find a report about the experiences of the demonstration of the lift at the fair InnoTrans in Berlin. The InnoTrans in Berlin took place in September 2012. The lift was presented installed into a UIC-wagon at the outside area of InnoTrans 2012.

The Deliverable also includes evaluation results about the experiences of users of the lift in other words the impressions of the passengers about the lift.

Another important point are the recommendations that are intended to improve the prototype which are also discussed in this Deliverable. These recommendations may affect the construction and the installation of the lift, but can also concern the operation and staff training.

Deliverables available for public consultation can be found on our project homepage www.pubtrans4all.eu.

3. Existing conditions: boarding assistance systems in public transport

3.1. Evaluation criteria

The survey is clearly showing, that there is a demand for a BAS that needs to be useable by everybody. Wheelchair users for example need a BAS for facilitating their boarding process one hand, for other user groups amongst persons with reduced mobility it is crucial to handle a BAS that is easy and simple to use on the other hand in order to improving the accessibility situation in general.

For the great majority of “other users“ there is a demand for a BAS in combination with luggage enabling level boarding, or only having one remaining stair to overcome. Also travellers with luggage would benefit from such a BAS in order to facilitating their boarding situation, as well operators would profit sustainably from it in terms of their service quality. Besides customer satisfaction, as well the dwell times at the station can be reduced if accessibility has been improved.

The question if a technical solution is the best way to go for the majority of travellers is not answered herein. It would be appreciated though, if most of the doors had an automatic BAS operated independently at all stations automatically, enabling level boarding or boarding with one stair at the most. Apart from wheelchair users, the other groups do not necessarily need a technical solution, if they had other effective solutions or alternatives available.

For technical solutions pre-defined operational standards need to be fulfilled. In addition, also dimensions on the train, e.g. 80 cm of door-width, and the lifting capacity of 350 kg needs platform. Also the operation of a BAS must not need longer than 2min. All technical details, especially the installation process of the BAS needs to be defined in the Deliverables to come.

3.2. Description of boarding assistance systems

In order to provide a barrier-free scenario, technical aids are used in the railway sector as well as in all other areas of transportation, and also within in daily-life. Relevant aids for the PubTrans4All area all devices that are applied in the railway sector and all other areas if adaptable for railway appliance.

The large number of various systems amongst the train-sector shows the need for a standardised solution. Many specific solutions which need a high amount of development-efforts are very costly. A standardised solution offers secured planning for both manufacturer and operator.

In railway transportation there are two main-categories of devices that manage to overcome vertical barriers. Those solutions are ramps and lifts, both applied as platform- and vehicle-based solutions. Both systems are available in a variety of designs.

Ramps operate automatically or are manually applied, depending on their length, and offer the advantage that they can be used by all passengers, and mean an improvement for the boarding and alighting process on trains for most passenger groups, in particular PRMs.

If the maximum tilt along the longitudinal axis is given, wheelchair-occupants, walking-impaired, people with luggage, and persons with prams can use a ramp. There is no logic hurdle that prevents passenger groups from its usage.

Most countries use ramps to manage small differences in height and to bridge gaps between the train and platform. There are also versions available which manage higher vertical distances and are used accordingly. Due to their nature of a considerable length, difficulties in regards to space on the platform are being faced.

Ramps are used for wheelchair-occupants only in many countries. The UK for example shows that it can be used by all groups of passengers and are quite welcome by the customers. Ramps are often applied for the use of all passengers - that includes people with luggage, prams and walking-disabilities.

Lifting devices are either permanently integrated into the vehicle, or permanently integrated into the vehicle, otherwise they are platform based. Usually their design is more complicated, hence more expensive, and subject to a higher failure-quota as compared to ramps.

Favoured systems in general are solutions that operate fully automatic, or are operated by the users themselves. Both operators and users are satisfied with lift-solutions. A potential hazard is vandalism and misuse of course, which is a fact that needs to be considered in this connection.

Due to the satisfaction-levels amongst operators and users, it seems to make sense to think about the possibility of a combination of both worlds. On one hand a lift handles large vertical distances, and a ramp can be used by all passengers on the other hand. Even if a ramp cannot handle the whole height-difference, surveys are showing that the great part of passengers experiences an advantage and improvement of their journey.

3.3. Boarding assistance systems evaluation

In order to provide a barrier-free scenario, technical aids are used in the railway sector as well as in all other areas of transportation, and also within in daily-life. Relevant aids for the PubTrans4All area all devices that are applied in the railway sector and all other areas if adaptable for railway appliance.

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4. Recommendations for improving PT boarding assistance systems

4.1. Short term recommendations based on best practise evaluation

Providing accessible rail transport to all passengers is nowadays a must. This is because of different national and European regulations but also because of ethical questions. That means every person must be able to use a public means of transportation. In light of this, the entrance to railway vehicles and the whole boarding process is a big challenge and causes huge difficulties. In order to be able to provide accessible boarding to all passengers, the consortium tried to define the biggest gaps that must be closed. For mid and long term thinking the results can be summarized as follows: Because level boarding is in the process of being or will be offered soon for all types of local, urban and suburban traffic; no systems are required. At this point, only horizontal gaps need to be bridged. Therefore, enough technical solutions already exist. In the rare case that level boarding is not possible, existing technical solutions can be used. For all high floor vehicles with an entrance door width of at least 90cm, enough technical solutions such as different lifts exist. A new development is neither meaningful nor necessary.

The intensive investigations of the consortium led to the result that for the huge number of UIC-wagons which are running and will be running within the next decades all over Europe no vehicle based BAS yet exists. There are too many design limitations. Due to the fact that UIC-wagons will still form the backbone in many European railway networks within the next decades; it is absolutely necessary to develop a BAS for this operation. Due to the different limitations resulting from the vehicle construction, it is also necessary to make several compromises. But the developed compromise allows about 99% of all actual wheel chair users to board a UIC-coach. In combination with a good personnel service at the entrance, which is also recommended in this project, the UIC wagons can also become accessible for nearly all passengers.

4.2. Prototype boarding system recommendations

This deliverable contains the results of the preliminary design process for a new boarding assistance system that should be used by nearly all people with reduced mobility. As shown all concepts presented in the beginning of the project were not applicable due to various reasons so that the only current solution for the BAS is based on the well-known swivel lift concept that has already been installed in railway vehicles. One of the main innovations of the new BAS prototype is the ability to retrofit based on the optimisation (see 4.7) of the dimensions and the weight of the whole system and to automate the operation of the system where it is reasonable.

Furthermore all main requirements that are standard in the railway industry have been briefly explained (see 5.1 ff) to keep them in mind during the specification and development of the new boarding assistance system. They will be supplemented by the topics that derived from the deliverables 3.1 and 2.1.

In the next phase of the project the PDG will start with the specification of the BAS following intensive feasibility tests with BDZ to verify the mechanical and electrical interfaces of the lift. In month 28 (January 2012) MBB Palfinger will deliver the prototype to Bombardier Hennigsdorf where it will be installed in a mock-up or an UIC coach. The prototype after evaluation will be presented at the InnoTrans 2012 and other exhibitions.

This deliverable contains the results of the development for a new boarding assistance system prototype. The details of the BAS in respect to its operation and its components are explained. This project shows the importance of the information in respect to BAS solution which depends on the special requirements of the entrance area as “all trains have differing widths, heights or shapes depending on the vehicle type”2. Due to the new requirements and collisions further investigations have to be made in respect to the design as well as to the necessary material, which will influence the project. Furthermore, the mock-up, where the prototype will be installed for testing might have to be adapted accordingly. The challenge is that BAS prototype will fit in the UIC wagon we saw in Sofia and to find a final and mutual solution for the presentation at the InnoTrans 2012 and other exhibitions.

5. Improved PT vehicle-based boarding assistance system prototype

5.1. Evaluation of PT vehicle-based boarding assistance systems ideas

At the beginning of the project the consortium consciously set the bar very high in order to get the best possible results. The primary defined goal of the project was to find a technical solution to provide accessibility to *all* passengers in *all* boarding situations. To get innovative and complete new ideas also a student competition was initiated. The consortium believed that students don't have the detailed knowledge about railway vehicles and therefor they are more independent in their thoughts. Experts usually have a tunnel vision because they think too much about reasons why something cannot work.

After a long research and discussion process, also including the excellent ideas form the competition the consortium concluded that many restrictions are necessary and the all-in-one solution is not possible. At this point it must not be forgotten that the PubTrans4All project is a research project which also has the goal to demonstrate what is possible and what not!

In the first step the different railway systems whole over Europe - now and future plans – have been analyzed in order to identify the biggest gaps. The result for which railway systems a new BAS must be developed is summarized in (Tab. 1).

applicability, vehicles	importance	useability
High speed trains	1	
Long distance trains (high floor vehicles)	1	
Local and regional trains with high floor vehicles	2	
Double deck trains with entrance height 55cm-60cm	XXX*	
Local and regional trains with entrance height 55cm-60cm	XXX*	
Commuter trains (S-Bahn)	XXX*	
Metro/Underground	XXX*	
tramway	XXX*	
busses	XXX*	

Tab. 1: applicability of a BAS in different vehicles

* XXX: No new development is needed or requested in that area.

For all local systems (including busses, tramways, metros, urban and suburban railway traffic) a new developed BAS is neither necessary nor meaningful. All these systems can be seen as so called "closed systems". Here the operators provide vehicles that correspondent with the existing platform height which means level boarding is provided. If level boarding is not provided yet then operators plan to adapt the platforms and/or their vehicles. Local traffic operators in general don't want to use technical devices (BAS) because of operational time reasons.

Level boarding is in general the best solution for travelers and for operators. It is the only situation which really offers accessibility to all passengers. Furthermore the passenger flow in the station can be speed up which means a shorter dwell time and therefor advantages for operators.

To offer level boarding it is necessary that the platform and the vehicle floor height go in common and the remaining horizontal gap between vehicle and platform is bridged. For that many technical solutions already exist.

For all situations where level boarding is not possible already different approved technical solutions like ramps or lifts exist.

Compared to the local traffic systems high speed, long distance and international railway traffic will not be able to offer level boarding. This is in consequence of following two main reasons: Because of static reasons high speed trains need a higher floor. The lowest floor height in high speed trains is offered in Talgo-trains (760mm). All other vehicles have got higher floor height.

The second reason is that in the TSI two different platform heights are defined as European standard (550mm and 760mm). That means also for the next decades all international trains need to stop at both levels!

Furthermore the investigation has shown that actually and also 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 can't be changed in a short or medium term.

So the decision was 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 either plan to provide level boarding in the future or – everywhere they cannot – they strongly wish to have vehicle based systems. Two reasons can be identified for that wish: Firstly operators want to be independent from the infrastructure and what to offer the possibility of accessible boarding everywhere. Secondly it is very difficult to provide a platform based device at all (!) platforms in a railway network.

In order to provide accessibility to all passengers ramps seem to be the only possibility because lifts cause a big bottle neck if every passenger at one door should use it. But here the big problem is that it was not possible to find a technical solution for installing a ramp system into existing vehicles. Furthermore ramps must be very long when they will be used for high floor vehicles.

Because of the impossibility to find any technical solution for rams in existing high floor vehicles the decision was to focus on lift systems for existing high floor vehicles. For the next steps of development two decisions have been necessary: Who will be the user and which vehicles are relevant.

The investigations show that for all types of high floor trains with an entrance door with of at least 90cm already different lift systems exist. It is not meaningful to develop another system because the existing systems work well enough, what the passenger and operator surveys have shown.

But there is one very big group of high floor railway vehicles in Europe, the so called UIC-wagons. This is a unique type of vehicles running in many European countries also for some more decades. In many countries the UIC-wagons form the backbone of the long distance railway traffic, especially in eastern European countries. But due to many construction limitations described in previous deliverables no technical solution has yet been developed. Therefor the consortium came to the decision that the most important step to offer accessibility to all is to focus on UIC-coaches!

A lift system under very limited frame condition means many restrictions and compromises. By regarding the user requirements wheelchair user 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 there is no chance than other solutions are acceptable. As other solutions special services at the entrance door are recommended within this project. There already exist good examples in different European countries which can be advanced.

At the end of the decision process it came out, that the most important case is to develop a vehicle based BAS for UIC-coaches. Since there are many restrictions because of the vehicle design, also for this situation it has been necessary to define some "compromise solutions" regarding to the construction. All recommendations for a vehicle based BAS for UIC-coaches are shown in the previews chapter "Detailed technical requirements for a BAS for UIC wagons".

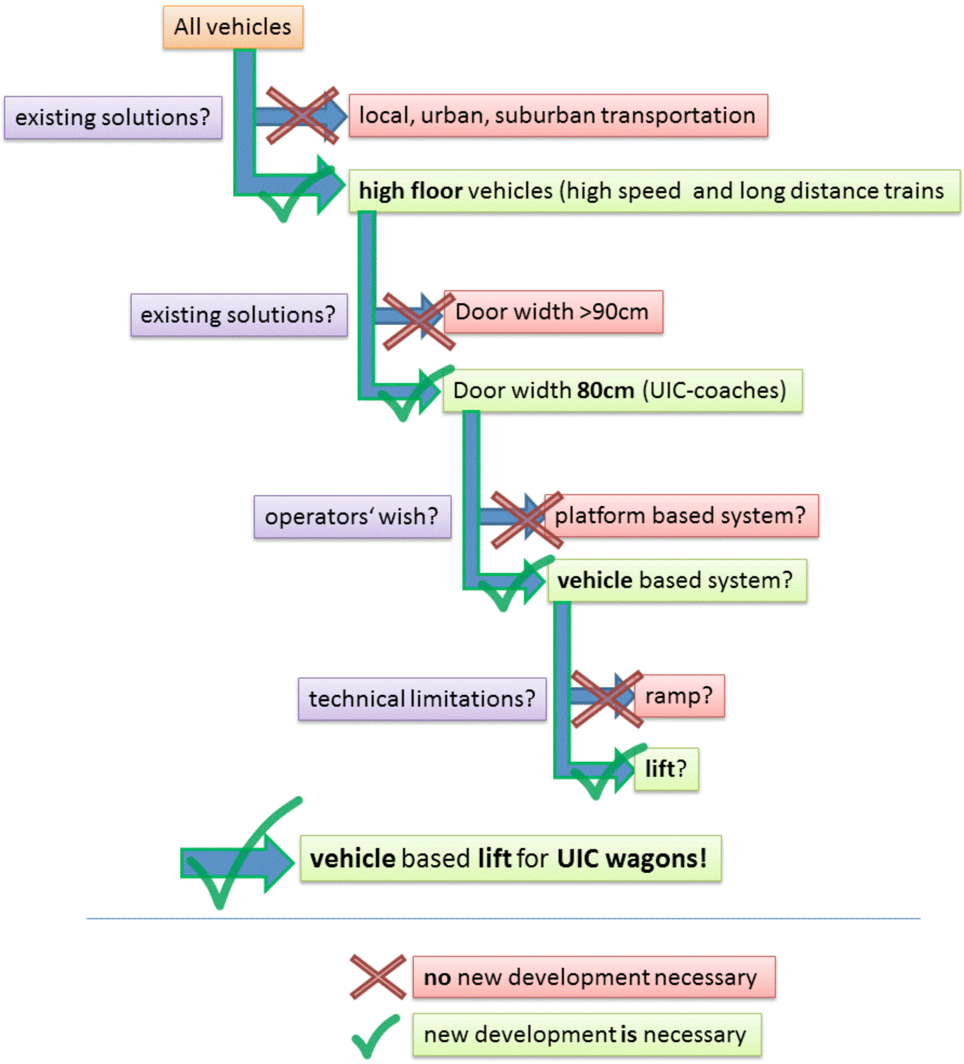

fig. 1 Decission making process

5.2. Design of PT vehicle-based boarding assistance system

The consortium decided to focus on a BAS that can be implemented into UIC wagons. Therefor at this point all technical requirements that have been identified especially for the implementation into UIC wagons will be described in detail. This information is based on the work in Deliverable 3.1.

5.3. Evaluation of PT vehicle-based boarding assistance system prototype

The following chapters are showing all relevant parameters discussed in deliverable 2.1, the „must haves“ and the „nice to haves“. Three main criteria had been identified (features rated as not important, are not shown here in). The evaluation criteria catalogue is a summary of all relevant parameters, criteria and frames that must be considered by the prototype of the new BAS and how far these requirements are met.

The assessment for the importance of the different criteria was performed by the following scheme:

1 Very important („must have“)

2+ important („nice to have“ – high customer and operator value)

2 Important („nice to have"– high customer value, BAS not necessarily needed, but a BAS is very welcome!

3 Merely important („nice to have" – customer and operator´s value, but not necessarily needed)

Score 2+ is a special evaluation of user groups, it means a BAS is not a must, but would mean a large improvement on the current situation.

The useabilities for each criteria of the new device are listed bellow, based on the criteria as described in Deliverable 2.2. In addition the feasibility of installation is assessed. Detailed information in regards to their adaptability for railways and feasible installations is described in deliverable 3.1.

The assessment for the useability of the prototype was performed by the following scheme:

1 ……. Very good usability

2 ……. Good useability

3 ……. Merely usable

4 ……. Not useable

1!, 2! …used in real life for applicable user-group

In theory the BAS prototype is usable for all passenger groups, in real-life it will be mainly used by wheelchair-occupants only though. The exact evaluation and rating of which groups can use the BAS or not will be done after the prototype test. The table is yet prepared for this evaluation.

User group	**importance**	**useability**
Power wheel chairs	1	1
Manuel wheel chairs	1	1
Walking disabled	2+	2
Frail people	2+	2
Elderly	2+	2
Baby prams	2+	1
Passengers with luggage	2	2
pregnant	2	2
Diminutive people	2	2
Overweight people	3	2
children	3	2
Visually impaired*	3*	2

Hearing impaired*	3*	2
Passenger with extra luggage (e.g. bicycles)	3	2

Tab. 2: user groups – importance of a BAS

* For visually and hearing impaired persons there is no special BAS needed. However, these impairments often go hand in hand. And all the frame conditions for visual and hearing impaired must be considered.

The following criteria summarize the requirements a BAS must fulfil from the operators' point of view.

- Reliability of BAS

  The BAS must work reliably, and in case of malfunction it must not influence the passenger-flow. In case of failure it must be ready to be operated manually. Since the BAS shall be a standardized solution for whole Europe it needs to be assured that the BAS is working under all (extreme) weather conditions such as snow, ice, gravel, heat, dust, water, and rain only to mention a few (Tab. 3)

Quality criteria	**importance**	**useability**
Time for operation (short dwell time required)	1	1
No hindrance of passenger flow (when system is in use)	2	2
No hindrance of passenger flow (when system is stowed)	1	1
Reliability of the system	1	1
Functional efficiency under all climate conditions	1	1
Operation in fact of breakdown	1	2
Vandalism protection	1	1

Tab. 3: Criteria of reliability and operational quality

- Operational quality

  The BAS should be operable independently and automatically. But the customer also except operating through train personnel due to legal reasons (putting somebody at risk!) (Tab. 4)

operation, handling	**importance**	**useability**
Self operation of the system by the customers themselves or by companion*	2	4
Automation of the system*	2	4

Personnel autarkic operation*	2	4

Tab. 4: operability

* It needs to be assured, that there is no hindrance caused by the BAS in terms of operations, and that it does not put people on danger.

- Costs

The BAS needs to be almost 100% reliable, and work as well in case of a malfunction not leading to a failure of the train, and to operate and use the BAS successfully. Low life-cycle cost and a long life cycle are also required. All costs for the required personnel and general costs (material etc.) for manufacturing, implementation and operation is valuated as “very important”. Only the effort for special personnel and special tools for maintenance is valuated as “important”.

Effort and cost criteria	**importance**	**useability**
Required personnel for operation	1	1
Required personnel for maintenance	2	1
Special technical tool required	2	1
Manufacturing costs	1	1
Structure intervention	1	1
Maintenance costs	1	1

Tab. 5: importance of following criteria: manufacturing, implementation, operation and maintenance

- Manufacturing cost / installation

To produce at low cost the system must be standardized which means it needs to fit in all the different vehicle and it needs to be able to be re-equipped and refurbished. Interference with static need and conversion work on the vehicle shall be reduced to a minimum in order to keep the stability around this vehicle area, transfer pressure, loads and pulling-forces to a minimum, and to keep the stiffness of the shell in order to keep comfort and crashworthiness.

- Safety risk and warning devices

The BAS has an influence on the homologation process of the vehicle. In order not to endanger passengers, only trained personnel shall operate the BAS to provide a safe operation for the customer. The BAS must fulfill all relevant safety criteria, especially if the system should work automatically. E.g., fall protections, emergency stop, optical and acoustical safety features are “must haves” (Tab. 6). A surveillance system shall contribute to the safe operation, using an integrated, advanced sensor system. Sonic and visual alarms need to avoid complications.

Safety criteria	**importance**	**useability**
Safety features (acoustical, optical)	1	1
Fall protection	1	1
Emergency stop (for passenger)*	2	4
Contact detection	1	1
Applicability outside of stations	2	1

Tab. 6: safety criteria

* For automatic systems: 1

- Environmental – friendly

criteria	importance	useability
energy consumption*	3*	1
recyclability	3	1

Tab. 7: sustainable criteria

* If the energy consumption is too high and the electric power supply must be fitted into retrofit vehicles, then the criteria is much more important!

- Design / aesthetics

  In general aesthetic is rated merely important, based on the customers' request there should be more focus on this subject though (**Fehler! Verweisquelle konnte nicht gefunden werden.**). The visibility of the BAS is scoring high though.

criteria	importance	useability
aesthetics	3	1
visibility	2	1

Tab. 8 aesthetic criteria

5.4. Evaluation of tests on Mock-Up

Due to the technical constraints given by a standard UIC wagons the BAS will be installed into, these restrictive constraints do have a major impact on the lift-design. A number of challenges had been discovered regarding the installation process, therefore a number of constructional solutions needed to be developed.

The proceedings had been made as follows:

- Checking potential collision scenarios of the BAS and the wagon interior (Virtual Reality Room, Siemens AG Austria, Vienna)
- development and building of a test mock-up
- testing of the BAS I practice on the test mock-up

During the fourth Prototype Development Group (PDG) meeting the findings of the study regarding the installation process have been tested within the Virtual Reality simulation at Siemens Vienna (fig. 2).

General technical questions such as constructional constraint and potential collisions of the BAS and the wagon-interior of the could be analysed in detail that way.

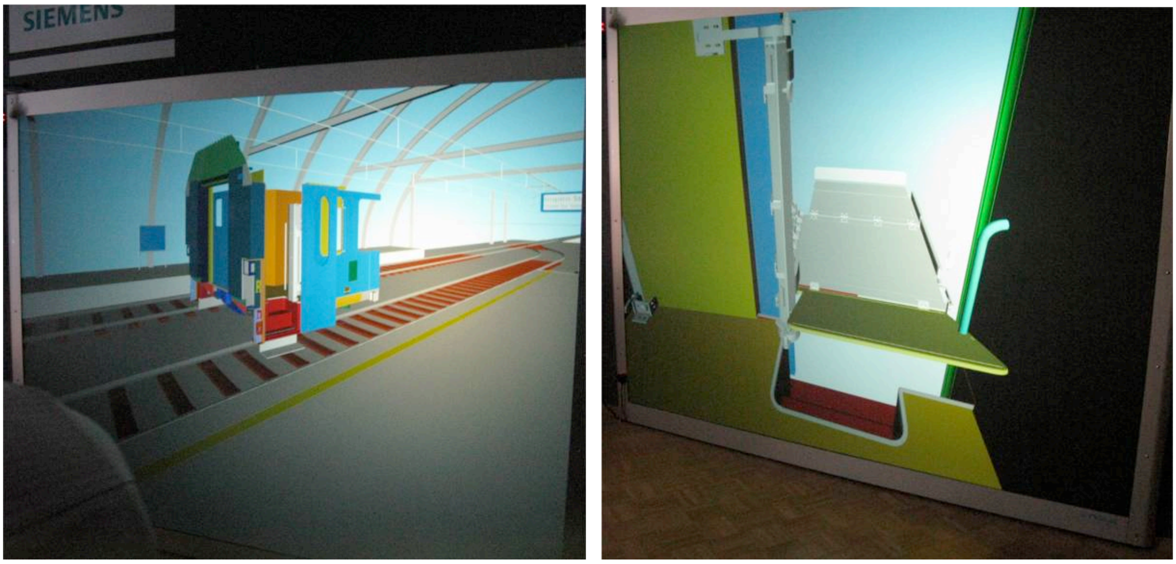

fig. 2 Virtual Reality Tests

Originally the BAS prototype should have been installed into the EUPAX-Model according to the Description of Work (DoW). The installation would have meant that the Eupax model would have been destroyed in the course of the conversions that would have been required. Therefor the consortia decided to design and build a new mock-up. This task was performed by Bombardier and further project-partners.

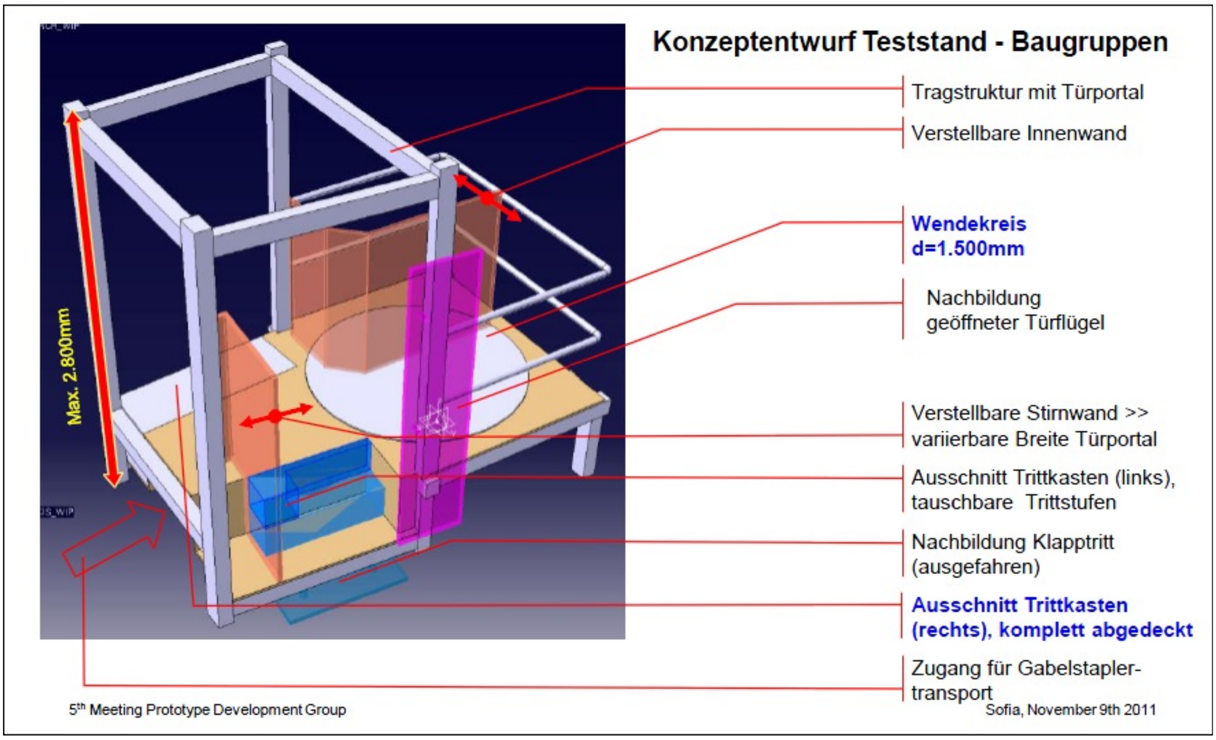

fig. 3 Mock Up

The mock-up's primary function is to proof the of the BAS' ability to perform all requires functions, including the loading capacities. The turning circle for wheelchairs according to the current requiremnts of the TSI PRM, also in revised TSI PRM, to be released 2014, was anticipated in the mock-up design, which was based on the entrance area of the Bulgarian UIC wagon. The door width and walls are flexible In order to make the mock-up useable for other applications as shown in fig. 3.

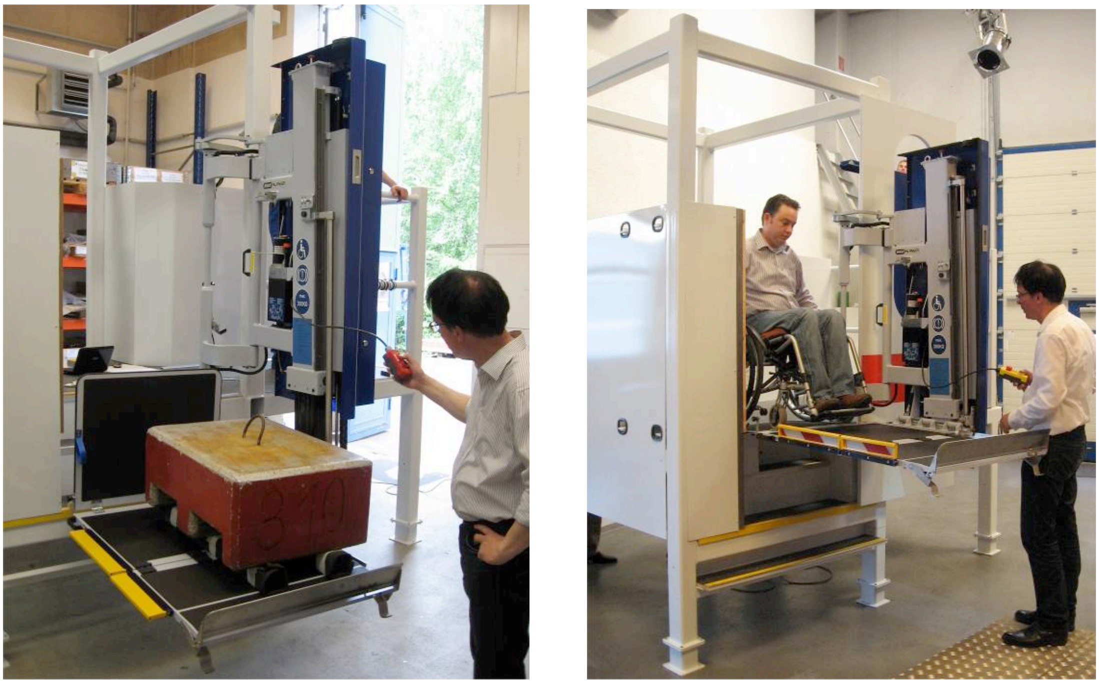

fig. 4 Tests on the Mock Up

Tab. 9 shows all prototype requirements of the BAS as defined in Deliverable 3.1. This paper will comment on the features that had not or partially not been fulfilled.

Maximum manageable floor-to-ground difference vehicle floor-platform - 1300mm.

The wish of a performable evacuation of a walking impaired person outside train stations in case of an emergency was originally anticipated. Due to engineering limits performing a successful alighting operation of the BAS on open track without platforms, and space limits in a tunnel, the idea had been withdrawn.

A cylinder performing a maximum lifting capacity of 1150mm enables a floor-to-ground operation of 1100mm, and applying the BAS at station platforms starting 160mm above track surface, which makes an emergency evacuation in between stations easier and more realistic.

A compact design in stored position is crucial in order to enable the wheelchair occupant to access the inside area of the , and deliver the required minimum width wall-to-wall width, (which is 800mm according to the current TSI PRM).

Also it was considered that the BAS should be able to be used by standing persons (assistants) on floor level when entering or alighting from the platform, requiring sufficient clear height at the door-entrance (as shown in pic. 3.16 in Deliverable 5.1)

No.	Characteristic	Set value in deliverable 3.1	Test result	Comment
1	Carrying capacity	300kg	✓	Test : 310 kg – working 360 kg – switch-off

No.	Characteristic	Set value in deliverable 3.1	Test result	Comment
2	Minimum clear width of lift platform	720mm	✓	on outer part of lift platform-803mm. Foldable part of the platform-720mm.
3	Minimum platform length	1200mm	✓	
4	Maximum working height difference vehicle floor-platform	1300mm	✗	Maximum 1100mm - limited because of the single stroke cylinder usage. Caused by necessity of slim lift design in stowed position.
5	Distance from the side of the coach when the lift platform is in lowered position:	As small as possible, but not less than 75 mm	N.A.	Foldable platform part in vertical position protects wheelchair user from possible foot entrapment.
6	Boarding/alighting parallel to the vehicle	Recommended	✓	
7	Handrail bound to the platform on one side, should be at the high	650 to 1100mm from platform level	✓	Up to 1320mm from the platform level.
8	Integrated folding seat for categories of users other than wheelchair users	Recommended	✗	
9	Finger force to activate control buttons	≤ 5N	✓	3N
10	Manual force to operate the lift by staff	≤ 200N	?	Missing data, but most probably fulfilled for empty platform lifting
11	Manual force to operate the lift by staff at movement start	≤ 250N	?	Missing data, but most probably fulfilled for empty platform lifting
12	Vertical speed in the operation	≤ 0.15 m/s	✓	
13	Operating speed variation: empty-maximum loaded	±10%	✗	0,099m/s lifting, full 0,072m/s lifting, empty 0,043m/s descending , full and empty
14	Speed of any point of BAS without load	≤ 0.2 m/s	✓	Folding/unfolding by hand
15	Acceleration during operation with load in any direction and at any point of the lift platform	≤0.3 g	?	Missing data, but must probably fullfiled. ~0,15g according to the

No.	Characteristic	Set value in deliverable 3.1	Test result	Comment
				test report of Trainlift 800 with a little bit different hydraulic aggregate.
16	Tilting speed of the lift platform	≤ 4°/s	N.A.	Platform can not be tilted.
17	Automatic roll-off protection height	≥100mm	✓	Front 100mm Rear 620mm
18	Lateral side guards height:	≥25mm min ≥50mm preferred	✓	62/27mm
19	End of travel mechanical limitation devices	Yes	✓	
20	Prevention of any unauthorized operation in the absence of the operator	Yes	✓	
21	Overload protection of the main power electrical circuit		✓	Fuse in the coach
22	In stowed position BAS must be safe against uncontrolled displacements. Mechanical securing devices dimensioning according to the accelerations:	$a_{longitudinal}=5g$ $a_{lateral}=1.5g$ $a_{vertical}=1g$	✓	
23	Activation possible only at:	V = 0 km/h.	✓	Indirect trough door operation dependence from speed.
24	Activation of the BAS should introduce activation of the coach brake system.	Yes	✗	For the purpose of lift demonstration this was not necessary and out of the funding and time schedule limits.
25	Minimum safety coefficient against yield strength	2.1	✓	
26	The lift platform surface should be smooth and must have slip-resistant surface	Yes	✓	
27	Easy removal of ice and snow must be possible	Yes	✓	
28	Gaps or holes in the platform area shall not accept a probe greater than:	15 mm diameter	✓	

No.	Characteristic	Set value in deliverable 3.1	Test result	Comment
29	Illumination of the lift working zone	Yes	✓	
30	The warning devices should be fitted at edges that can come in contact with persons or injure passengers or personal.	Yes	✓	
31	Visual and audible warning signals during the lift movement must be activated	Yes	✓	
32	The operation control should be of type hold-to-run.	Yes	✓	
33	Movement no more than 100mm for any part of the lift platform after release of the control is tolerable to slow lift down	Yes	✓	
34	Controls shall be designed to avoid unintentional lift actions.	Yes	✓	Recessed buttons
35	One control position is recommended	Yes	✓	1 control
36	Safety devices shall preferably operate through active positive action.	Yes	✓	
37	A stop in overload protection should be present at overload more than	25%	✓	360 kg i.e. 20% overload
38	An emergency stop button within reach of the user and staff (vehicle and lift based) should be present	Yes	✓	For the personnel only
39	Additional protecting measures like obstacle detector, foot entrapment protection etc.	Recommended	✓	
40	During lift platform closing the risks of crushing or shearing of the arms or head must be avoided.	Yes	✓	Folding/unfolding by hand using provided handles minimises risk of injuries.

Tab. 9 Recommended features for the new BAS – fulfilment (Test results)

Point 10: Manual force to operate the lift by staff $\leq$ 200N

Point 11: Manual force to operate the lift by staff at movement start $\leq$ 250N

Point 15: Acceleration during operation with load in any direction and at any point of the lift platform $\leq$ 0,3g

These features have not been measured. The MBB Trainlift 800, operating in a similar way, performs these operational features. A smaller hydraulic aggregate with more compact dimensions has been used. Tests showed that there was only little power needed for powering up the empty platform, the downward function is performed by a smooth gravity down operation, preventing sudden movements or jerk. Activation of the BAS should introduce activation of the coach brake system - this feature was not applied when testing the prototype BAS, as it would have required a re-certification of the braking system.

5.5. Installation Requirements Evaluation

A number of adaptions of existing UIC wagons are inevitable when re-fitting a coach with a BAS as mentioned in D 3.1. Each wagon requires its own specific installation plan, as UIC wagons are designed differently in general. The following key items need to be taken into consideration

- Accurate analysis of the available space next to the door entrance, left or right depending on the side of entrance to the wagon, clear width of the passage (wall-to-wall) for wheelchair-occupants when the lift is in store-position, as well as the clear area required for the swivel-operation of the BAS, and the required adaptions of the construction.
- Replacement of the mechanic connection between the door-opener and folding-step performed by pneumatic, electric or hydraulic power, including the anti-trap protection required by law
- Connecting Door-operator and the power-on function of the BAS
- Defining the lift anchorage/mounting positions, including the assessment of the local strength and stability
- Influence on the wagons breaking system (prevention of train movements while operating the BAS)
- Required homologation of the BAS installation (re-fitting the vehicle with a technical appliance) and re-certification of the vehicle

First the front-wall of the BDZ wagon was moved by 45mm in order to prevent a collision of the BAS during operation (swiveling-out movement (fig. 5). The existing double-wall between the corridor and toilet was removed in order to provide sufficient space for the wheelchair-occupant when passing through (see fig. 6)

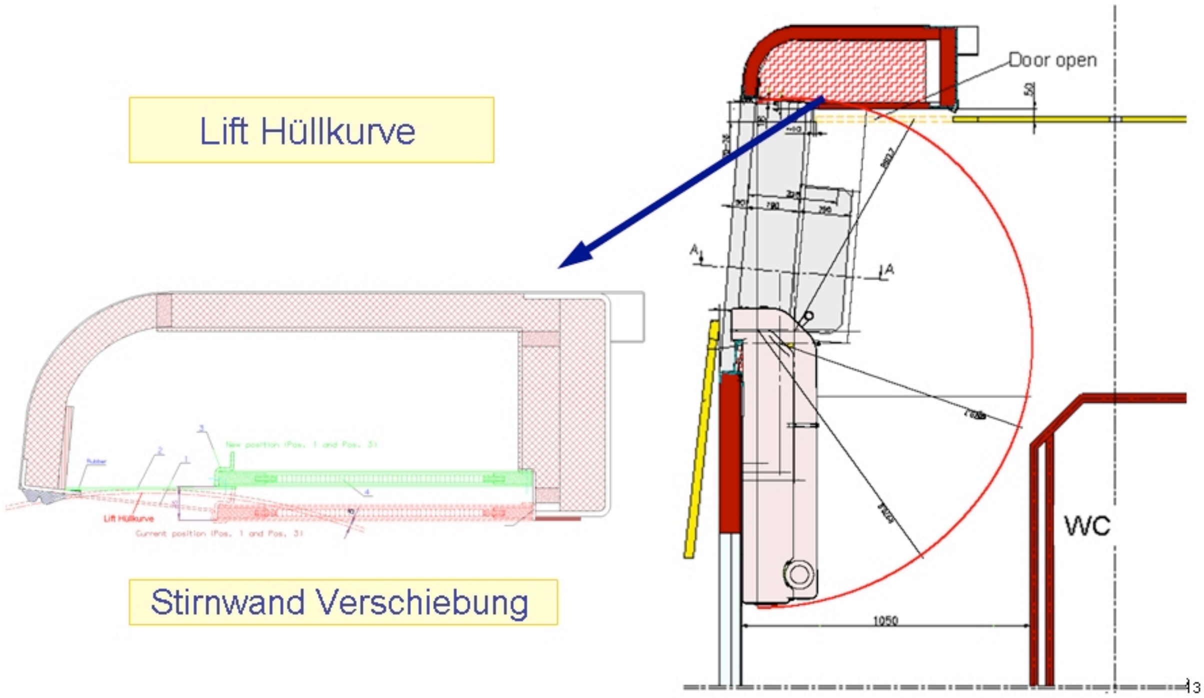

fig. 5 Front-Wall Removal

fig. 6 Removal of double-wall between toilet and corridor

fig. 7 The mechanical power-shaft (left) replaced by a pneumatic drive underneath the vehicle floor (right)

In order to provide sufficient space for the BAS operation, the mechanical drive-shaft was replaced by a pneumatic drive, fig. 7. The function of the long, regular anti-trap spring integrated into the shaft, was repaced by a torsion spring within the folding-step. A valve is controlling the pneumatic cylinder, which is operated by a door-switch.

According to the manufacturers installation guidelines, the mounting brackets for the BAS have been welded to the wagons structure (fig. 8). A local re-enforcement has been made and validated by a mechanical strength calculation.

fig. 8 mounting-plates for installation

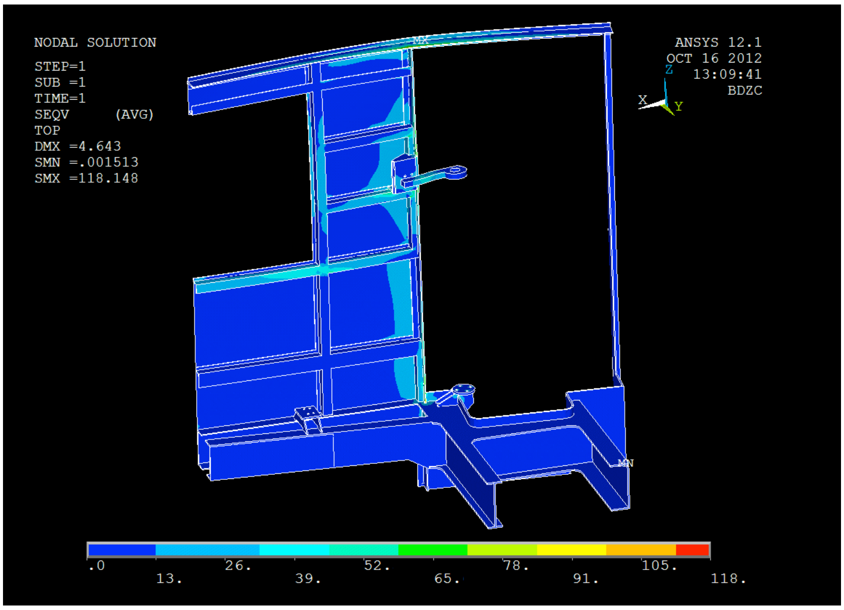

fig. 9 mechanical strength calculation under maximum work-load

The experiences regarding the installation procedure showed that the required work-hours were acceptable. Time and cost for installation incl. hardware needs to be calculated for 2 lifts (mirror version of the BAS at the opposite entrance). The installation should be performed by a well equipped workshop for trains, in order to execute the installation within the required installation tolerances.

This chapter covers the challenges which occurred during the installation and tests, providing potential proposals for improvement.

fig. 10 contact of slewing column with door-lock

During lift installation the sqare part of the slewing column got into contact with the door-lock mechanism, fig. 10. As the door-lock was not anticipated during the mock-up installation, this problem remainded undiscovered until the actual installation of the BAS. Luckily a part of the locking mechanism could be removed. In orde to avoid that problem, the round end of the slewing column needs to be 100mm shorter, as marked in red colour.

The release handle was positioned to far up, as shown in fig. 11, and was covered within the slewing column and the door-lock. The handle was re-welded in a position 100mm further down, and the release wire was shortened accordingly.

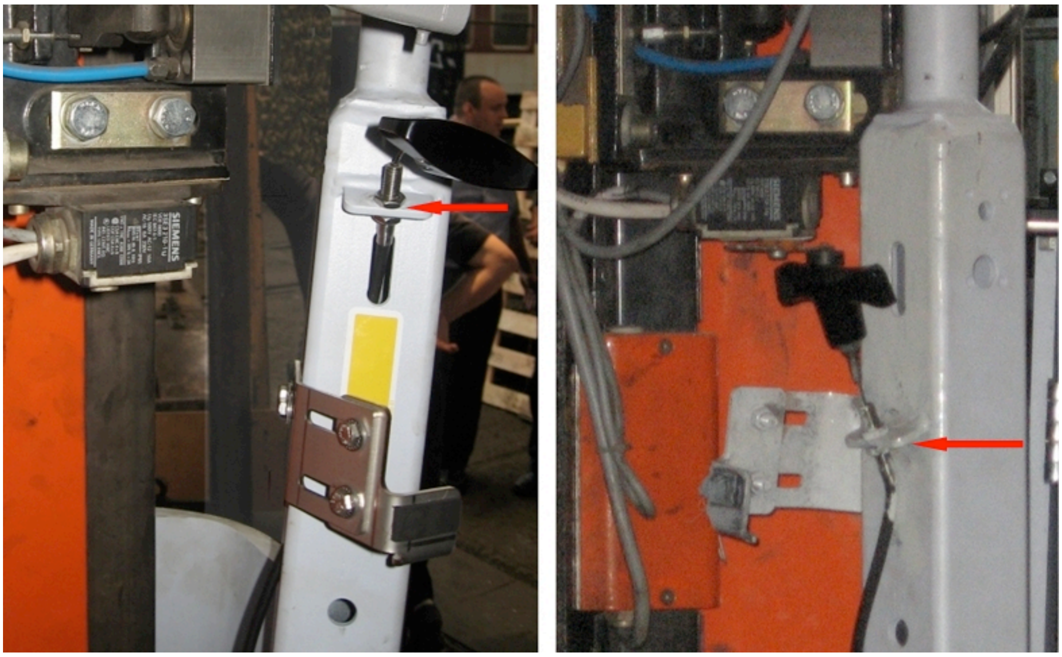

fig. 11 contact of slewing column and door-lock

Releasing the BAS in swivel-out position has only been possible by applying maximum physical strength, the problem became worse in the course of operating the BAS over and over again.

It seems that he axis for the fixation-hole of the axis of the slewing columns' pin were not parallel. A conical form of the pin is advisable.

Also the detention-whole turned out not to be covered, being subject to dust and dirt (fig. 12) which can potentially lead to an increased coefficient of kinetic friction. This problem can be overcome by welding on a cover.

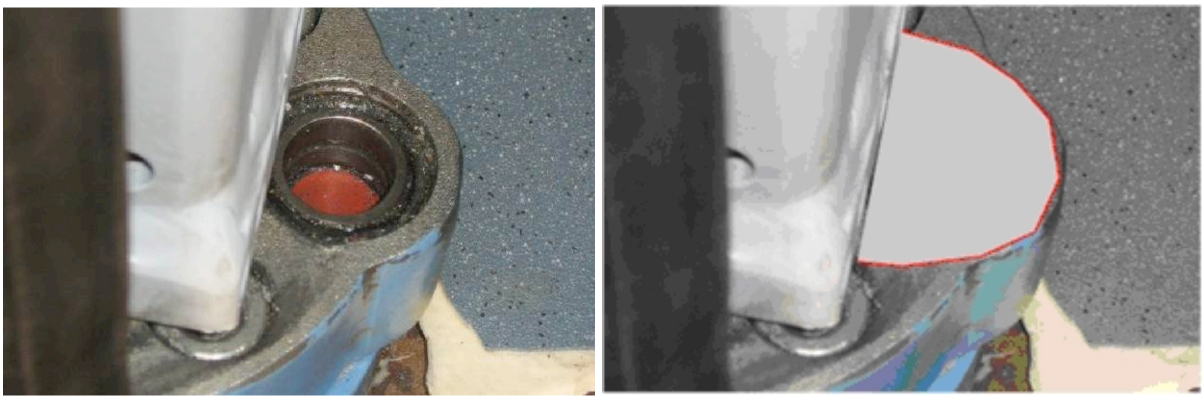

fig. 12 detention hole

The locking knob for locking the BAS in stow-position unscrewed itself during operation during tests carried out in Bulgaria and at the Innotrans show in Berlin 2012 - a protection avoiding this scenario is inevitable.

fig. 13 locking-knob of the foldable platform

The swivel-in operation requires a manual handle, leaving limited space for fort he hand at the wagon fig. 14, as on the first day of the mock-up test, the door had not been built into it, hence the problem was not visible.

It is advisable to use a bent handle facing to the wagon-end which is not deeply positioned between the collapsed platform and the actual door.

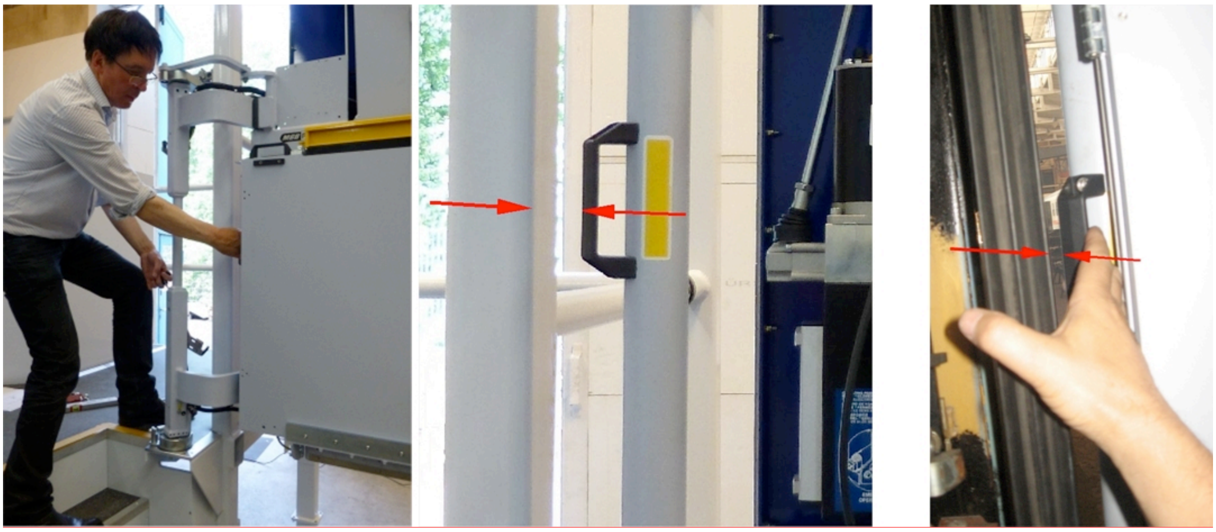

fig. 14 handle for swivelling-in movement

Based on the limited space for a manual lever restricting actual net-deflection the manual pumping operation of the hydraulic cylinder, it is advisable to use a long, cranked handle, to limit the time required for a full ground-to-floor manual operation to a minimum, by making use of the full available deflection.

fig. 15 manual pumping

The shoes of the manual release levers for the mechanical roll-stop are too low, they need to be positioned higher up, and/or longer shoes are advisable in order to manually release the roll-stop, as they need to touch the ground (platform) as first part of the platform and so that the roll-stop, which is also a boarding and alighting aid for the wheelchair, is positioned 20mm above ground (fig. 16)

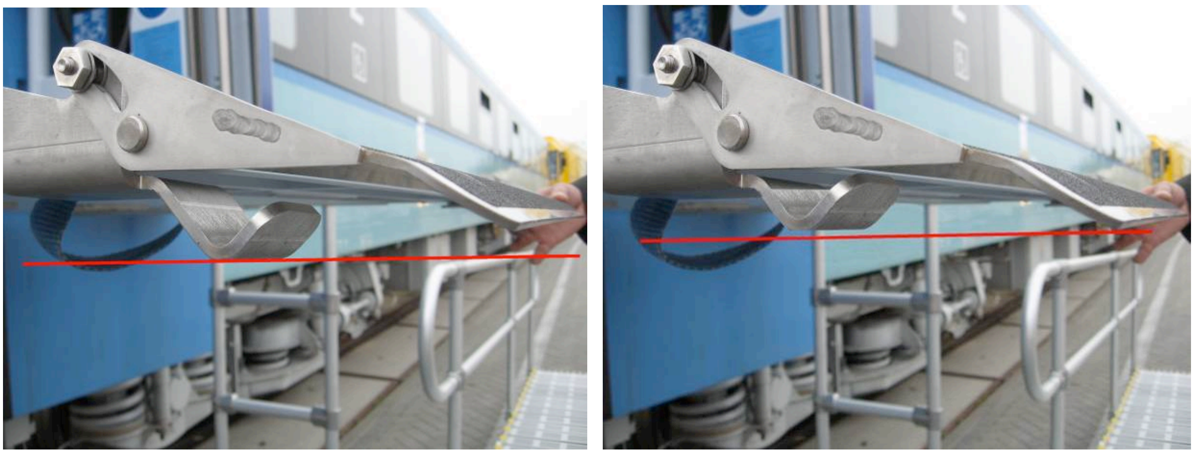

fig. 16 manual lever

More often than not the roll-stop remained in opern position after leaving ground-level during demonstration at the InnoTrans show 2012 (fig. 17). That specific safety-feature is crucial. The malfunction might have several reasons.

Specifivally the correct type of (a durable) spring and the load applied is a classic source for a malfunction as described above amongst passenger lift-manufacturers.

fig. 17 roll-stop

When boarding or alighting the platform sideways, the collapsible outboard-barrier serves as a short ramp, which is indeed too short to fulfil this function correctly and safely in longitudinal and lateral direction. This problem is evident on irregular platform surfaces. The outboard barriers' height should be doubled in order to perform as required. Also the roll-stop height should be lengthened, also to dampen the boarding and alighting process for wheelchair occupants

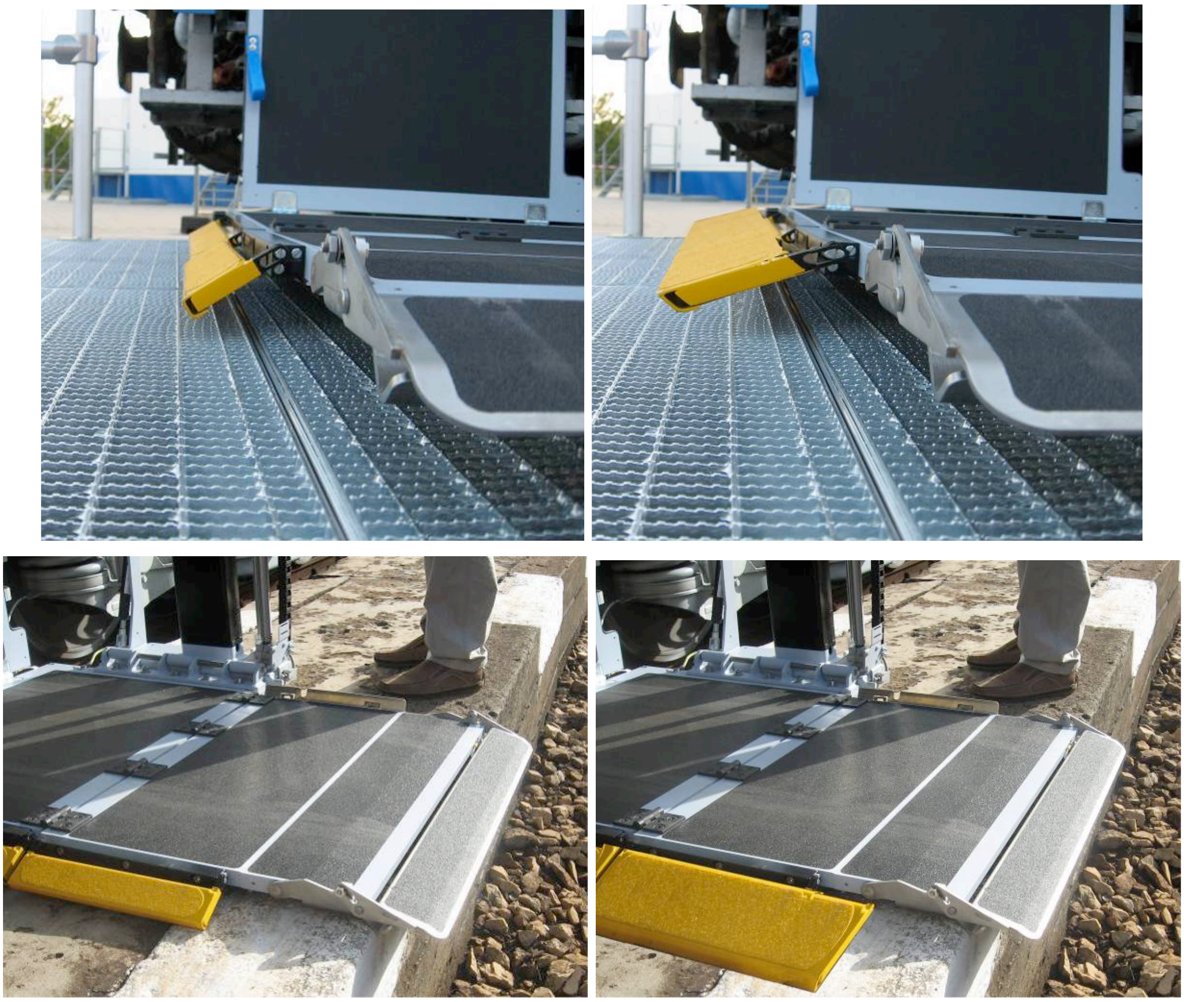

fig. 18 platform sideways

Retention plates of sufficient strength (and thickness) need to be applied, as well as effectively mounted screws (fig. 19) in order to guarantee a trouble free operation (and maintenance).

fig. 19 Loose Screws (swivelling mechanism)

The BAS covers consists of two parts, left and right. First the right side is to be released und unlocked with a key by unfolding the cover (fig. 20), then the left hand cover is opened by pulling on the handle. If the operation is performed incorrectly, the covers are subject to deformation and prevents the cpvers to fully close again.

Proposals:

Both covers should lock automatically by pushing against them, which is now only the case for one oft he covers. The release function should be applied from one point only and activate both covers (e.g. via a cable).

fig. 20 BAS covers

fig. 21 retention brackets (a) not deformed; b) deformed)

If needed, the back-side of the bridge plate could be used as a gap-bridging for comfort providing facilitated access for all, equipped with a slip-resistant surface, as proposed by Siemens Austria (Mr. Wieder)

fig. 22 Access for all ((a) existing, foldable bridge plate; b) recommended additional comfort feature)

6. Evaluation of PT during the tests in Bulgaria

In August 2012 a test ride and operation of the BAS prototype was conducted in Bulgaria in order to test the BAS extensively under real-life conditions.

A number of various platform types and different infrastructures were available along the train-stations of the test ride. This included different platform-heights, platforms positioned in a curve radius including and excluding super-elevation, platforms inside and outside the curve radius, and a variety of platform gradients and surfaces.

10 stations and 20 different boarding and alighting situations had been tested as described below:

- Curve radient 275 m
- super elevation of tracks max. 145 mm
- platform heights 110 mm-800 mm
- platform width mind. 1,12 m
- platform gradient 1-7 %

The test train (fig. 23) consisted of a locomotion and one UIC wagon only with the re-fitted BAS prototype, the interior had not been adapted then so the wagon was not usable for regular passenger transport.

fig. 23 testtrain

Both wheelchair users testing the BAS are used to travel throughout Europe by train and do therefore have specific experience and know-how. The BAS could be assessed by the experienced users' point of view (fig. 24).

The BAS was operated by BDZ personnel that had been present during the first tests in Bremen in May 2012 and therefore used to the operation of the BAS. During the course of the test ride a learning by doing effect was apparent, as the required time for a full operation decreased continuously.

A full boarding and alighting process for a wheelchair occupant while using the BAS takes approx. 3mins each when performed at a platform height of 110mm. After getting used to the operation, a full circle took 2mins30s only. The full operation-cycle includes the complete manipulation of the BAS from stow-to-stow position. The ower the platform, the shorter the operation cycle.

fig. 24 Test-users and assisting personnel, Sofia Train Station

The tests which had been carried out have clearly shown that it is applicable for re-fitting UIC wagons. The BAS was designed for this type of application, which could be applied within other types of high-floor wagons as well.

The limits of the application of the BAS had been evaluated in specific detail in the course of the test ride that had been carried out. Straight platforms enable the application of the BAS without limits down to a platform height of 110mm. Lowering the platform to track-surface level is possible in general, has not been tested though in practice.

The BAS was tested to a platform width of 1,12m, which represents the absolute minimum. Otherwise it conflicts with the opposite clearance gauge which asks for operational measures. The BAS was boarded and alighted sideways due to the collapsible outboard-barriers (fig. 25, fig. 26).

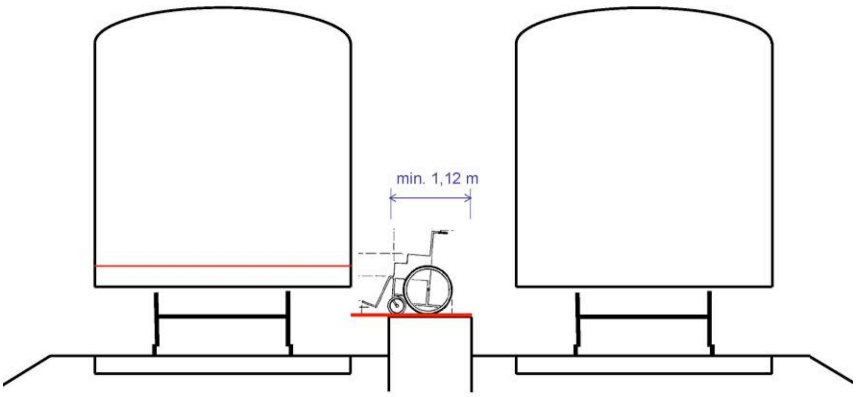

fig. 25 The drawing above shows the minimum platform with for the application of the BAS

fig. 26 application of the BAS at narrow platforms

A platform within a curve radius causes problems when using the BAS. Due to super elevation of the tracks, measured up to 145mm during the test ride, the whole train vehicle is inclined up to 10% . In Europe a super elevation of 11% (160mm) is possible. Super elevation is mainly common in within national local railway-traffic at stations along the train line, and seldom in actual train stations.

The following drawings are clearly showing the difficulties caused by super-elevation in curves:

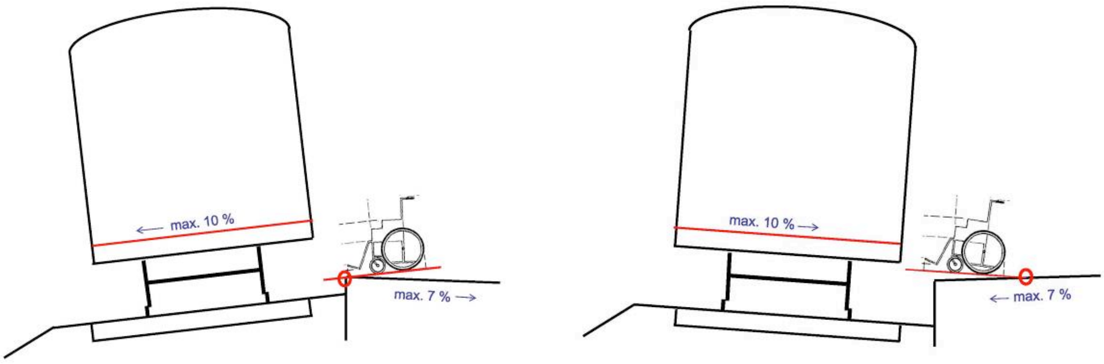

fig. 27 super-elevation in curves

These problems influence the trouble-free operation of the BAS on one hand, and the feeling of safety of the BAS-user.

Platforms positions at the outside of super elevated curves, as shown in the left picture, prevent the BAS from releasing the roll-stop. Due to the super elevation the BAS cannot be lowered to the maximum position, as the BAS-platform touches the station-platform before being lowered to the required position.

Platforms positioned at the inside of super elevated track curves do not face that problem.

During the tests carried out the BAS has been applied at platforms with a super-elevation of up to 10%, without BAS users though due to safety reasons. Users explained their fear of falling off the BAS platform due to the steep angles.

The different platforms surfaces tested in Bulgaria, which in general do play an important part when applying the BAS, did show no negative effect on the performance of the BAS. There is the risk of tip-over for wheelchair (and walking aid) users though when it comes to wholes and tears on the platform, causing entrampment of reels and tip-over of the wheelchair and walking aid.

From an operators' point of view the BAS is easy to operate and handle without failures or malfunctions once having been successfully trained, which is a crucial safety-factor. The operator of the BAS needs to be aware of the general requirements, potential problems and safety hazards, and potential individual needs of wheelchair occupants (WO).

Operators explained the wish to use pictograms on the lift parts that need to be operated in chronological order in order to facilitate the correct manipulation of the BAS.

The BAS operational cable unit needs to be stored in a lower position on the BAS, enabling also personnel of smaller stature on low platforms to grab hold of the operational unit with ease (fig. 28).

fig. 28 Positioning of the operational unit and the retention

Both WO rated the performance of the BAS very highly. It is regarded as a large steps towards a more accessible railway system in Europe.

Users explained the wish for a safety bar they could hold on to when alighting from a position high-up above ground, which makes the WO feel uncomfortable. This bar would also operate as a visual barrier for the WO, and prevent rolling off the platform in case of an unforeseen event (fig. 30).

fig. 29 Additional foldable safety bar in order to increase the safety-feeling for WOs

fig. 30 platform sideways

7. Evaluation of PT during the presentations in Berlin

The BAS has been tested for several days on Europe's leading trade show within the railway industry, InnoTrans Berlin, in September 2012. On the public days, a number of WO tested the BAS on a free-will basis.

Various WO of different age-groups using various types of wheelchairs with different needs made use of the BAS prototype. In general the feedback and wish for such type of a boarding aid on a large scale has been great.

The wheelchair occupants (WOs) testing the BAS had made various experiences with BAS. They have had made experiences with platform based boarding aids (lifts, ramps), vehicle-based lifts had been new to most of them.

The active wheelchair occupants using propelled (manual) and powered wheelchairs independently, had no difficulties whatsoever to use the BAS.

From the users‘ point of view, it makes sense to provide the option to use the BAS together with the wheelchair occupant, as persons with severe disabilities (physical or psychological) cannot operate the BAS independently themselves, nor can they board or alight the train on their own without assistance. Children with mental disabilities had tested the BAS as well. Due to safety- reasons, assisting personnel had not been allowed to board the BAS. They needed to await the boarding procedure and could only board the train afterwards.

Users explained the wish to operate the BAS themselves independently, as commonly done in private Minivans and Minibuses (passenger cars). This is impossible due to safety reasons and liability reasons for the operators.

8. Conclusions

In order to provide a barrier-free scenario, technical aids are used in the railway sector as well as in all other areas of transportation, and also within in daily-life. The main accessibility problem for railway operators are the significant vertical differences, between one and very often three or four steps between the vehicle and the platform. Because of the very long service life of the current rolling and their using for many more years, there must be found temporary solutions until the fleet will be replaced with modern fully accessible rolling stock. 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. The findings of the survey clearly shows, that in cases with higher vertical differences, electro-hydraulic lifts are the typical occasion.

The evaluation of the comprehensive test of the initial aid operations in the Bulgarian railway network has shown that existing UIC coaches can be retrofitted with the appropriate adaptations to the accessibility requirements. The prototype of the BAS is stated all requirements and also allows to perform in adverse situations such as low platform heights or platforms in sheets with elevation.

From the perspective of the operator and the users the operation of the BAS is easy to handle and user friendly. Due to the different limitations resulting from the vehicle construction, it was necessary to make several compromises but the developed compromise allows about 99% of all actual wheel chair users to board. In combination with a good personnel service at the entrance the wagons can also become accessible for nearly all passengers.

9. Publications

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Vortrag: Successful Austrian railway technology seminar, Tel Aviv; 14.12.2010.

11. B. Petutschnig:
"*Accessibility within Public Transportion - A Natural Must Have ? Equallity in Accessibility for Everybody -How and for whom?*";
Vortrag: European Mobility Group EMG Annual General Meeting AGM, Amsterdam; 23.09.2010.

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Vortrag: Conference Public Transportation - Accessibility for All, Wien; 19.05.2010; in: "*Public Transportation - Accessibility for All - proceedings*", (2010), S. 9 - 14.

13. B. Petutschnig, G. Simic, B. Rüger:
"*Boarding For All*";
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