
# PubTrans4All

**Public Transportation - Accessibility for All**

## Deliverable 2.1

# Boarding Assistance System Evaluation Criteria Report

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# 1 Introduction

This document Deliverable D 2.1 is showing all crucial evaluation-criteria which need to be considered in order to assess a new Boarding Assistance System (BAS) to be developed as well as existing systems in use. User-groups are being defined, who, together with operators and manufacturers, explain their requirements on a BAS and assess the need of its existence.

The technical and operational environment of a BAS and its capabilities under which it needs to perform will be explained, as well as its potential important role. Both criteria are being evaluated from an operators´ and manufacturers´ perspective. The evaluation criteria assess how much time and space are needed for the operation and installation of a BAS.

Furthermore, useful and required applications for the BAS that will be developed are determined. As a result, it seems to make sense to focus on heavy rail using conventional high-floor vehicles. On a smaller scale, it also makes sense to look into local and regional trains, which are using high floor-access. It is not required to develop a new solution for the underground, tram, busses, low floor vehicles etc.

The evaluation criteria of this paper are applied for existing BAS as well as for assessment of new systems to be developed.

# 2 Methodology

In order to gather all necessary information in order to assess the functions required for a BAS, the following working methods have been applied:

## 2.1 Literature and Internet Research (secondary research)

Based on extensive literature and internet research in several languages, basic information in regards to various requirements has been developed. The information determines the requirements that need to be fulfilled from a users´ perspective, as well as norms and directives. Some areas are looked into more severely than specific norms do require. A large amount of the supplied information is directly connected to subjects covered in further deliverables, and therefore not covered herein.

## 2.2 Interviews with operators and users

In order to fulfil the requirements of operators as well as users it was necessary to ask their opinion directly. This is necessary as the majority of the data required is not available through literature on one hand and on the other hand, to learn to know the exact needs. On top of that, in-depth knowledge and a better understanding have been gained.

In conversations with operators and users, they have been asked about their experiences with systems currently in use. The majority of that information is part of deliverable 2.2. A lot of that information shows the importance of these criteria, which had been discussed in interviews and therefore re-defined in some cases. These results are part of this deliverable.

Alongside personal interviews with local representatives of operators and organisations in various countries, a wide range of information has been gathered by an electronic survey using electronic questionnaires. These questionnaires covered the importance of various criteria and definition of the environment and existing limits.

The Interviews with operators have been conducted in the following countries; AT, CH, DE, DK, SE, NO, UK, IE, FR, ES, BG, HU, SLO, HR, SRB, RO, NL, BE, SK, BIH, MNE, including face-to-face interviews, partially as well representatives of user-groups.

This large number of countries was necessary in order to cover the wide range of needs and environmental limits of various countries in the best possible way.

## 2.3 Traveller survey

14.000 interviews in countries such as AT, CH, DE, HU, SLO, BG, HR, SRB, BIH, and MNE have been conducted in order to learn to know the difficulties that various user-groups face within different environments.

# 3 General Mobility Barriers

## 3.1 Mobility Barriers within Daily Life

According to EU regulations, it is a must that public transportation systems need to be accessible for anyone without restrictions and it is also a must for all European railway operators. As a consequence of the ageing society there is an increased need for mobility and effective methods in order to overcome accessibility obstacles. There are also further groups of people with reduced mobility, which influence the variety of needs of passengers in regards to accessibility of public transport systems.

Mobility barriers within daily-life situations and the number of people with permanent reduced mobility are larger than suspected in general. Based on statistical data these numbers are proven. A publication of the DG XIII of the European Union in 1994 states that 10% of the population of the European Union is affected by a permanent physical or psychological disability. In 1994 out of 400 million people, more than one million blind people, over a million deaf people, almost three million wheelchair users and various ten million people with reduced mobility (hearing difficulties, visually or mentally impaired) lived within the European Union. Between 40 and 50 million people do need an additional aid for compensating their disability in certain situations [Bas Treffers, barrierefrei – ein internationaler Überblick, Grüne Reihe, Fachgebiet Verkehrswesen, University Kaiserslautern, 2002/04].

Permanent Reduced Mobility is classified within the "International Classification on Impairment, Disability and Handicap (ICIDH) " of the World Health Organisation

- **Impairment**

  Loss or abnormal development of physical and mental functions, e.g. deafness, blindness, loss of sight on one eye, paralysis or loss of a part of the body, mental deceleration.

- **Disability**

  Limitation or inability to do a typical, "normal" operation due to an impairment seen as normal by other people. Examples for a disability are problems with seeing, speaking, and hearing, troubles to walk etc.

- **Handicap**

  Handicap can be described as a potential disadvantage occurring from impairment or a disability, and potentially limiting fulfilling persons´ role as a "normal" member of the

society. Examples for disabilities are confinement in bed, not being able to use public transportation etc

## 3.2 Mobility Barriers in Transportation

There are a number of barriers in transportation, which do affect each individual user differently depending on the individual disability. Depending on the type of disability, the severity of the mobility barrier raises in case of several barriers. In some instances, barriers are not even recognised! Improvements on barriers for one user-group could mean a potential deterioration of the situation for another user-group.

## 3.3 Overview on methods to overcome barriers (technical solutions, services)

### 3.3.1 Daily mobility

People face a number of barriers in various daily-life situations. During the last decades, the situation improvements have been made due to norms for the construction of buildings in order to remove those barriers.

- **Building construction**

  Building construction has been integrating the accessibility aspects and concepts required for modern buildings for many years already, also adapting existing building accordingly. Besides minimum measurements for door widths and steps, the design and measurements of ramps and lifts are considered in general, access areas without any steps at all represents a universal solution, for wheelchair-users, as well as people with temporary and permanent disabilities.

  - **The installation of lifts**

A variety of systems is being used, mainly depending on the number of floors being served and the number of usage. Besides classic lifts, also smaller lifting-devices are being used to overcome low heights (Pic. 1 and Pic.2).

**Pic. 1: Wheelchair-lift**

Source: http://www.garaventaliftgroup.com/de/products/Senkrechtlifte

**Pic.2: Stairlift (CAMA)**

Source: http://www.cama.de/produkte/cama-lifttreppe/galerie.html

- **Installation of Stair lifts**

A stair lift is a good alternative in case of a difficult situation for a lift installation connected with high cost. Those stair lifts are installed on existing stairs and enables vertical transport for persons with walking disabilities and wheelchair users (Pic.3 and Pic.4).

**Pic.3: Stairlift (ANGO M 1000)**

Source: http://www.ango-reha.de/sitzlifte_m1000.php

**Pic.4: Stairlift (ANGO)**

In cases where an installation of a lift-type device is impossible independent systems such as step-crawlers are being used (Pic. 5).

**Pic. 5: Stair Climber**

Source: http://www.garaventalift.de/03Produkte/037Treppenraupen/03710treppenraupen.htm

- **Information Systems**

  Due to a variety of requirements that people with hearing and visual impairments do have, accordingly information systems need to be designed for usage without any barriers. For people with visual impairments for example it is important to position signs at the right height and using the correct type of letters and contrast. Wheelchair-occupants and people affected with rheumatism and arthritis need signed to be mounted relatively low. People with hearing-impairments depend on effective visual signage.

### 3.3.2 Railway-traffic

Due to the liberalisation of railway infrastructure a growing number of private train-operating companies are investing in regional rail traffic and the low-floor vehicles, which now

becoming the new standard. On the other hand, the existing platform infrastructure often forces the use of ramps or sliding-steps to bridge the gap between train and platform.

Long-distance trains are still operated by the former federal railway companies. The existing fleet typically consists of high-floor vehicles without any integrated boarding assistance system. Existing differences within the platform infrastructure require the use of platform based lifts or ramps.

One of the key areas representing barriers is the lack of accessible train stations. Platforms, which are just reachable by using stairs or by crossing the tracks even are not accessible for People with Reduced Mobility or only accessible with great difficulty.

Within the area of railway traffic in Europe "there are two European Commission proposals which impact on rail travel for disabled people: the draft Technical Specification for Interoperability – Accessibility for People with Reduced Mobility (TSI-PRM) and the draft proposal for a Regulation on International Rail Passengers` rights and obligations. The TSI-PRM will set minimum standards for the specification of accessible infrastructure on the Trans European railway Network and for new and upgraded rolling stock. [..] The proposed Regulation would establish rights in relation to international rail travel including specific provisions covering disabled people." [Department for Transport, Railways for All -The Accessibility strategy for Great Britain's Railways, March 2006]

Quite often existing standards do show discrepancies, e.g. the TSI PRM currently still referring to outdated wheelchair standards dating back to 1985, while the reality shows real heavyweight power wheelchairs nowadays, representing a potential hazard for the occupant and other passengers in case of an accident during transportation when not sufficiently secured. An integrated view on all existing and also effectively working standards enhancing mobility should help improving efficiently European Accessibility and Mobility Regulations.

In The United Kingdom, an integrated approach has been conducted in terms of design needs, operators´ needs and staff training. "Towards an Accessible Railway - Railways for All - the Accessibility strategy for Great Britain's Railways" is a report compiled by the department of Transport, describing how to improve access to UK Railways, to the point it states the following:

"A transport chain is often only as strong as its weakest link. We have therefore structured this strategy to describe how we intend to improve access at all stages of rail travel, including:

- finding information, buying tickets and making reservations
- access to station buildings and platforms
- accessibility of train carriages

- Quality and consistency of our staff training [...]

The gap between the platform and the train is a concern for many disabled people and can undermine the confidence of mobility or visually impaired passengers to use the railway. [..]" [Department for Transport, Railways for All -The Accessibility strategy for Great Britain's Railways, March 2006]

Also a number of handicap organisations in the UK are involved in the improvement process for accessibility, such as the Joint Committee on Mobility of Blind and Partially Sighted People (JMCBPS): "Rail and Underground Accessibility: We have continued to highlight our concern over the lack of tactile paving to warn of platform edges at train stations. We responded to Department for Transport consultations on Train and Station Design for Disabled Passengers: A Code of Practice; and on How to Write Your Disabled Persons' Protection Policy: A Guide for Train and Station Operators. " [Joint committee on Mobility of Blind and Partially Sighted People, Annual Report 2008, Reading, Berkshire]

Staff training represents a key area of executing affective mobility. The inclusive Mobility Report of the Department of Transport in the UK refers to this subject as follows:

"Staff who are in regular contact with the public need to have awareness of how to serve a disabled person without discrimination and how to mitigate the effects of inaccessible premises, vehicles and services etc., in compliance with the Disability Discrimination Act (DDA). All staff needs to be able to think on their feet in unexpected situations or in an emergency.

Some transport operators and other organizations have produced training programmes on disability awareness which can be used by other organizations. Training in disability awareness should form part of both induction training and refresher or promotion courses for staff. Disabled people should be involved in the design of training programmes as well as their delivery where possible. Training should be tailored to the particular job function [...]" [Department for Transport, Inclusive Mobility, London 2010]

### 3.3.3 Travelling by air

"Significant recent European Union developments include: A European Regulation on the Rights of Disabled Persons and Persons with Reduced Mobility when Travelling by Air. This prevents carriers from refusing boarding to such persons (save in defined categories of case) and makes airport operators responsible for providing assistance to disabled passengers - moves towards possible EU legislation on the rights of persons with reduced mobility travelling by sea and inland waterways - European standards on rail vehicle accessibility for disabled persons and persons with reduced mobility for interoperable rail systems". [British Government, RVAR, Rail Vehicle Accessibility Regulations - Guidance, 2008]

Air traffic is currently using converted vehicles, typically minibuses, to transport the wheelchair occupant to the aircraft as commonly used in community transport systems. The current aeroplane shuttle-buses in use are normally not equipped with Boarding Assistance Systems. The transport into the aircraft is usually done manually, with the assistance of trained personnel, e.g. carrying wheelchair and user into the aircraft.

### 3.3.4 Road traffic

Within road-traffic, a large variety of assisting boarding systems and other assistance systems have been in use for some decades already. Road traffic for people with reduced mobility is probably the most developed area within the adaption of transportation vehicles for people with reduced mobility, covering the area of public bus transportation, community transportation services, and most of all private motor vehicles.

- **Motorised Individual Transport**

Those especially converted motor-vehicles, private cars and vans, as well as mini-buses within community transport, are using Boarding Assistance Systems such as lifts, ramps, kneeling systems, wheelchair stowing systems, plus wheelchair tie-down systems integrated below floor surface, adapted assisting driving systems for self-drivers for steering, clutches, acceleration etc. It goes as far as electronic joystick steering systems for people in wheelchairs, driving their van from the wheelchair, using-wheelchair docking stations to secure the wheelchair as a motor-vehicle seat. These especially converted vehicles are called "WAV" – Wheelchair Accessible Vehicles.

The list is long, and the variety of available products is permanently growing in this area. Organisations for people with handicaps in Europe and organisational and industrial Lobby-groups in the European Union have common goals they try to achieve together, e.g. currently seeking for a harmonised driver-licence for people with disabilities and handicaps within the European Union:

The area of Boarding Assistance systems in private motor vehicles is handling the access for wheelchair-users and people with walking disabilities. Wheelchair-stowing systems enable wheelchair users who do have the physical ability to use their upper torso, to move over to the driver or co-driver seat by themselves, while the wheelchair stowing systems is taking care of stowing the wheelchair correctly into the car, typically into the second seat row (see Pic. 6) or the trunk, and providing it again to the door when the wheelchair-user leaves the vehicle again. Swivel-seats assist people with walking difficulties when accessing the vehicle (see Pic.7), while a companion is taking care of the storage of the wheelchair.

**Pic. 6: Wheelchair stowing-system (Edag)**

Source: http://www.paravan.de/auto-mobilitaet.html

**Pic.7: Swivel-Seat (Autoadapt)**

Source: http://www.paravan.de/auto-mobilitaet.html

- **Public Transportation**

Public buses within urban transportation have been using fleets consisting of vehicles using low-floor technology equipped with kneeling systems mostly using air-suspension. Tramways are still using manual ramps for barrier-free accessibility solutions (Pic.8), in some cases even cassette-lifts for high-entrance solutions.


**Pic.8: Low-floor entrance (Darmstadt Tramway), left**
**Electro Hydraulic Ramp MBB Palfinger (Bremen Tramway), right**

Source: http://de.academic.ru/dic.nsf/dewiki/1018990,
http://www.mbbpalfinger.com/palfinger/23287_DE.495BB6caa3b9b95e58c315d21de2f0dc55fde

At the beginning of the last decade, the European Union has implemented the 2001/85 Bus Directive specifying accessibility in public transportation within the area of busses. Amongst low-floor busses, which are commonly used in urban areas also, high-floor long-distance busses are using Boarding Assistance Systems such as electro-hydraulic lifts which are either integrated into the stairs (see Pic. 9) or installed into the rear part of the vehicle (see Pic. 12).

**Pic. 9: Cassette lift**

Source: http://www.braunability.com/commercial/uvl.cfm

**Pic. 10: Kos-lift (ContracCobus Optimo Bus)**

Source: http://www.contrac-optimo.de/43-0-optimo--2300-care.html

The Community Transport Association (CTA) and contracting transportation service companies in the United Kingdom for example mainly uses electro-hydraulic lifts within their vehicle-fleets for wheelchair occupants in order to accessing their Minibuses for transportation (see Pic. 13). In Germany where the "Berufsgenossenschaft" specifies

transportation standards within community transport, as well as in France, where GHIP, the French community transportation association, mainly manual ramps are being used and specified, while in Sweden kneeling-systems and ramps had been recently specified as a standard within the community-transport system, called “Faerdtjaensten”.

**Pic. 11: Dual Parallel Arm Lift, with vertically (left) and horizontally (right) split platform**

Source: http://www.braunability.com/commercial/vista-2.cfm

Besides the requirements of CEN and DIN Standards in regards to Boarding assistance systems and accessible motor-vehicles the DIN Standard has now integrated requirements of the International Standard Organisation, the ISO 7176-19 and ISO 10542 specifying crash-worthiness for transportable wheelchairs and wheelchair secument systems, also called Wheelchair Tie-Down Occupant Restraint Systems (WTORS).

# 4 User groups

## 4.1 Qualitative and quantitative description of User-Groups

### 4.1.1 Types of Reduced Mobility

When talking about people with handicaps, children, bulk luggage, etc in transportation they are referred to as "Persons with Reduced Mobility", a term that is commonly in use within the European legislation.

In the United Kingdom, the Department for Transport, London, has looked in depth into the specific needs of passengers in regards to accessibility requirements within rail transportation the operators´ needs and the environmental infrastructure, as well as the legal requirements in regards to the UK Disability Discrimination ACT of the U.K. for example, as well on a European level into the TSI PRM (Technical Standard for Interoperability for Persons with Reduced Mobility), being a European Union draft that is developed by the TSI PRM working group. The following this chapter will give an overview of the specific groups amongst persons with reduced mobility and describing them, the next chapter emphasizes on their specific needs.

"Basic human factors information, definitions: It is essential that design for people with mobility impairments should be to the highest possible standards. This requires knowledge of the capabilities of different types of person. This section provides information on the basic human requirements for ease of movement. In designing or modifying facilities, the aim should be to be generous in the allocation of space.

The term disability is a broad one. It includes people with physical, sensory or mental impairment; at a conservative estimate between 12 and 13 per cent of the population have some degree of impairment. Many, though not all, face barriers to movement in the environment. This [.] is intended to show how these barriers can be removed or at least reduced, but it does have a wider relevance because there are many other people not conventionally considered to have a disability who also encounter barriers to movement.

People with small children, people carrying heavy shopping or luggage, people with temporary accident injuries and older people can all benefit from good design of the pedestrian and transport environment. Without a barrier free environment, many of these people will be mobility impaired.

While it is true that there are many aspects of design in the pedestrian environment that are helpful to all or most disabled people (and many others as well) there are also some specific facilities needed by people with a particular kind of impairment.

Manual wheelchair users need sufficient space to be able to propel the chair without banging their elbows or knuckles on doorframes or other obstacles. However, someone who walks with sticks or crutches also needs more space than a non-disabled walker; so too does a long cane user or person carrying luggage, or a lot of shopping bags, or with small children. Thus providing adequate clear space on pavements, along passages in public buildings, through doorways etc, is of benefit to many people.

Similarly, visually impaired people need a good level of lighting in transport buildings and elsewhere and, if information such as a train or bus timetable is displayed, a print size that they can read easily. But almost everyone else benefits from good lighting, not least because it gives a greater sense of security, and practically everyone finds reading timetables easier if the print is clear and large.

These are just two examples of design requirements that are essential for people with a particular impairment but which have a much wider relevance. [..] The term disability is a broad one. The Disability Discrimination Act in the United Kingdom defines a person as having a disability if he has a physical or mental impairment, which has a substantial and long-term adverse effect on his ability to carry out normal day-today activities.

There are various ways or models used to define disability but in functional terms, this guide is mainly concerned with the following:

**Locomotion**, which includes people who use wheelchairs and those who can walk but only with difficulty often using some form of aid such as a stick or walking frame. Approaching 70% of disabled people have locomotion difficulties: those with walking difficulties outnumber wheelchair users by about 10:1.

**Seeing**, which can be sub-divided into blind and partially sighted people. [..]

**Hearing**, which can also be sub-divided into those who are profoundly deaf and those with impaired hearing, ranging from severe to mild deafness.

**Reaching, stretching and dexterity**, frequently the result of arthritis, which can make these movements painful and difficult, or of muscular dystrophy causing a loss of muscular strength, or of complaints of the nervous system.

**Learning disability**, making it hard to understand complicated information or to use complex machines (like some ticket machines). It should be remembered that these categories are not mutually exclusive. Many disabled people, particularly older people, have more than one impairment." [Department for Transport, Inclusive Mobility, London 2010]

The TSI-PRM (Technical Standard for Interoperability Persons with Reduced Mobility) distinguishes between two main groups, "People in wheelchairs" and "Other groups of people

with reduced mobility". According to the TSI-PRM, the following user-groups are regarded as user-groups with reduced mobility:

- **Wheelchair-Occupants/Wheelchair users**

Wheelchair-users face the greatest barriers when it comes to train accessibility. They rely on heavily on their wheelchair and face tremendous difficulties when accessing or alighting the train.

The planning of accessibility solutions without barriers means taking the following design-needs and requirements into account: a wheelchair user-friendly boarding assistance system, a capacity-load up to 300k and above, measurements according to door opening width (see chapter 5.4.4) and the vehicle-area of installation.

The primary function of a wheelchair is to compensate for mobility impairment. Wheelchair design priorities for wheelchair occupants are Toileting, Comfort, Posture Management, Pressure Management and Tissue Integrity. The transport of wheelchair user enables social inclusion such as access to education, to leisure, to work and access to facilities such as to the public transport system (B. Appleyard, Chair BSI CH173/1 "Assistive products for people with disability: Wheelchairs" PubTrans4All Conference Vienna, Austria, May 2010).

- **Other Persons with Reduced Mobility**

  - ***Persons with walking disabilities and their extremities***

    Technical aids and rehabilitation products such as walking stick, crutches, wheeled walker etc. are necessary for many walking disabled. Gaps, an uneven ground and unforeseen obstacles, height differences when accessing a vehicle, and other hurdles often cause accidents for people with walking disabilities. Persons with griping problems are facing tremendous problems when using vending machines, buttons and handles, handrails etc. Also small people who are growth-restricted face these problems. Various types of walking disabilities, disability aids, and required space are described in chapter 4.2.

  - ***Persons with Children***

    Persons with children and prams are requiring space, which usually two or three people can share in public transportation vehicles. Travellers with wheelchairs often need help from foreigners, as they need more time to access and alight the train.

    A simple ramp is usually preferred over a lift based on recent research. The ramp needs to be easy to operate, not too steep, and operable and manageable without any further assistance.

- ***Persons with heavy or outsize luggage***

  During peak-time of the holiday period and tourist season, many people travel with heavy luggage. This fact is a tremendous bourdon for elderly people, getting less vital and mobile with age.

  The weight or the size of the luggage items represents a big problem in combination with stair-access areas of vehicles.

- ***Elderly People***

  Elderly people often face one or multiple limitations with regards to their reduced physical abilities due to age. The definition "elderly" is defined by the effects and impact of age, rather than the level of age. As mentioned, a combination of limitations is quite common.

  The elderly generation suffers from visual and hearing impairments, as well as limitations to move combined with declining muscular strength. Critical Aids are handrails and similar devices to hold on to, which assist as well children and small people due to their size.

- **Visually Impaired and Blind Persons**

  The group of visually impaired people consists of persons who are blind, and person with visual impairments. One differentiates between people who were born blind and the group of people who went blind in age. For People who went blind due to an accident or sickness the access and exit, area of public transportation vehicles represents inevitable hurdles and danger-zones. Blind people heavily rely on their tasting, smelling and tactile senses. Supporting measures such as red flags and usable sonic information are needed in order to improve their mobility.

  People with several visual impairments cannot see almost anything in poor light. Potential danger zones are stairs and uneven ground. In order to prevent accidents and reduce risk, information and warning signals need to be marked by using contrasts. These warning signage needs to be identifiable by hands, feet, blind stick or audible.

- **People with hearing impairments and deaf people**

  People with hearing impairments are either hard of hearing or affected by deafness. They rely heavily on visual information and warning signals, as they suffer from disturbances of equilibrium, and cannot realize sonic warning signals.

  Accessing a vehicle does not mean a problem to persons with hearing impairments, nevertheless gaining information in real-time, which means visual information provided by efficient signage, is crucial, as well as the assistance of trained personnel, facilitating the journey for this group of people.

The described impairments in regards to mobility can either be permanent or temporary, regardless the duration of the impairment peoples' mobility must not be affected by barriers.

## 4.2 Special Needs and Requirements for Train-Accessibility

The user-needs of persons with reduced mobility had been found out by an online survey amongst handicap organisations. Existing boarding assistance systems (BAS) are not or merely satisfying for many of those handicap organisations, amongst other unsatisfiable services being criticized such as lack of personal assistance, and limited access to accessible platforms. There is further criticism in regards to the short retention time and short time available for the boarding and alighting process at the station.

### 4.2.1 Special Mobility Needs of the Specific User Groups - Improvements and Reduction of Difficulties

An unlimited use of traffic systems is important to all user-groups. Independent usability is not a general need but a possible usage without a boarding assistance system is a big wish.

Generally speaking, a growing number of operating low-floor vehicles is an advantage for all user-groups. Executing specific measures represent a potential advantage for several user-groups, e.g. improved contrast. Using of ramps for all user-groups is a possible alternative to existing access systems.

- **People in Wheelchairs**

  The mobility of people in wheelchairs is heavily affected by stairs. Stairs and gaps which cannot be overcome as well as little available space or even space conditions that are too tight represent a huge problem for wheelchair-users.

  Wheelchair users are interested in level-boarding solutions, which do not use any type of stairs. The use of a small ramp to bridge the gap between platform and vehicle is not a problem also wheelchairs with small wheels can access the train trouble-free. The increase of the door-width is also a possible improvement enabling the wheelchair to move more freely. Nevertheless, in reality, changing the door width at an existing vehicle is almost impossible.

  Touch sensitive devices such as push buttons and rotary knobs mean challenges as well. The Code of Practice BS 8300 (British Standard) describes the easy or comfortable reaching distance without too much movement of the torso and the maximum or extended reach, which is just possible with movement of the Torso. The optimum height for feature buttons, door handles etc is defined by 750 to 1200 millimetres. The reachable distance

for a wheelchair-occupant from the person to the touching-point depends on the tallness of the wheelchair-occupant and the height and extent to be covered.

- **Persons with Walking Impairments, Elderly People**

  Persons with walking-impairments criticise the lack of handrails that they would like to hold on to around the vehicle access-area. The transparency of the gap between train and platform is not sufficient and raises the risk of tumbling and falling.

  Persons with walking impairments do need sufficient devices to hold on to such as handles and handrails. Stairs of a low level and sufficient depth, as well as a coloured contrast against the background are needed. The whole access area needs good lightning and doors need sufficient width.

  Vehicles providing kneeling systems represent a good alternative. The use of ramps is also possible.

- **Visually Impaired**

  Visually impaired people require strong contrasts in order to identify their environment, but they are often insufficient. Also grids represent an additional problem. Platforms of various heights and various distances between vehicle and platform make the access even more difficult.

  Persons with visual impairments are interested in standardised accessibility solutions that are used everywhere. The main goal is the standardisation of platform heights and bringing different heights to the same level all across the network. Also sufficient contrast and lightening ensures risk- free accessibility of the vehicle. A ramp, as specified earlier in regards to contrast and surface, is an alternative to stairs.

- **Blind People**

  Barriers for blind people are the gap between platform and vehicle, the stairs around the access area and handrails. Additional aids to improve the ease of access are the visibility and contrast around the entrance in order to identify step, as well as a structured floor in the entrance area.

  Finding the entrance doors and the orientation to find buttons and other touch-sensitive devices is difficult and often impossible without assistance. Low recognisability of the distance between platform and vehicle is a potential hazard, as well as the recognisability of the doors' closing mechanism for blind-sticks and a guide-dogs' lead.

  Lack of announcement via sonic speaker systems when only visual information is available, is a huge problem.

The reduction of horizontal and vertical distances between platform and vehicle, as well as optimising the door closing-mechanism, reduces potential of danger. Through standardisation of the access area of the vehicles, finding and operating buttons and devices is facilitated. Tactile signs and sonic information enable a quicker orientation.

- **Hearing Impaired and Deaf People**

  Missing or insufficient visual signs represent problems for hearing impaired and deaf people.

- **Small People**

  Small people face difficulties when using high stairs and large gaps. The usability of handrails is limited due to their usual installation heights.

  A sufficient number of handrails and handles and minimizing the gap between vehicle and platform, reduces potential risk when accessing the train. The usage of ramps is a possible alternative.

## 4.3 Role and Importance of a Boarding Assistance System

The primary research was conducted in order to find out about the role and degree of the importance of a Boarding Assistance System (BAS) from different perspectives. Opinions of user groups, operators and manufacturers had been collected.

Opinions differ between users, operators and manufacturers, as well as amongst the groups. Some operators value all passengers as very important in regards to the existence and use boarding assistance system. Others only value a BAS for wheelchair-occupants. Amongst those two main-trends, most operators have a variety of opinions and views in regards to the importance of Boarding Assistance systems amongst those groups. These views as vary amongst the manufacturers and user-groups.

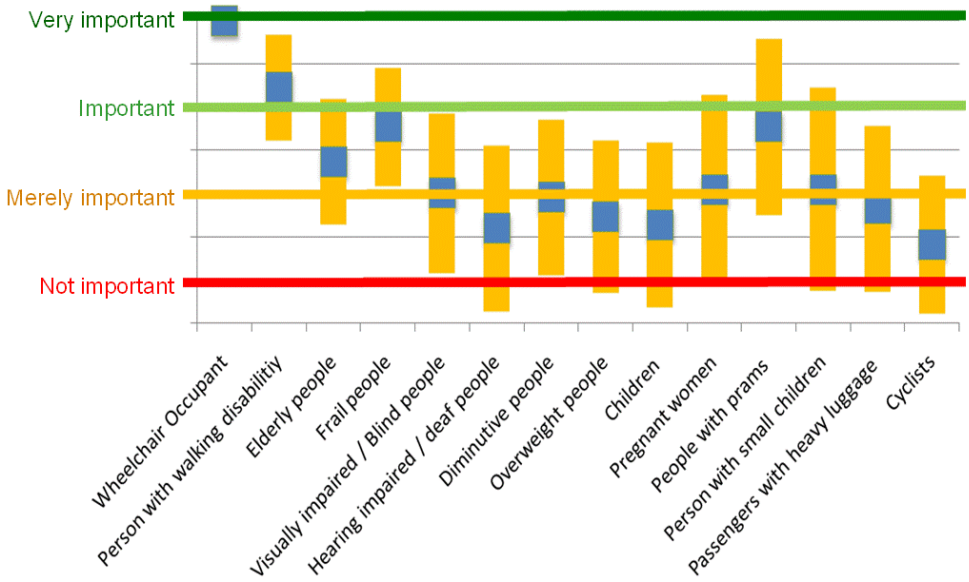
The following charts describe the importance and role of the usability of a Boarding Assistance System to a specific group of users (in order to make the charts readable, user groups are sometimes specified as important, merely important, not important – what it means in detail, is the importance of a BAS to the specific user-group).

### 4.3.1 Operators´ perspective (see Pic. 12)

On average, operators perceive the importance of a BAS for the potential user-groups as follows:

- **Wheelchair Occupants** are rated as **very important** by the operator.

- **Persons with Walking Impairments** and **Elderly People** are rated as **important**.
- **Hearing Impaired / Deaf People** and **Visually Impaired** as **merely important**
- **Small People, Children** and **Overweight Persons** as **merely important**
- **Persons with Prams** are rated as **important**
- **Pregnant Women, Persons with Children** as well as **Persons with Luggage** or **bicycles** are rated as **merely important**.

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**Pic. 12: Operators'perspective: importance of BAS for different user groups**

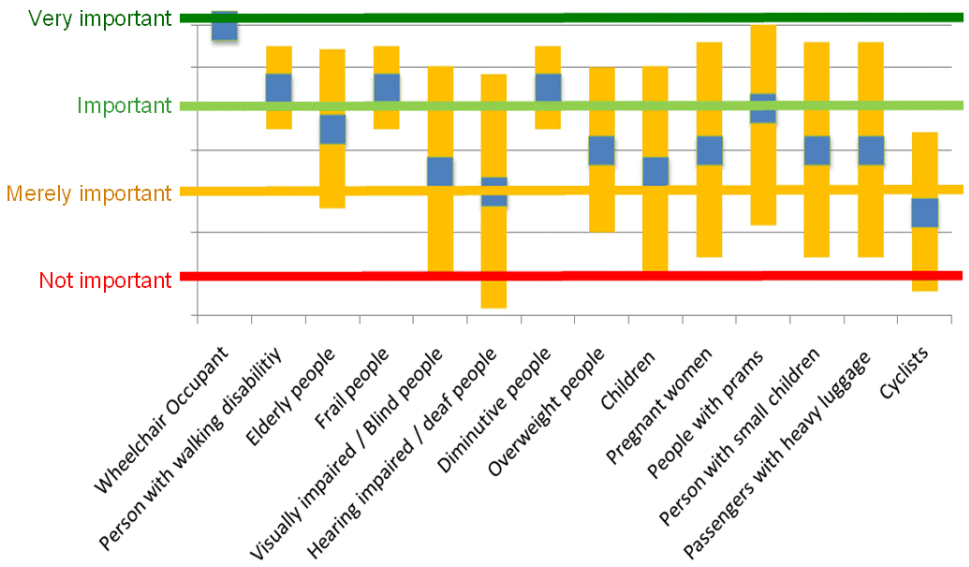
A remark shall be made at this point as often multiple mobility impairments occur at the same time. E.g., people with walking impairments could be blind as well and would need to be able to use a boarding assistance system taking into account the fact of the users' visual impairment.

### 4.3.2 Manufacturers´ perspective (see Pic. 12)

On average manufacturers, perceive the importance of a BAS for the potential user-groups as follows:

- **Wheelchair Occupants** are rated as **very important** by the operator.
- **Persons with Walking Impairments** and **Elderly People** are rated as **important**.

- **Hearing Impaired / Deaf People** and **Visually Impaired/Blind People** as **merely important.**
- **Small People** are rated as **important**, obvious differences appear amongst the manufacturers´ assessment of this specific user group.
- **Children** and **Overweight Persons** as **merely important** and **important.**
- **Persons with Prams** are rated as **important.**
- **Persons with bicycles** are rated as **merely important**.
- **Pregnant Women, Persons with Children** as well as **Persons with Luggage** or **bicycles** are rated as **important** and **merely important**.




**Pic. 13: Manufacturers'perspective: importance of BAS for different user groups**

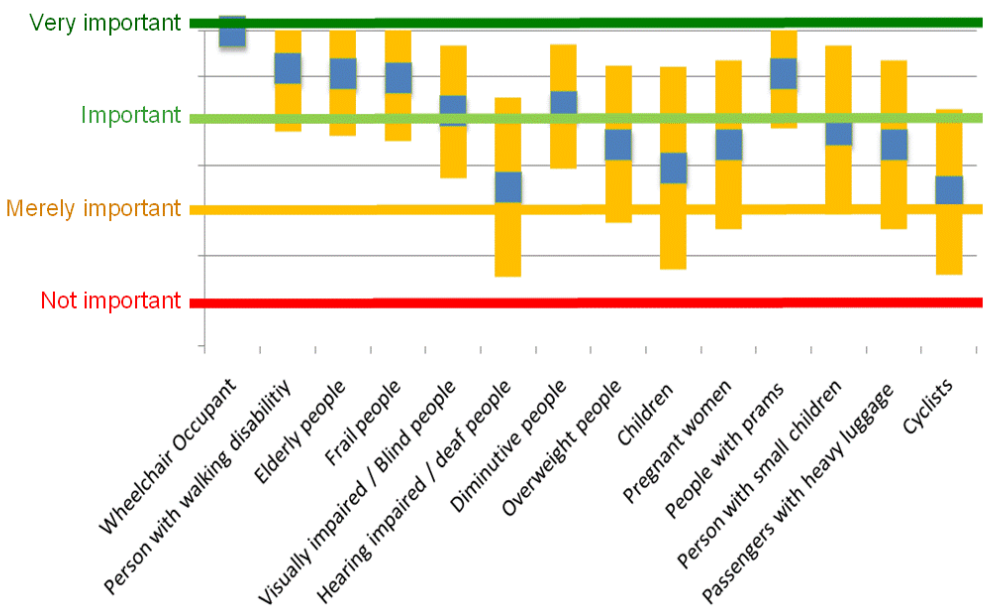
In general, manufacturers assess the role of some user groups more important or slightly more important than operators do.

### 4.3.3 Users' perspective (see Pic. 14)

On average representatives of the user groups perceive the importance of a BAS for the potential user-groups as follows:

- **Wheelchair Occupants** are rated as **very important** by the all users groups.

- **Persons with Walking Impairments** and **Elderly People** are rated as **important** and **very important**.
- **Visually impaired** are rated as **important**
- **Hearing Impaired** are rated as **merely important.**
- **Small people, Children** and **Overweight Persons** are rated as **important.**
- **Persons with Prams** are rated as **important and very important.**
- **Persons with bicycles** are rated as **merely important**.
- **Pregnant Women, Persons with Children** as well as **Persons with Luggage** or are rated as **important**.



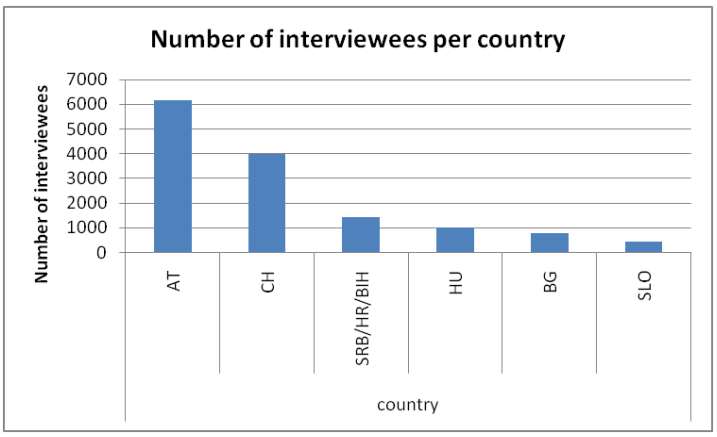

**Pic. 14: Users'perspective: importance of BAS for different user groups**

There seems to be some slight tension between the operators´ perspective and the perspective amongst user groups, which is a result that one could have expected. In general, representatives assess the importance of many user-groups higher than the operators do, which is clearly shown as a wide gap when comparing the results of the operators´ and user groups´ ratings.

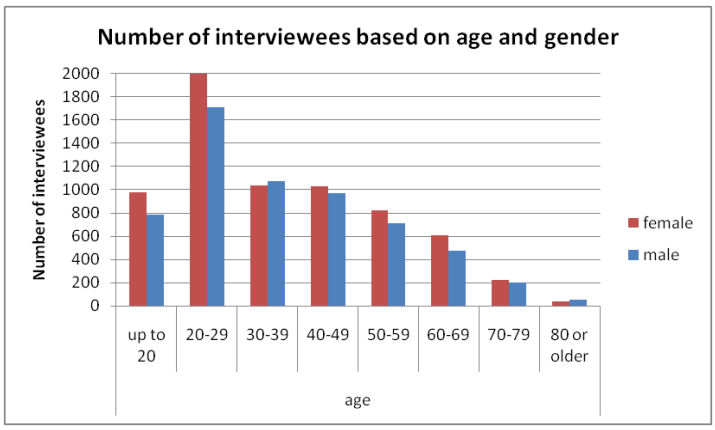
## 4.4 Needs of the travellers in general

### 4.4.1 Traveller survey - introduction

In order to find out about the needs of travellers and the difficulties they face, 14.000 personal interviews had been conducted in all partnering countries (see Pic. 15 and Pic. 16).




**Pic. 15: Number of interviewees per country**



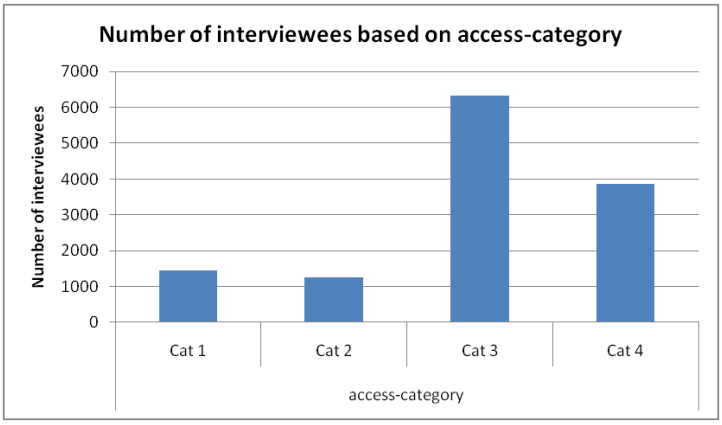

**Pic. 16: Number of interviewees based on age and gender**

In order to compare results within different operational environments and to identify clear trends and develop statements, personal data (age, gender, luggage taken along, mobility impairment/reduced mobility) and details about the technical environment (accessibility situations and limitations – platform height, vehicle type, access-type) had been asked at the same time. Also, the degree of the train utilisation was assessed as a train-specific factor in order to compare the results with general impressions that all passenger groups have.

The following four access-categories have been selected based on the technical and constructional access-characteristics of the vehicles as well as behavioural characteristics of the passengers when accessing a train:

- Cat 1:  level boarding or one stair max.
- Cat 2: Stairs with flat angle stairs and wide door – ICE train or TGV
- Cat 3: RIC wagons („classic“ InterCity train wagons)
- Cat 4: old-type vehicles with steep stairs

Cat1 implies the platform height based on level-boarding or one remaining stair while Cat 2 cover platform heights of 55 and 76cm. Cat 3 and Cat 4 and are not being covered herein. The number of interviewed passengers based on the categories is shown in Pic. 17.




**Pic. 17: Number of interviewees based on access-category**

The following chapters are showing the results for passenger needs concerning the access-situation and further significant findings.

### 4.4.2 Mobility Impairments

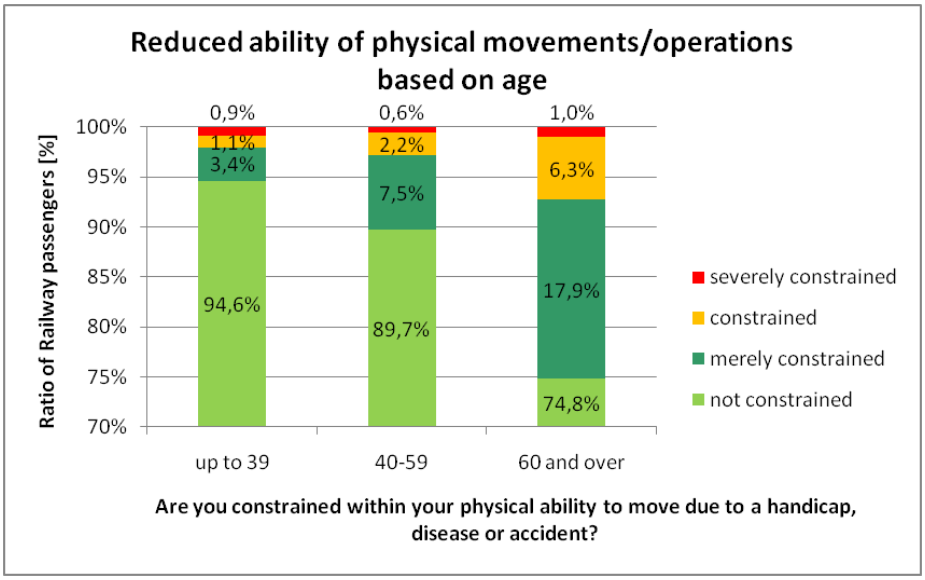
As covered in previous chapters there is a variety of mobility impairments. Besides physical impairments, luggage or prams also represent impairments as well as a combination of several difficulties due to multiple physical impairments due to age for example.

Impairments or disabilities based on signs of age cannot be defined by an exact age it is usually a combination of a variety of impairments such as less physical vitality, muscular strength and visual limitations. Pic. 16 shows the frequency of passengers older than 60 years.

At the age of 60 and older a growing number of difficulties concerning personal mobility such as walking, weight lifting and stair climbing is become apparent, which is shown when accessing a train. This fact is being covered and proved in the following chapters.

This chapter also covers „classic“ mobility impairments amongst train-passengers who are permanently or temporarily mobility impaired due to an accident, a disease or handicap.

Age category up to 59 years shows 2-3% of travellers who show reduced mobility, amongst travellers older than 60 years more than 7% show signs of reduced mobility. 25% of the generation 60+ is stating that they show at least signs of minor impairments.

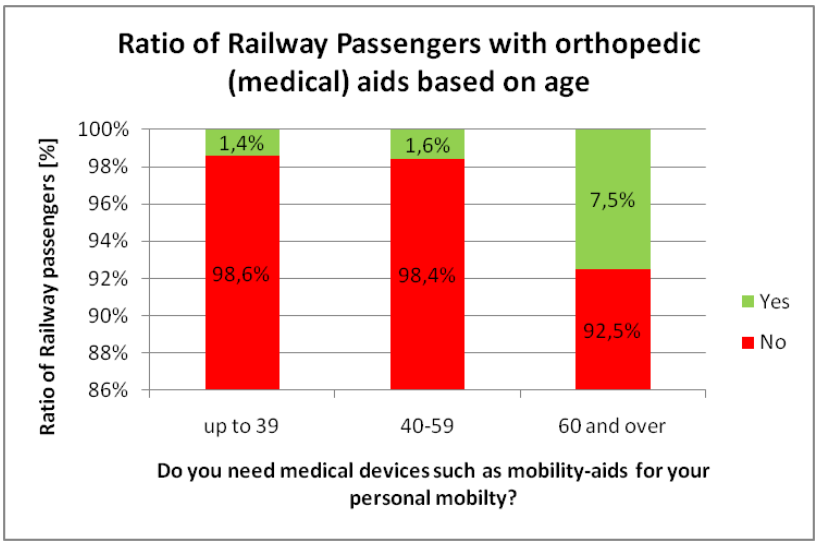



**Pic. 18: reduced ability of physical movements/operations based on age**

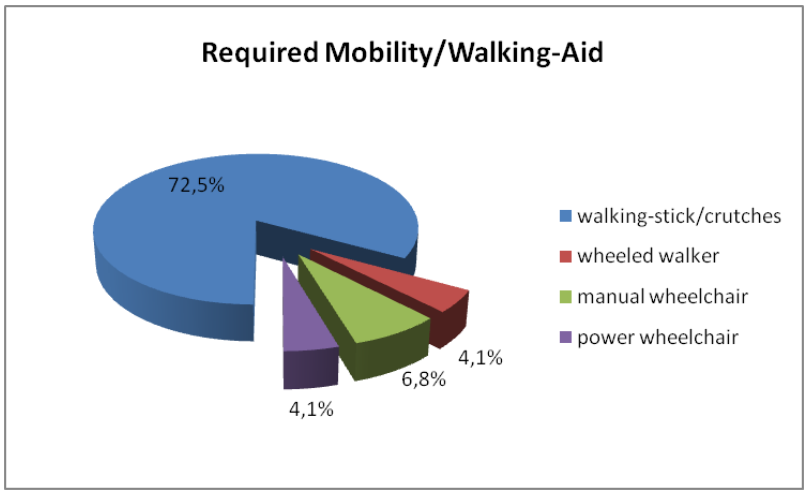
Whereas only 1.5% of travellers that are under 60 years old use orthopaedic aids the ratio is rising up to 7.5% amongst people that are older than 60 years (see Pic. 19).

Sixty percent of the people who are under 40 years old do need an orthopaedic aid (e.g. crutches) only temporarily, whereas also 60% of people who are over 60 need those aids permanently (Pic. 21).

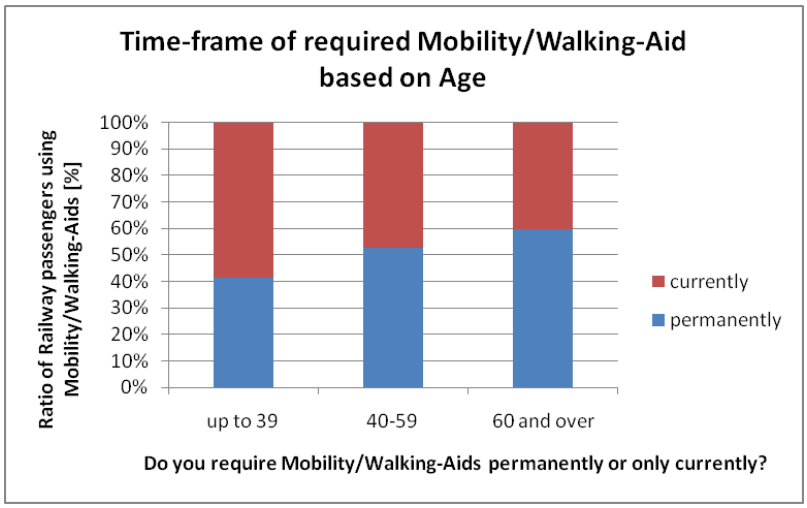
Around three fourth of these aids are crutches and walking sticks, 10% represent wheelchairs, and 4% consist of wheeled walkers (see Pic. 20). The numbers are based on all active rail travellers (not representative for the whole population).




**Pic. 19: Ratio of railway passengers with orthopaedic (medical) aids based on age**




**Pic. 20: Required mobility/walking-aid**




**Pic. 21: Time frame of required mobility/walking-aid based on age**

### 4.4.3 Use of Luggage

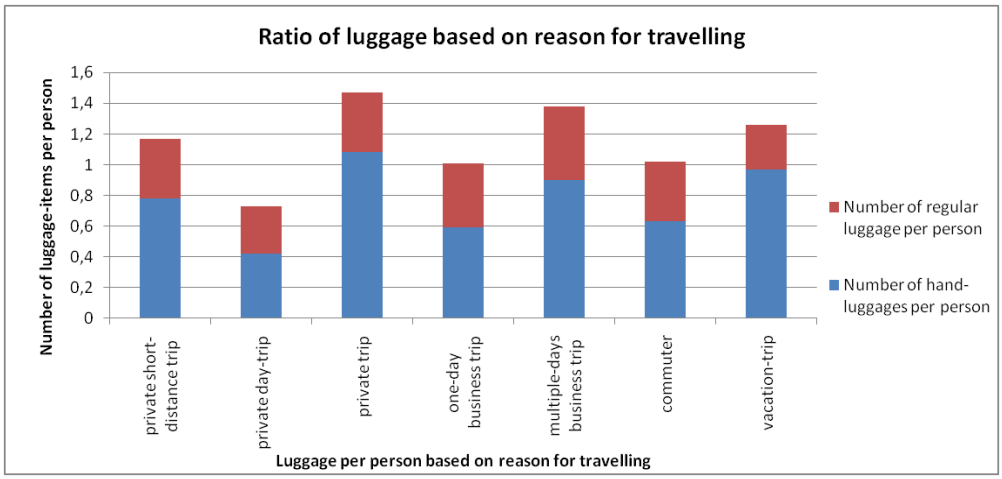
Many passengers are facing difficulties with their luggage and as this passenger group represents the largest user group amongst persons with reduced mobility it makes sense to conduct a research about the amount of luggage being taken on board by travellers. Aside from the amount of luggage per person, its size and weight, there are other influencing factors such as age, gender, reason for travelling, size of the group travelling together, and the duration of residence at the final destination.

Luggage can be distinguished between regular luggage and hand luggage, as specified for cabin luggage in air-traffic (56cm x 40cm x 25cm) and regular luggage with mid-sized and large suitcases, trolleys, travel bags and rucksacks that are larger in size than allowed for aircrafts.

Besides size, also the weight of luggage has a relevant influence when accessing the train, representing a potential source for difficulties that passengers face. The average weight per luggage item is 18 kilos, ranging between 10 and 30 kilos.

When looking at the challenges that go with the boarding and alighting process when carrying suitcases, trolleys and travel bags, they can be summarised in one category, as rucksack and hand luggage can be summarised as a category though their handling-nature.

The amount of luggage taken along on a journey is influenced by the reason for travelling and shown in Pic. 22. Travellers who go on a journey for at least 5 days carry at least one suitcase. Also business travellers carry a considerable amount of luggage with them.



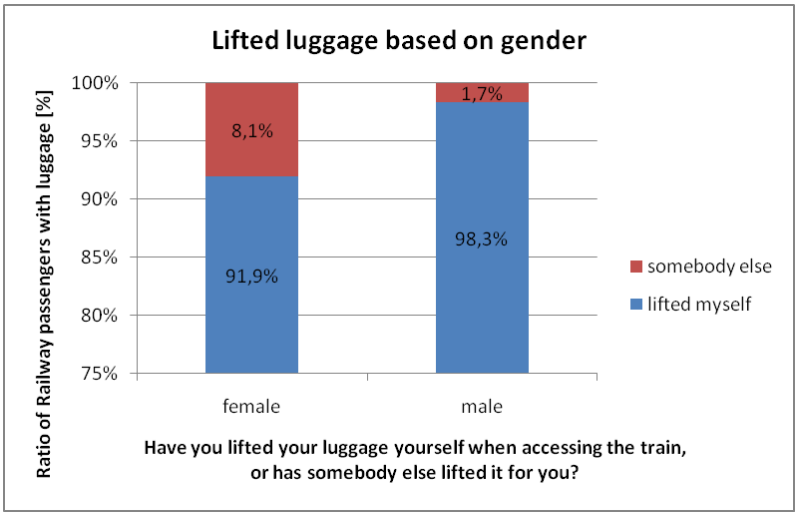

**Pic. 22: Ratio of luggage based on reason for travelling**

### 4.4.4 Mobility Impairment "Luggage"

Every second person takes along a medium or a large size type of luggage when travelling with public transport. Access situations when facing narrow doors and tight conditions in terms of space around the entrance area represent a big problem for many travellers.

The difficulties based on luggage are not to be viewed isolated but in combination with environmental circumstances such as type of access and also age of travellers and occurring mobility impairments. The primary research shows as well apparent findings, which emphasize on the mobility impairments caused by luggage.

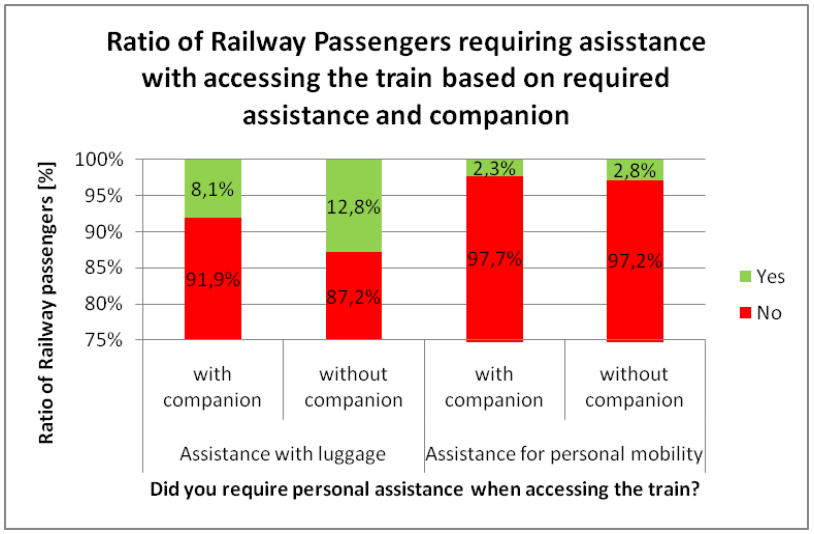
Due to the physical situation women are disadvantaged in terms of physical strength when accessing the train with heavy luggage, 8% of women are asking other passengers to help them lifting luggage into the train, which is five times more than men (see Pic. 23).




**Pic. 23: Lifted luggage based on gender**

15% of female travellers and 4% of male travellers need assistance with their luggage when accessing the train (see Pic. 24), half of them needing someone else to lift the luggage for them. This message is consistent with the fact that 8% need assistance when accessing the train, supporting the fact for need of assistance (see Pic. 25).


**Pic. 24: Ratio of railway passengers requiring assistance with accessing the train based on gender**



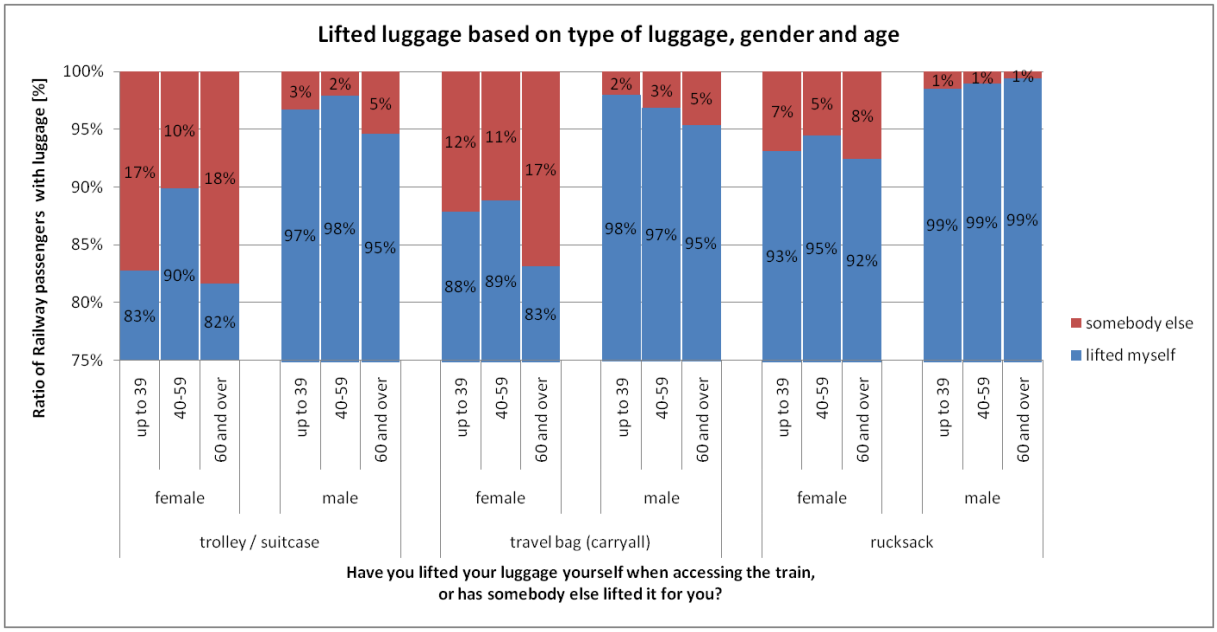

**Pic. 25: Ratio of railway passengers requiring assistance with accessing the train based on required assistance and companion**

Half of the travellers who had been helped with lifting their luggage travel without compagnion, showing that 10% of female travellers do need assistance for larger travel bags and trolleys.

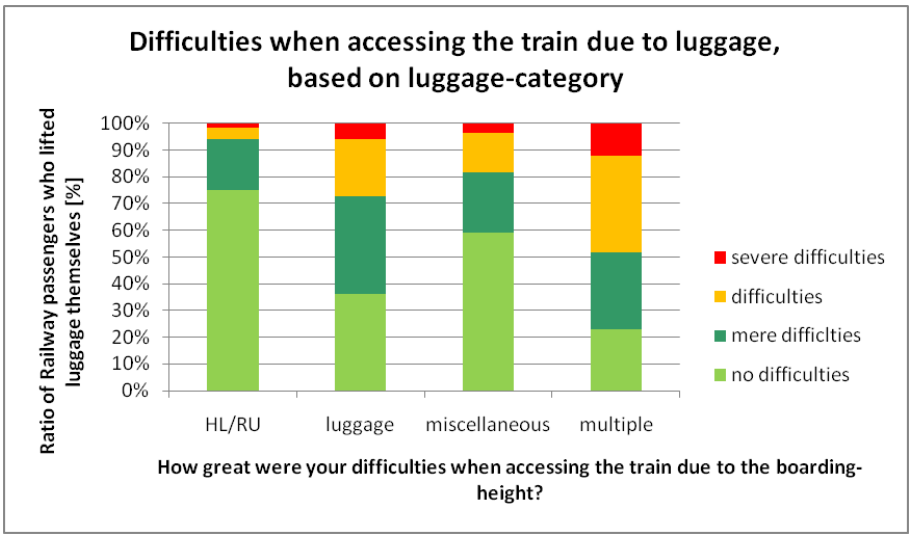
Mainly medium-sized and large trolleys and travel bags are causing large problems for female travellers. Depending on age 18% of female travellers state that they have not lifted the luggage onto the train themselves (Pic. 26).

This fact is emphasised on and reflected in Pic. 27, showing that 30% of travellers are using medium and large sized trolleys and travel bags, and that 50% of travellers have troubles when accessing the train when carrying multiple luggage items. It is clearly showing the severity of difficulties and the level of mobility hurdles luggage can potentially cause. This fact shall also be considered in regards to customer satisfaction and potential solutions facilitating the access situation with luggage.

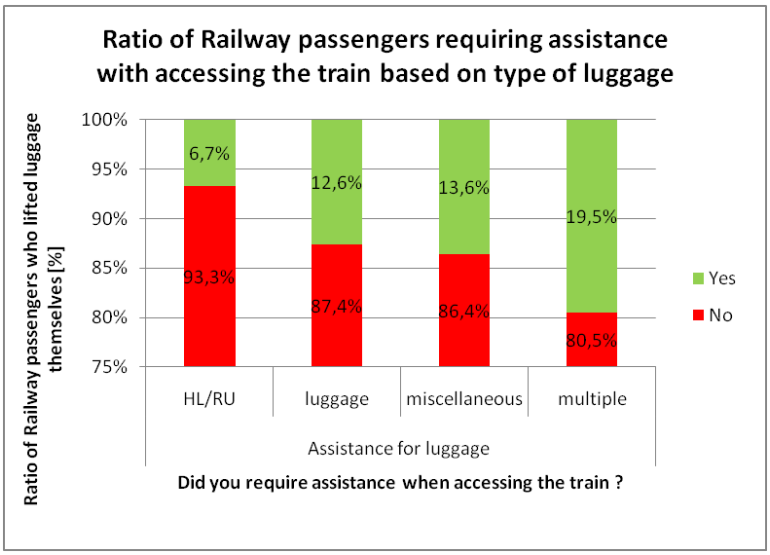
Another circumstance that was found out is emphasizing on this fact that 12% of travellers with luggage and around 20% of the travellers with multiple luggage items taking advantage of foreign help when accessing (see Pic. 28).




**Pic. 26: Needed help for lifting luggage based on the type of luggage, gender and age**




**Pic. 27: Difficulties when accessing the train due to luggage, based on luggage-category**




**Pic. 28: Ratio of railway passengers requiring assistance with accessing the train based on type of luggage**

### 4.4.5 Difficulties caused by Access Situation

As described in chapter 4.4.1 the various access situations in reference to access design in combination with platform heights and occurring difficulties can be categorised in four categories:

Pic. 29 to Pic. 32 are showing the combinations and connections between parameters such as access type, luggage and passenger-age:

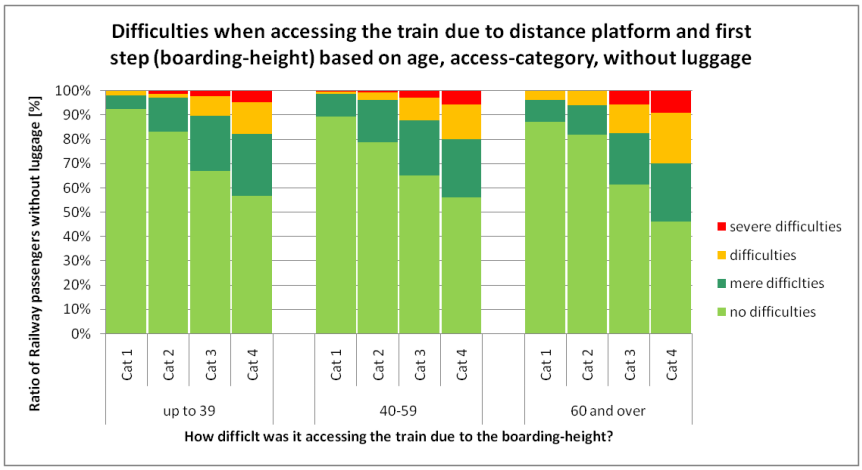
- **Level Boarding, one Stairs max.**: travellers of all ages, with or without luggage, rarely have difficulties.

- **Access with two stairs, wide doors, and stairs with flat angles:** travellers with luggage independently from age have rarely 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 foreign help.

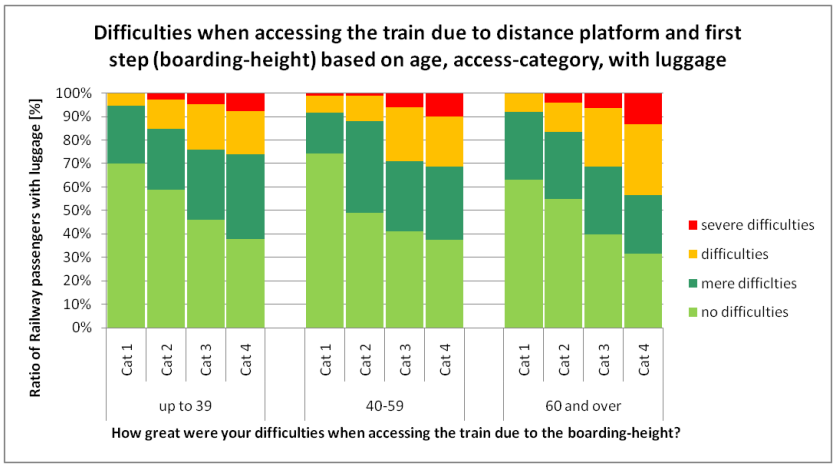
- **Access with RIC wagons and related trains (3 stairs from platform):** Between 10-15% percent of travellers have difficulties or a lot of difficulties with accessing the train without luggage and 25-30% with luggage. Whereas only between 1 and 2 % need assistance for themselves, more than 10% need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

- **Old-type vehicles, steep stairs (3-4 Stairs from platform):** 20-30% of travellers do have difficulties and severe difficulties without stairs and 50% of travellers with luggage, this group including up to 20% that have a lot of difficulties. Approximately 20% of travellers having luggage do need foreign 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 with accessing the vehicle.

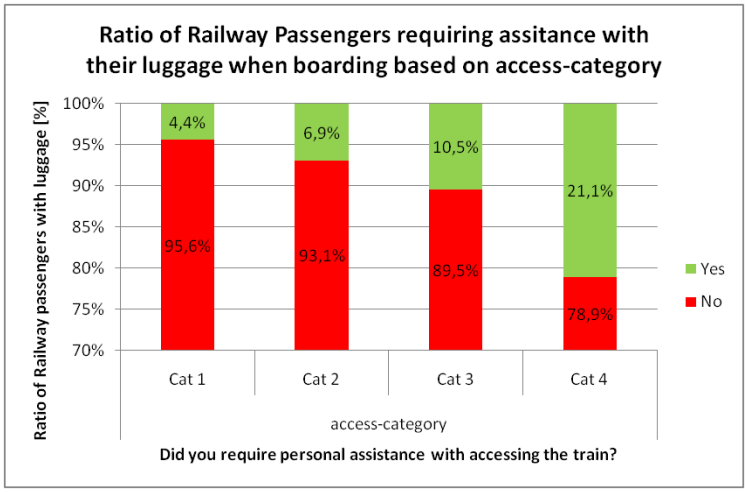
The survey clearly shows that the great part of the travellers experience no problem when using an access with no step or even one step. With two steps in combination with luggage the difficulties are growing rapidly.



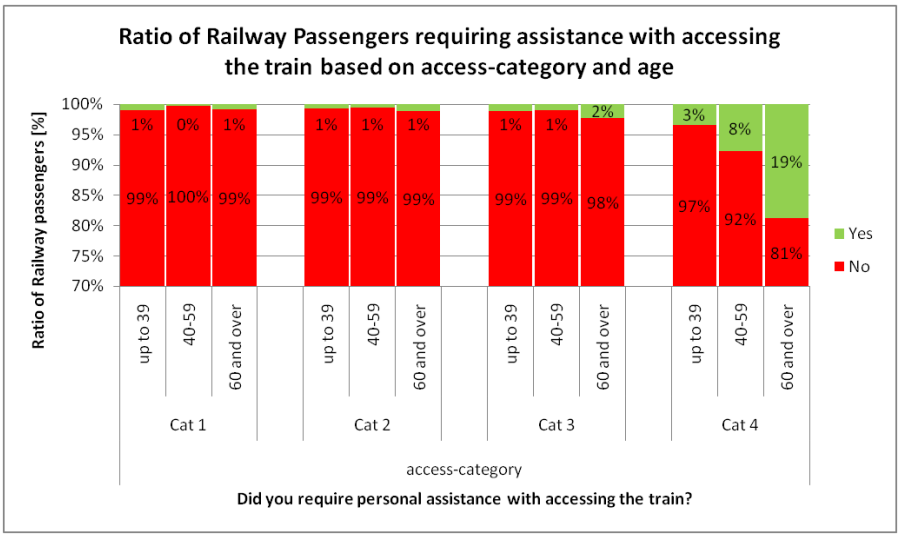

**Pic. 29: difficulties of passengers WITHOUT luggage when accessing the train**




**Pic. 30: Difficulties of passengers WITH luggage when accessing the train**



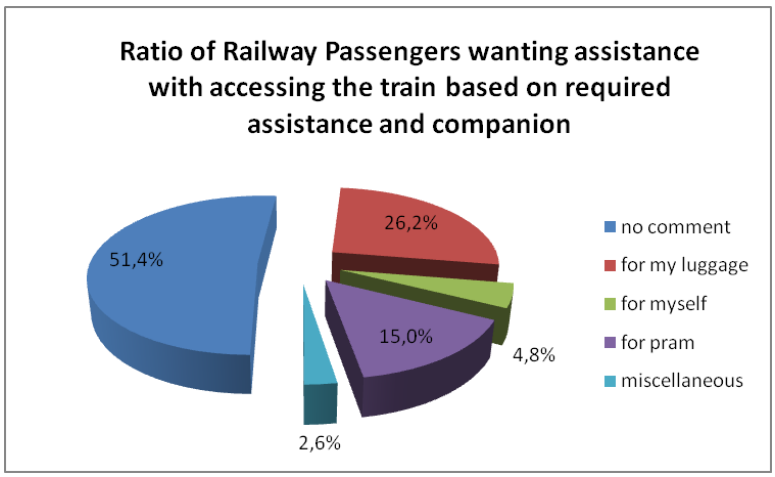

**Pic. 31: Needed help when boarding with luggage based on different access-categories**




**Pic. 32: Needed personal assistance when boarding based on different access-categories and on the age**

### 4.4.6 General need of assistance when boarding

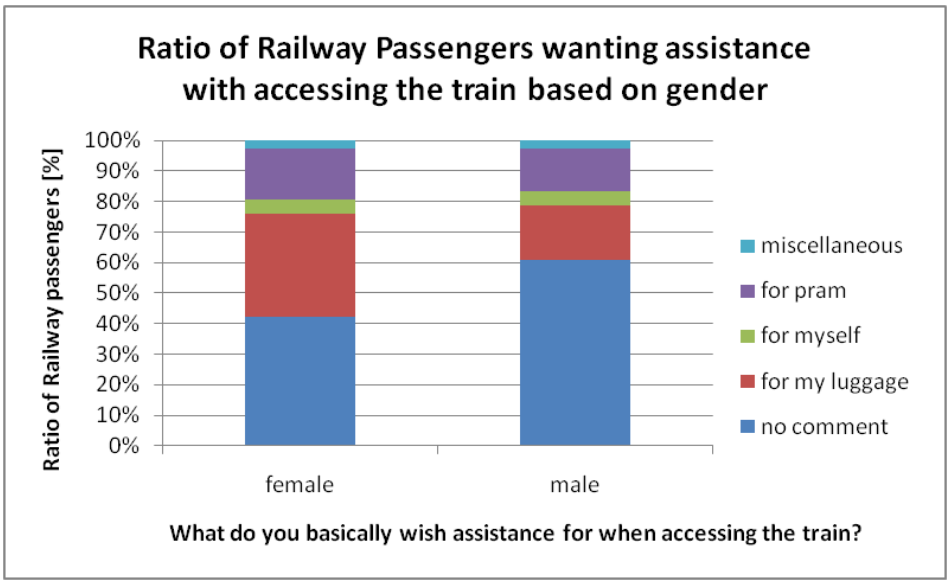
50% of travellers have no specific wishes in reference to boarding assistance system, which would represent an improvement for all passengers. About 25% of all travellers would like to obtain assistance with lifting their luggage and 15% wish assistance with prams. Each twentieth traveller would like to make use of a Boarding Assistance System (see Pic. 33).



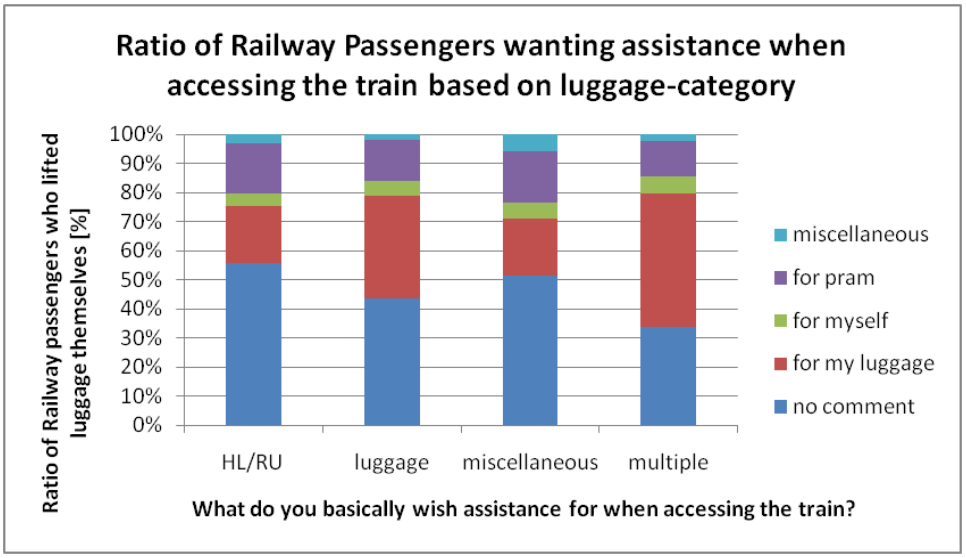

**Pic. 33: passengers wanting assistance when boarding for …**

There are gender-related differences in reference to the wish for assistance when accessing a train but no significant differences in reference to age.

40% of male passengers would like to have assistance when accessing the train whereas 60% of female passengers seek assistance. There are no obvious differences between genders in reference to the wish for assistance for handling prams, whereas there is an apparent difference between genders in reference to the wish for assistance with luggage. Around 35% of female passengers, more than twice the amount of men, seek assistance reference to accessing a train with luggage. It is mainly travellers who carried luggage by themselves when being interviewed, who seek assistance for lifting their luggage. Specifically the majority of travellers, more than 50%, with multiple luggage items seek assistance (see Pic. 34 and Pic. 35).

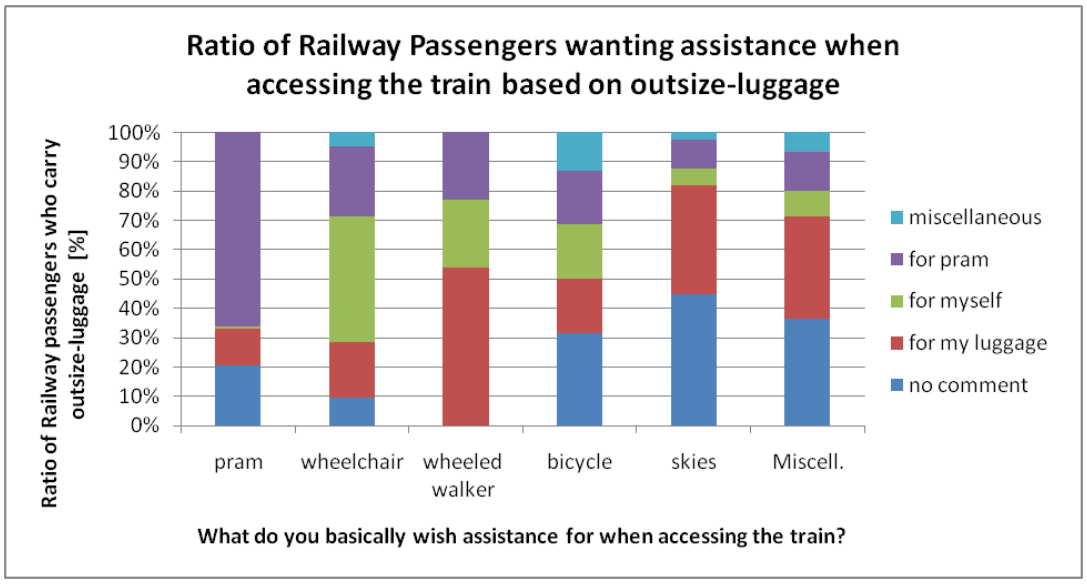



**Pic. 34: Passengers wanting assistance when boarding based on the age and the gender**




**Pic. 35: Passengers wanting assistance when boarding based on luggage**

As expected, based on specific personal mobility impairments, there is a big wish for assistance when accessing the train. 70% of travellers with prams for example seek for assistance, only 20% of travellers with prams do not have specific wishes (see Pic. 36).




**Pic. 36: Passengers wanting assistance when boarding based on outsized-luggage**

Whereas 50% of the travellers who do not feel affected by reduced mobility have no specific wishes, wheres 25% of travellers who are affected by reduced mobility do have specific wishes. Around 40% seek assistance with luggage and around 20% would like to get personal assistance when accessing the train (see Pic. 37).


**Pic. 37: Passengers wanting assistance when boarding based on mobility-impairments**

### 4.4.7 Travellers´ Wish for a Technical Aid

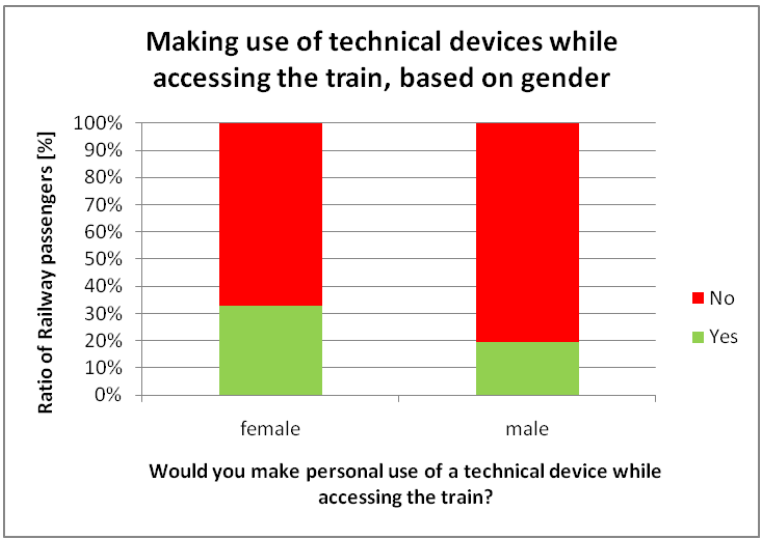
Chapter 4.4.6 covers general questions in regards to the wish and request for assistance when boarding the train. These questions are making it very clear, that there is a need for assistance.

When being asked about possible making use of a technical aid when accessing the train the interviewed travellers where holding back with their ansers of course, due to the lack of imagination and experience with such a boarding aid, which everybody would benefit from.

Most travellers are automatically thinking about common aids such as lifts which primilinary serve wheelchair users when accessing the train. Therefore it is important within this project to show the existing basic need for such a boarding assistance system.

Nevertheless the following results in regards to the question of a potential use of a boarding assistance system are making it clear, that many travellers would make use of such a system.

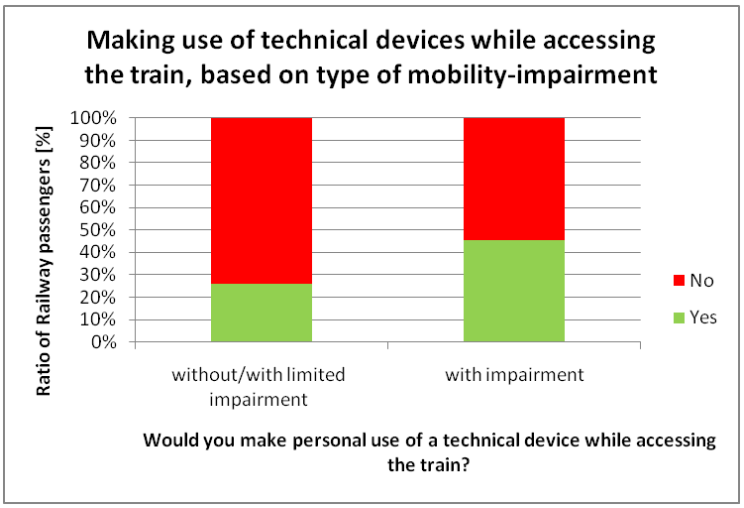
30% of women and 20% of men who travel would make use of such a device (see Pic. 38). Differences based on age are not visisble.



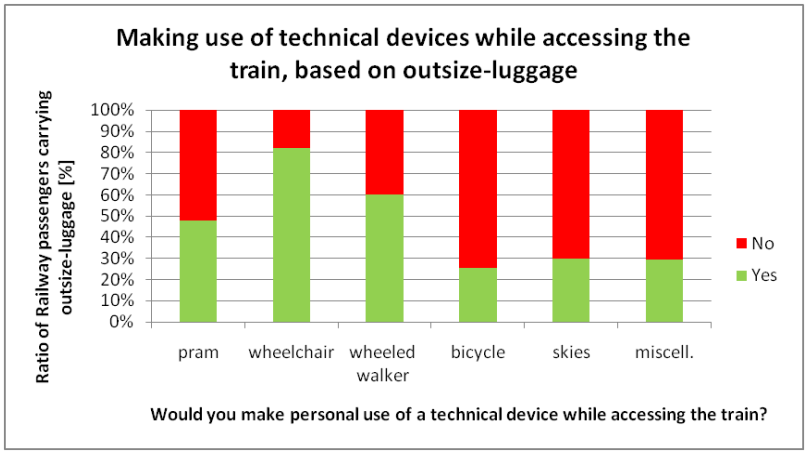

**Pic. 38: Making use of technical devices while accessing the train based on gender**

Of course a personal disability, luggage and prams influence the results, showing that around half of the travellers would like to make use of a technical aid when accessing the train (see Pic. 39). Every second person with a pram, 60% of people using wheeled walkers and 80% of people in wheelchairs would like to use such a technical aid (see Pic. 40).

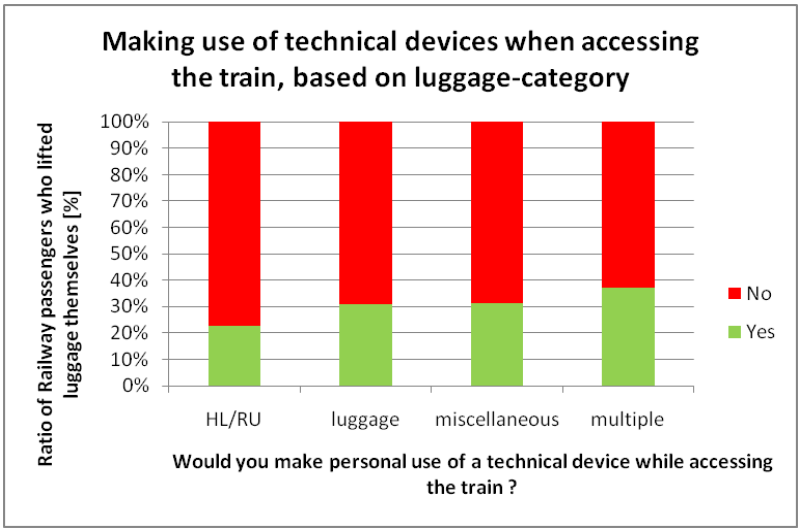
The other 20% of wheelchair users who do not use the wheelchair permanently, and are able to get out of the wheelchair and access the train themselves and walk for some short distance. Usually manual folding wheelchairs are used in those instances. 30% of Passengers with luggage would make use of a technical aid (see Pic. 41).




**Pic. 39: Making use of technical devices while accessing the train based on mobility-impairment**



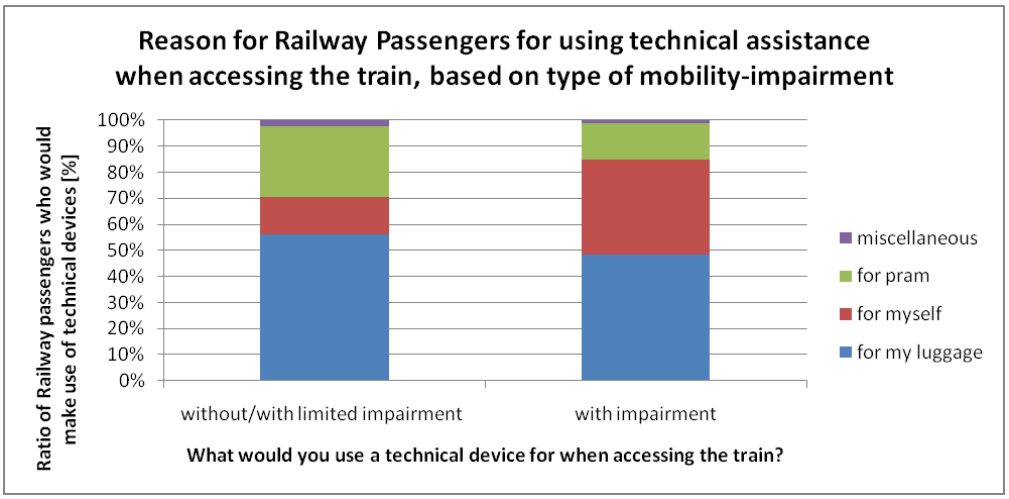

**Pic. 40: Making use of technical devices while accessing the train based on outsized-luggage**



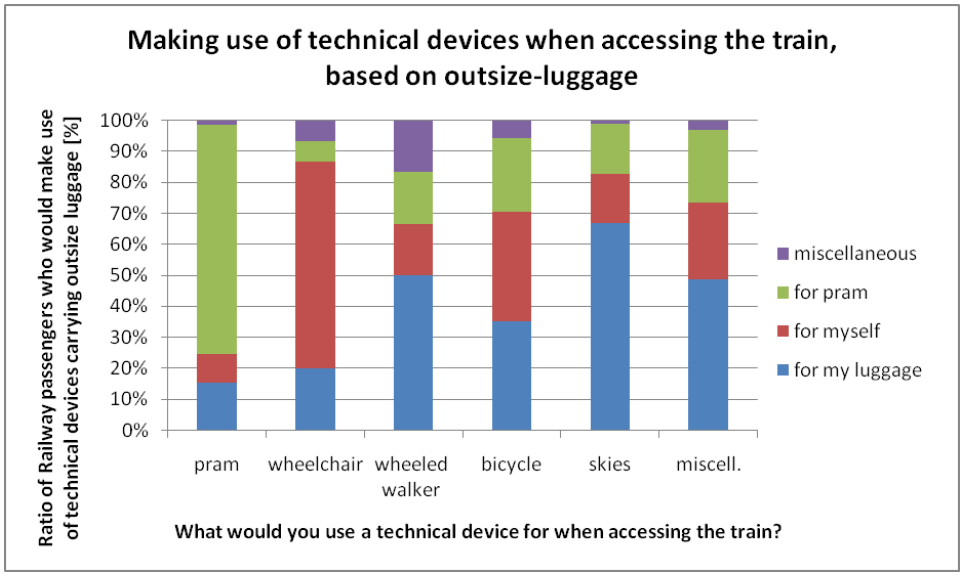

**Pic. 41: Making use of technical devices while accessing the train based on luggage**

40% of travellers who suffer from personal disabilities wish to use a technical aid for themselves and 50% of them for their luggage.

Of course wheelchair-occupants would like to make use of such a technical aid for the great part as well as persons with prams (80%) (see Pic. 42 and Pic. 43). Other passnger groups would like to use those technical aids for luggage (see Pic. 44).



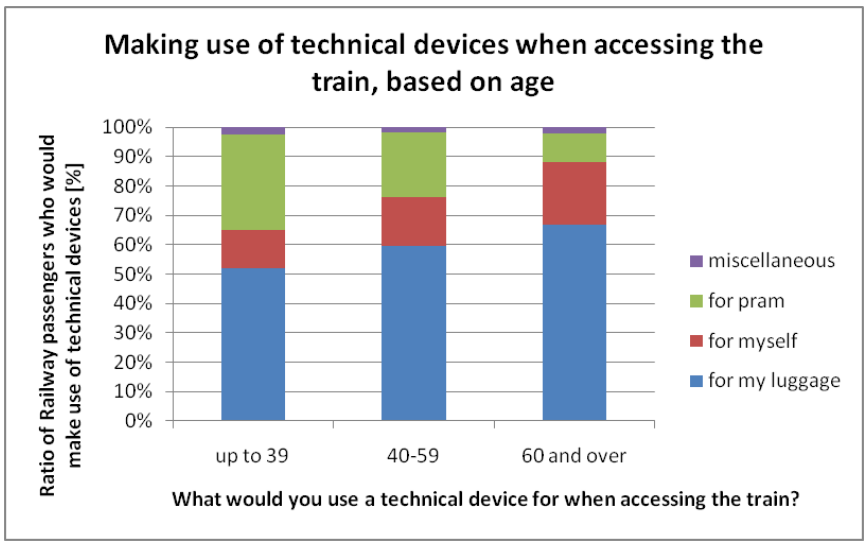

**Pic. 42: Reasons for passengers for using technical assistance when accessing the train, based on type of mobility-impairment**




**Pic. 43: Reasons for passengers for using technical assistance when accessing the train, based on outsized-luggage**

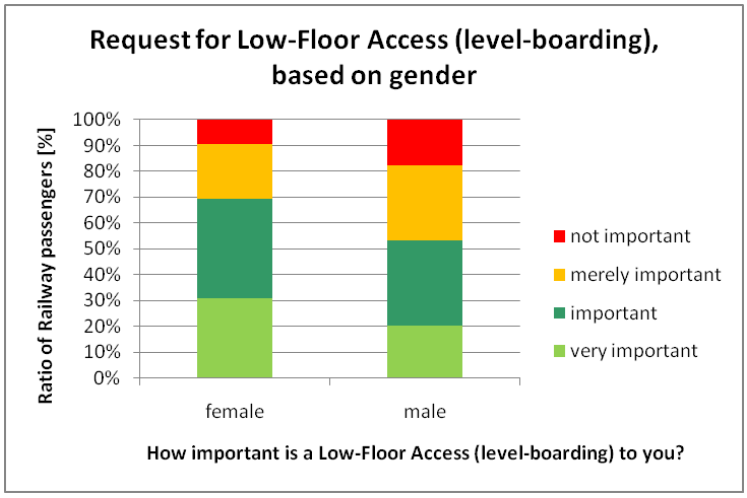
In reference to age it becomes clear that the wish for personal use or use for luggage of a boarding assistance system is growing with age. The older people get, the more they seek for technical assistance.

One third of the travellers within the age-group of 39 years and younger would use such a technical aid.

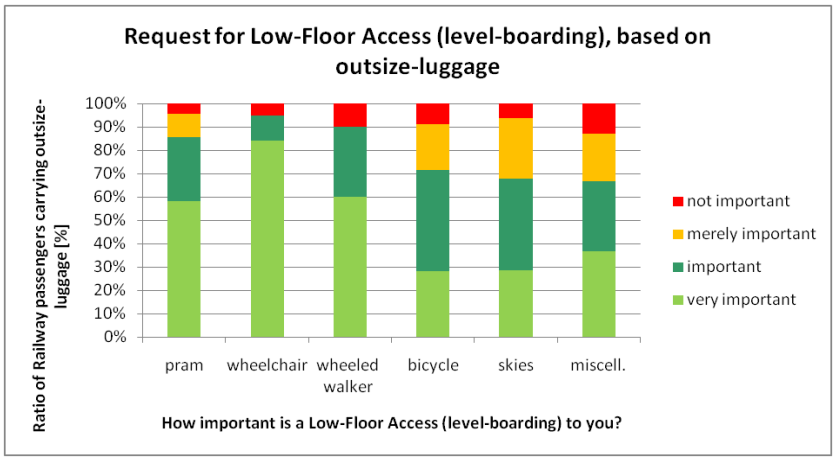



**Pic. 44: Reasons for passengers for using technical assistance when accessing the train, based on age**

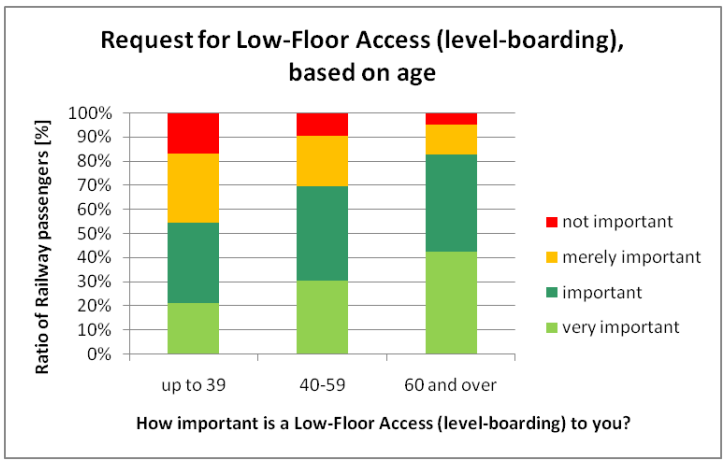
The general wish for a comfortable boarding situation is reflected by the fact that low floor vehicles play an important role for passengers, Pic. 45 to Pic. 48 are showing the wish for level boarding amongst female passengers, passengers with travel luggage or multiple luggage items, persons with prams, wheelchairs of walking impaired people.



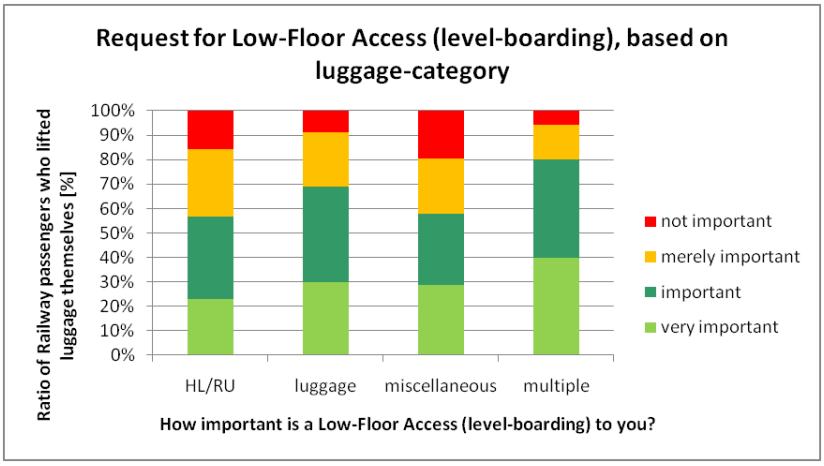

**Pic. 45: Request for low-floor access based on gender**




**Pic. 46: Request for low-floor access based on outsized luggage**




**Pic. 47: Request for low-floor access based on age**

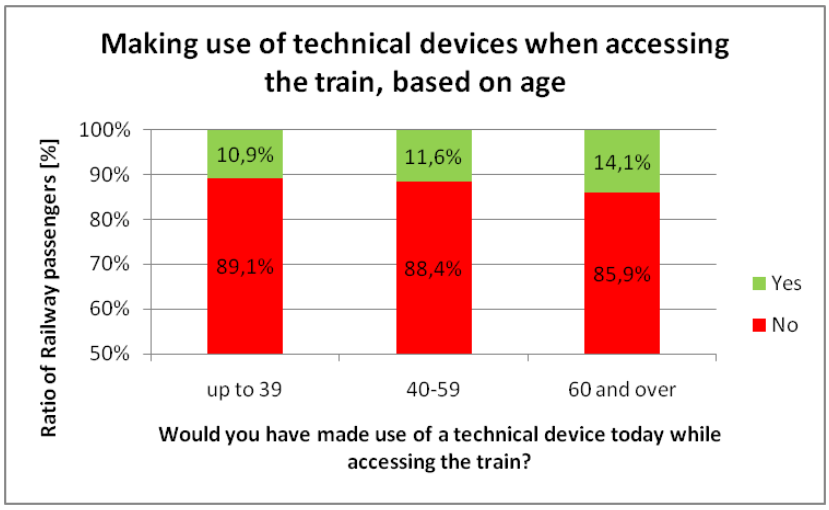



**Pic. 48: Request for low-floor access based on luggage**

### 4.4.8 Travellers´ wish for a specific Technical Aid

Besides the general wish for support when accessing the train (chapter 4.4.6) and the general demand and wish for a technical aid (chapter 4.4.7) the main question in this chapter is based on the "minimum requirements" that passengers have in regards to a techical aid, a Boarding Assistance System.

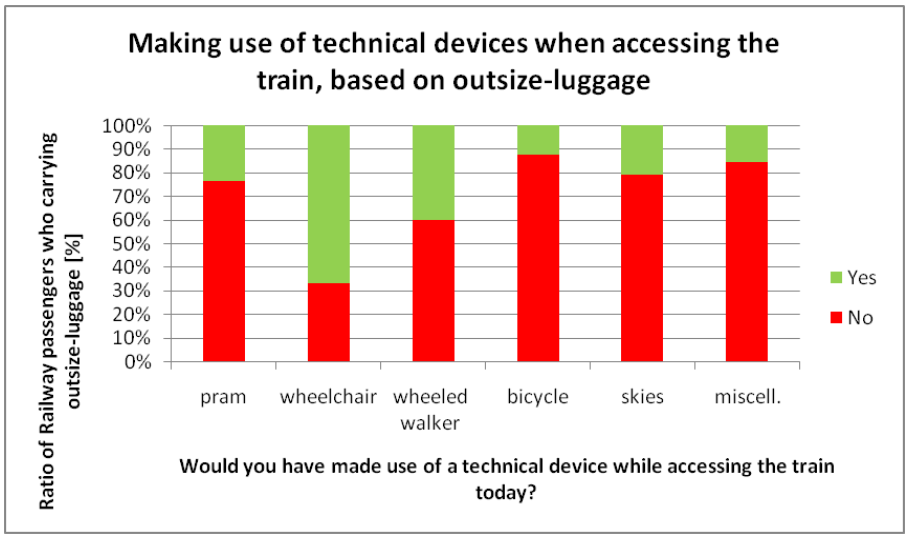
Depending on age, on the day of when the interviews had been conducted, 11% and 14% would have taken advantage of a technical aid for boarding the train (see Pic. 49).



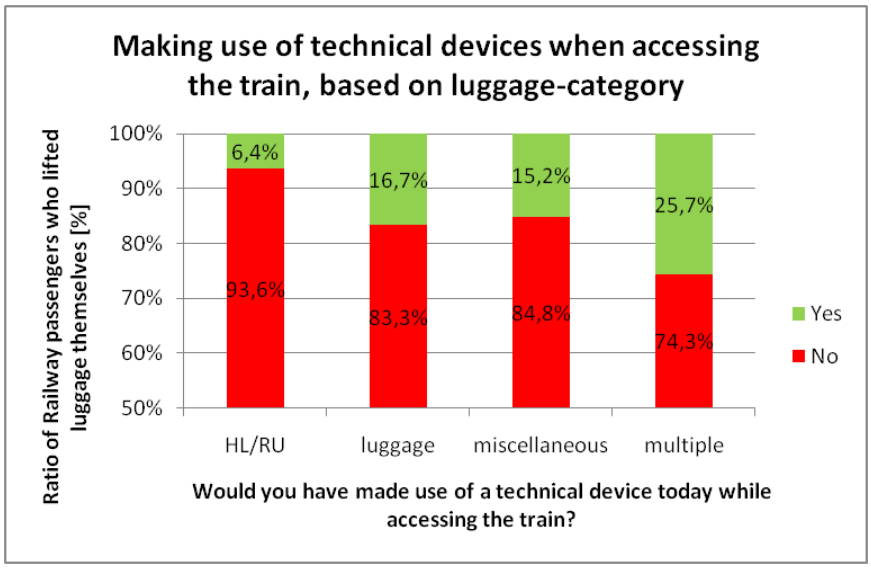

**Pic. 49: Whish of making use of a BAS based on the age**

Approximately 70% of wheelchair-users and 40% of walking-impaired persons who are using wheeled walkers would have used such a boarding aid. Also each fourth traveller that is using a pram would have used a Boarding assistance system (see Pic. 50).

Around 17% of all passengers with luggage as well as approximately 25% of all travellers with multiple luggage items would have used a technical aid on the day of travel (see Pic. 51).



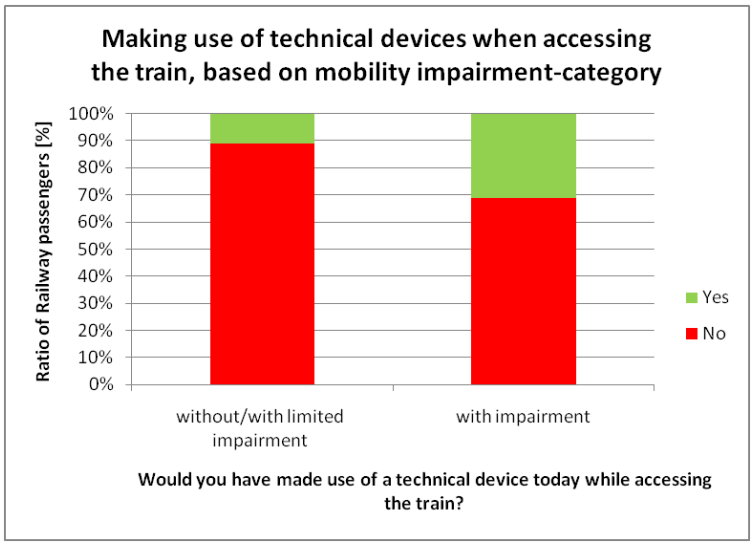

**Pic. 50: Whish of making use of a BAS based on oversized luggage**



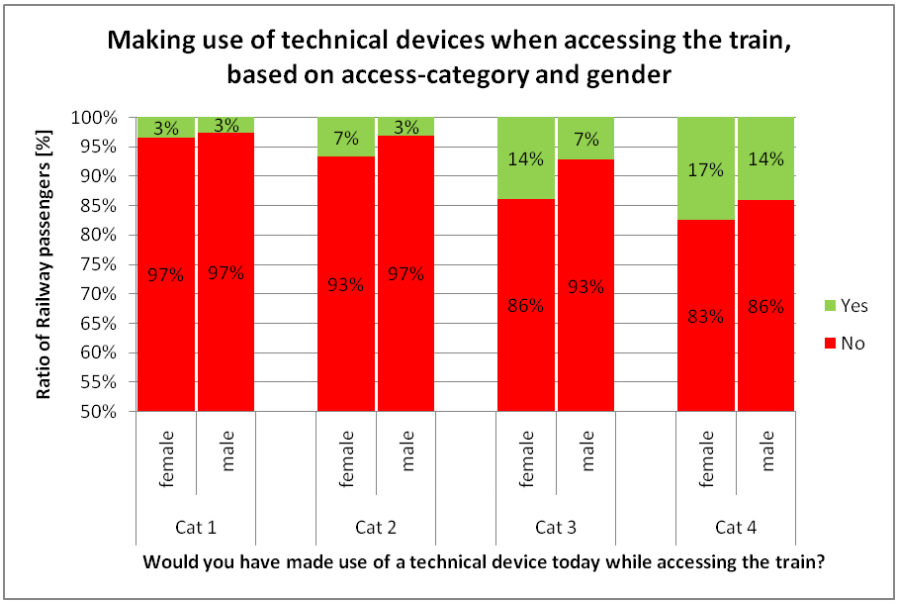

**Pic. 51: Whish of making use of a BAS based on the luggage**

30% of the group of mobility impaired passengers would make use of an access device (see Pic. 52).

In situations of level boarding and boarding situations with only one stair, almost nobody would make use of a techical aid. Regardless the luggage situation, 14% of women would use a technical accessibility aid, and 17% of women would make use of it when using a classic train (see Pic. 53).




**Pic. 52: Whish of making use of a BAS based on mobility impairment**




**Pic. 53 Whish of making use of a BAS based on the access-categories and gender**

### 4.4.9 Summary of passenger need

There are a number of groups of mobility-impaired person, and each group has different difficulties, needs and request based on the type of impairment in regards to technical aids.

The survey amongst 14.000 interviewees clearly shows that not only wheelchair user shall be covered when developing a boarding assistance system.

Depending on the boarding situation, gender, age, number and type of luggage items, there are different needs and difficulties identified amongst the various groups of travellers in reference to a boarding assistance system.

The following information is showing the different needs, wishes and difficulties the various groups of persons with reduced mobility have.

**Wheelchair Occupant:** A technical accessibility device is crucial for wheelchair occupants, even though some wheelchair users are able to stand up and walk a couple of steps, that way some of them can also enter a train in some instances. 80% of wheelchair users would make use of a boarding assistance system.

**Walking Impaired Persons:** 60% of the people with walking impairments using walking aids and wheeled walkers would make use of a boarding assistance system. Half of them would use it for their luggage.

**Persons with Prams:** 70% of all travellers with prams would make use of assistance when accessing the train, half of them would like to make use of a technical access aid.

**Travellers with Luggage**: This is the largest group of persons with mobility impairments. Each second traveller amongst this group is carrying luggage, during peak periods almost every passenger is carrying luggage. 30%-50% of travellers face difficulties and even big difficulties on classic old-type trains with heavy luggage. 15% of female passengers need foreign help when accessing the train. 30% of female travellers seek help with their luggage when accessing the train they would also make use of technical aids.

**Elderly people:** Elderly people suffer from either physical impairments such as walking impairments and therefore seek assistance when accessing a train with luggage.

The use of a boarding assistance system would improve the quality of the journey for all travellers and user groups based on this analysis, would have a positive impact on service, and would provide added value to more satisfied customers, which again would be a gain within the area service quality provided by operators for their customers.

## 4.5 Request for Self Service

The question if a Boarding Assistance System can be operated by the traveller himself or a companion or another passenger cannot be answered in all clearness.

The majority of representatives of the user-groups request that all travellers be enabled to use the train completely independently. Operators have a range of opinions, ranging from independent usage by the traveller to assistance though trained personnel only.

On top of that, the legal framework and guidelines need to be considered, e.g. a guideline specifying that only trained personnel is allowed to operate Boarding assistance Systems. These guidelines shall prevent accidents and potential danger.

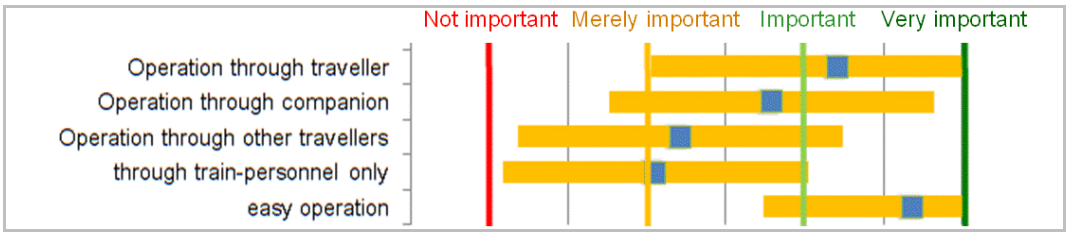
Pic. 54 to Pic. 56 are showing the average (median) of the opinions that operators, handicap-organisation and manufacturers have (blue dot). The orange bars are representing the variance amongst given answers.

### 4.5.1 The User Perspective (see Pic. 54)

On average from a user perspective (a number of handicap organisations) it is important/very import that a Boarding Assistance system can be used by the traveller. An automatic function of the system without the need to be operated by anybody is also acceptable for them, at least it should be easy to operate for a companion.

It is not that much important to them that other passengers or train personnel are able to operate the boarding assistance system. This opinion is based on the desire to operate the BAS independently.

A very important request is the ease of use of a BAS.




**Pic. 54: Wish for autonomous handling from a users´ perspective**

### 4.5.2 Operators´ perspective (see Pic. 55)

On average, the operators´ perspective is showing a wide range of opinions – to some of them it is it is very important/important - while others state that it is merely important - that the BAS shall only be operated by train-personnel, which is influenced by operational and regional factors.

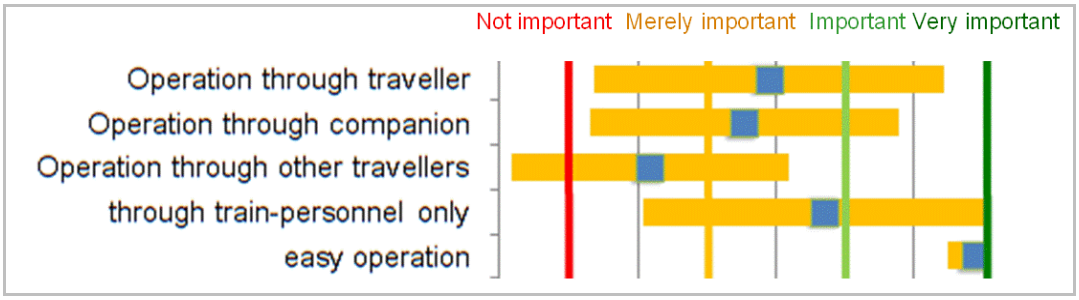
Within one country amongst various operators, and even within one company between different persons in management, the opinions differ to quite some extent in regards to the operations.

An independent operation by the traveller is regarded as merely important and important by the operators, which is less than handicap organisations do.

There are operators who would like to use an automatic boarding system, they even request a fully automatic system, which offers rapid operation and enables a short stop at the station with little or no malfunctions.

Operation by other passengers is regarded a merely important or not important.

All operators have the opinion that a BAS needs to be easy to operate.

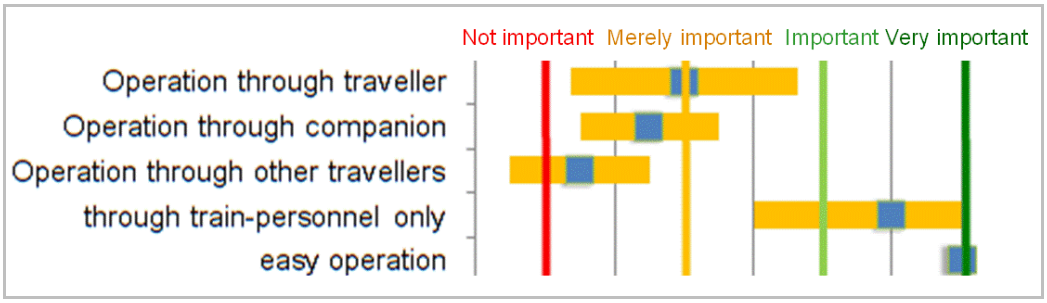



**Pic. 55: Wish for autonomous handling from a vehicle and a BAS manufacturers´ perspective**

### 4.5.3 Vehicle and Lift Manufacturers´ Perspective (see Pic. 56)

Manufacturers request the BAS to be operated by well-trained train personnel it is assessed as important and very important. The operation of a BAS by companions is regarded as merely important, through foreign travellers as not important.

Manufacturers agree that a BAS needs to be easy to operate.




**Pic. 56: Wish for autonomous handling from a vehicle and a BAS manufacturers´ perspective**

### 4.5.4 Operating the System – Summary

Whereas representatives from handicap organisation think, it is important/very important that an accessibility aid needs to be operable by the traveller or companion, the operators' opinion is a different one. In fact, operators do have quite different opinions about that subject.

Based on personal interviews with operators and representatives of handicap organisations, on top of the electronic surveys that had been conducted, the results show that there is a desire

for an automatic, self-service system, as long as it bears no risk for travellers and the operation of the train.

Operational considerations show tendencies towards automatisation due to tight schedules and arrival times that need to be met, as long as the operational procedures are not endangered.

Sliding steps bridging the gap between platform and vehicle are prime examples for automatic boarding assistance systems.

# 5 Requirements of an Operator

## 5.1 System Overview and Limits

Operators do have different requirements in regards to infrastructure and operation, as well as technical requirements. In general, operators can be separated into two categories:

- **train operators**
- **regional/city public transport**

Train-Operators typically manage transportation in classic long- distance and regional trains. Depending on the infrastructure and available vehicles, a variety of access-situations are faced which goes from level boarding with platforms at floor level as far as access situations with multiple stairs.

### 5.1.1 Requirements in Public City Transport

City operators are operating tramways, underground and busses. Busses are not covered herein. Interviews had also been conducted with those operators in order to find out about their needs in regards to boarding assistance systems. The findings are showing clearly, that there is no need for boarding assistance systems due to several reasons.

Local city operators do have the advantage that they can operate within a closed system providing a harmonised infrastructure. That way they are able to provide level boarding throughout the entire network. The majority of operators already operate within low floor vehicles in combination with level boarding platform or plan to do so in the future.

Even operators that are using a mixture of vehicles, low and high floor, have adapted their infrastructure accordingly or plan to do so in the near future, in order to accommodate to the needs of barrier-free travelling at all stations throughout their network.

As level boarding fulfils all requirements of different user groups (e.g. bridging the gap between platform and vehicle), a development for a BAS is not required for those operators.

### 5.1.2 Requirements of train-operators

Within the area of classic train operators, regional train networks represent a closed area itself. Also in this area, regional trains a being acquired due to operational reasons.

The findings of the survey clearly shows, that operators which provide regional, InterCity and long distance service, short and medium term investments are not economical, and therefore

on a long term view, most of the barriers will exist in that area. For this area, it is required to provide a technical accessibility solution, improving the accessibility for al travellers.

Regional transportation services are making use of low floor vehicles, which usually have floor height of 55 to 60cm measured from the track surface, which provides level boarding in a best-case scenario, or only one stair that needs to be overcome in cases where the infrastructure of the platform has not been adapted.

One stair can still be overcome by persons with reduced mobility (see chapter 4.4.1). In this case, ramps are in used, which proved to be an effective solution. In some cases, the platforms can be too narrow in order to use ramps. This is the typical occasion when electro-hydraulic lifts come into action in order to bridge the remaining stair.

### 5.1.3 Decision Making Process

Based on the extensive research that had been conducted with train operating companies the following overview of vehicles and "traffic categories" determines whether to use a boarding assistance system or not.

**No technical Access solution** (new development) is required for:

- **Local City Transportation**
    - busses
    - tramways
    - underground
- **Regional- and local trains**:
    - "S" Bahn
    - Regional Low Floor Train
    - Double Deck Trains with 55-60cm platform height around the access area
- **Long distance – InterCity Traffic**
    - Double Deck train with 55-60cm platform height around the access area

**A technical Access Solution** (new development) is **required** for:

- **High Floor vehicles**
    - **High Speed Trains**

- **Long Distance** (InterCity-, EuroCity-, etc)
- Regional service, if **existing vehicles** are being used
- Long-distance and regional service with **Tilting Trains**

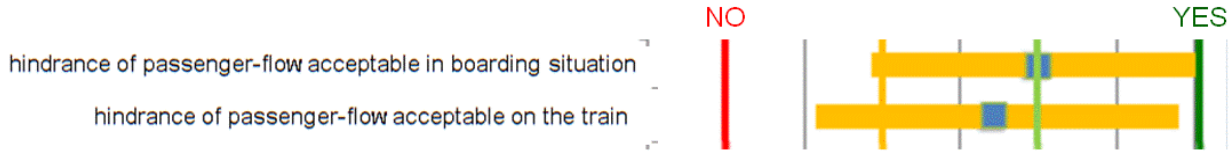
All data within this document refers to vehicle categories that need an access solution, which needs to be developed. Other areas are not covered herein.

## 5.2 Specific Operators´ Requirements

The following chapters cover the needs of operators, based on the personal interviews that had been conducted. Allowed answers: "yes", "merely yes", "merely no" or "no". Findings are shown as median in the blue box, and the variance is shown as standard deviation.

### 5.2.1 Passenger-Change hindrance when operating system

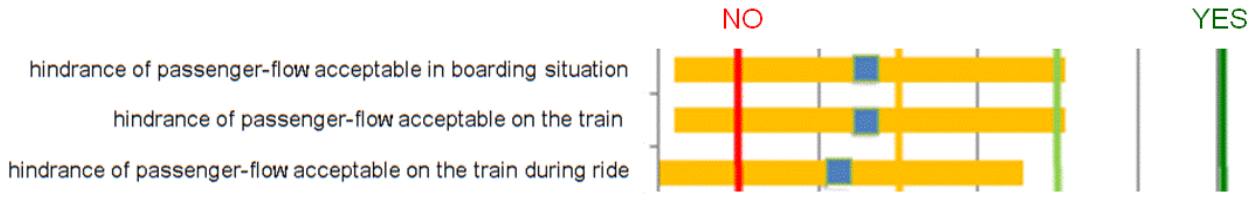
It is acceptable for operators that the flow and change of passengers is hindered, also inside the train, when a BAS is being used (see Pic. 57).




**Pic. 57: Acceptable hindrance of passenger-flow when BAS in use (operators´ perspective)**

### 5.2.2 Hindrance of Passenger-Flow when System is stowed

A stowed BAS shall not influence boarding and alighting procedures at the station or the passenger flow in the vehicle during the ride, according to the majority of operators (see Pic. 58).

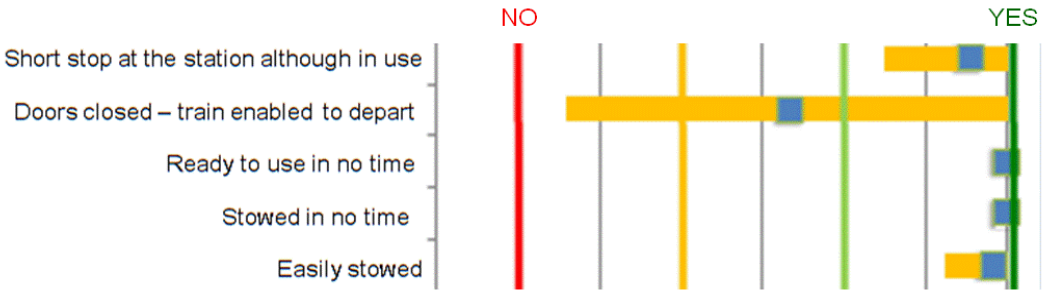



**Pic. 58: Acceptable hindrance of passenger-flow when BAS not in use (operators´ perspective)**

### 5.2.3 Operational Requirements when using BAS (see Pic. 59)

When the BAS is in use, the great majority of operators still demand a **short stop** within the scheduled retention time at the station. The BAS needs to be ready to operate instantly and easily stowed at speed.

There are different opinions amongst operators whether a train needs to be able to depart even though the BAS is not completely stowed or not stowed correctly due to failure. In regards to operational safety, it is a demand that possible defects or not correctly stowed BAS shall not lead to **delays in the schedule**. Also the safety of passengers and train personnel shall not be endangered at any times.



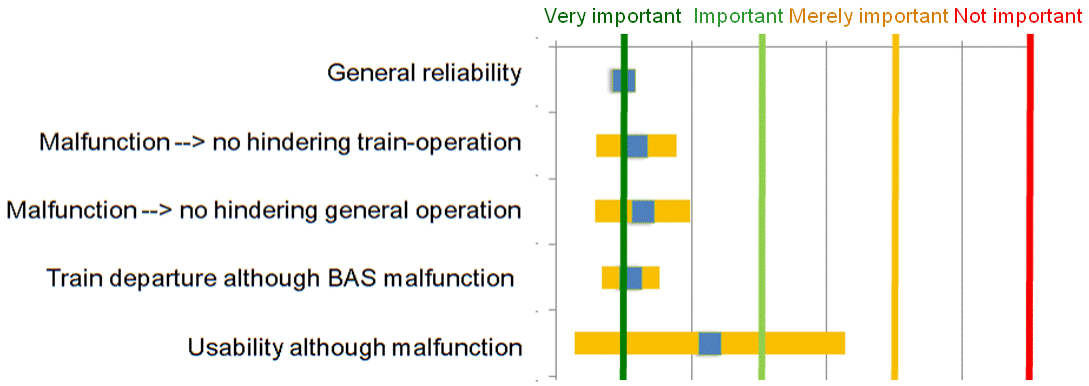

**Pic. 59: Operational needs when using the BAS (operators´ perspective)**

### 5.2.4 Dependability of Boarding Assistance Systems (see Pic. 60)

The majority of operates is rating dependability as a very important factor, referring to general reliability, operational safety and operational quality within railway traffic in cases of malfunctions or interferences of the BAS (see also Chapter 5.2.3).

It is also a requirement that the train is enabled to depart from the station in case of a defect BAS if doors can be closed, without danger for passengers or personnel.

This gives good reason for the ability to operate a BAS in case of malfunction. This requirement is being assessed differently, still rating between important and very important. A back-up system (e.g. manual) is being required in case that the BAS cannot be operated the normal way.



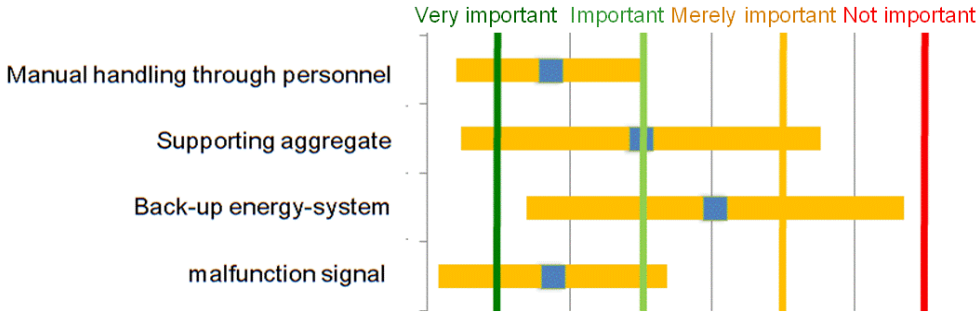

**Pic. 60: Reliability of BAS, effect on quality of regular daily operation**

### 5.2.5 **Troubleshooting** (see Pic. 61)

In case of malfunction of the BAS it still should be operable manually, an abele to be stowed so that the train can still depart. The existence of a back-up aggregate and energy source is assessed merely important.

All wheelchair users shall also be able to alight the train according to the capacity of wheelchair spaces per wagon. According to TSI-PRM, two wheelchair spaces need to be available on trains of a length of up to 205m (3 places for up to 300m, 4 places above). Those wheelchair places can be spread around the train or located in one wagon only.

Effective, clear troubleshooting is another crucial factor, enabling taking measures accordingly.




**Pic. 61: Management of malfunctions**

### 5.2.6 **Potential factors causing malfunction** (see Pic. 62)

A critical view has been also taken on environmental influences such as weather conditions etc. Whereas in Scandinavia snow and ice are the largest potential source of malfunction which have the biggest impact on the reliability, in southern in southeastern countries heat and dust need to be considered.

Gravel being used in icy conditions as well as the amount of snow and ice which is a contributing factor on reliability in Scandinavian countries, e.g. an additional impact on stationary systems.

BAS that is useable on a universal scale need to withstand the harshest weather-conditions, taking the most extreme conditions as a reference-guideline.

The relevant weather conditions are influenced mainly by geographic terms and region of use. The following impacts need to be considered from an operator´s point of view

- **Rain and Water**

  Due to electro mechanical operations performed by a typical BAS, needs to be ensured that the impact of weather-conditions on operational functions is reduced to a minimum.

- **Snow and Ice**

  The impact of ice, snow and water on an almost trouble-free operation represents a potential hazard on operational functions. Long-term weather conditions also need consideration due to climate conditions.

- **Gravel/Sand**

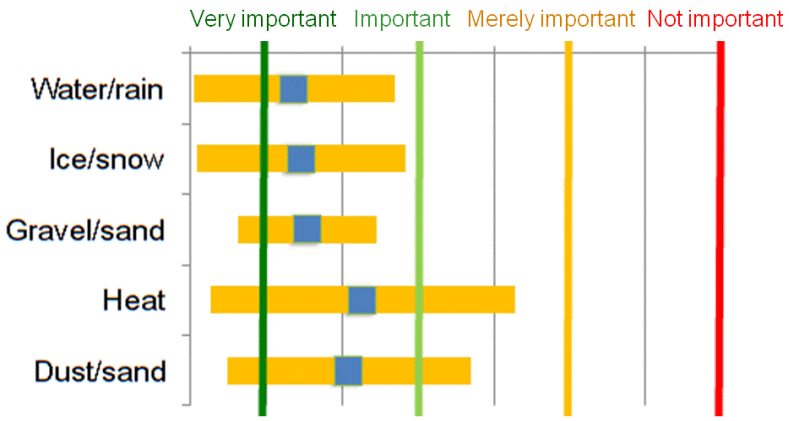
  Due to the use of gravel and sand during the winter to prevent slipping and tumbling, the operational functions of a BAS are potentially at risk. This impact needs to be seen in combination with harsh weather conditions.

- **Heat**

  Longitudinal constructional changes caused by heat are potential sources for malfunctions need to be taken into consideration.

- **Dust/Sand**

  The influence of dust and fine sand has plays a minor role in the eyes of operators.

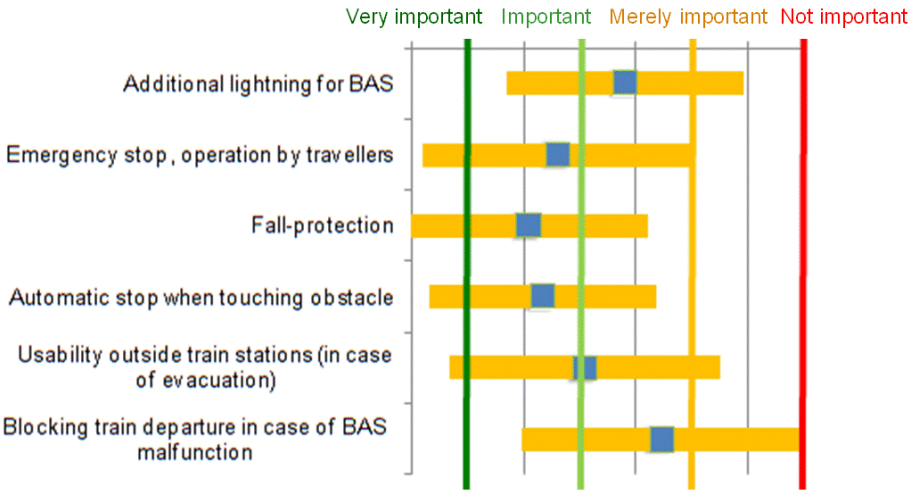



**Pic. 62: Environmental influences on potential malfunctions**

### 5.2.7 Requested Safety Features

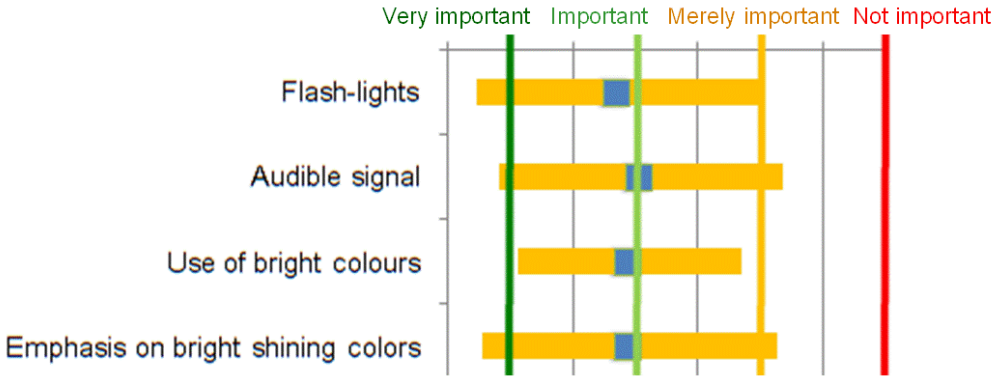
Roll-stops and side plates preventing the user falling off the BAS are a main requirement for operators, especially when substantial height differences need to be overcome. Another request are features like automatic stop, e.g. provided through the use of switches which sense resistance and identify when the BAS hits an obstacle. An emergency push button is assessed as important.

On an average, the usability of a BAS outside the platform area is considered as important, e.g. in regards to emergency-evacuation situations, so that travellers who rely on a BAS are enabled to leave the vehicle.




**Pic. 63: Safety-features required**

An important device in the operators' point of view are flashlights, audible signals when the BAS in moving, and the use bright colours (even though the operators´ opinion is widely spread about this question).




**Pic. 64: Additional safety-features, which are required**

## 5.3 Purchase decision criteria for a new BAS

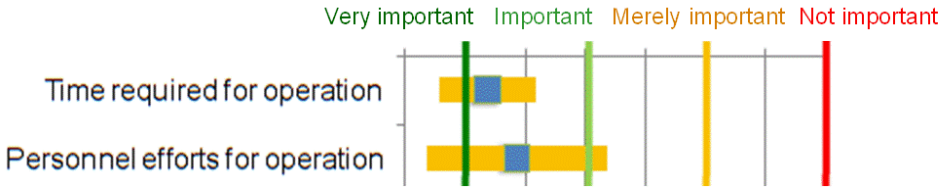
Based on the criteria for the decision making process in regards to the purchase of a new BAS there are further contributing factors that need to be considered.

### 5.3.1 Time required and personnel efforts for operation of BAS

Time required and need for personnel – those are the main decision criteria in the decision-making purchase decision (see Pic. 65).

As covered in Chapter 5.2.3, a short dwell-time while stopping at the station according to schedule if possible according to schedule and a short duration for operating the BAS is highly important.

The expenses for personnel is connected to cost at one hand based on the time required for the whole procedure to operate the BAS, especially when using own personnel. A driver operating the BAS if no conductor is on board is the worst case cost-wise. This is the reason why at least some operators request an automatic system (see chapter 4.5).

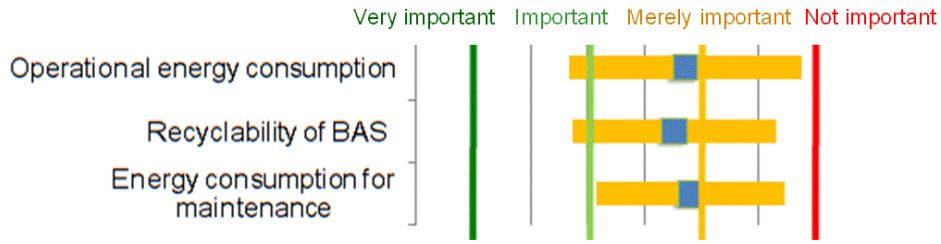



**Pic. 65: Purchase decision-criteria for a new boarding assistance system – time and personnel required**

### 5.3.2 Energy Consumption Recyclability

Unfortunately, these subjects are considered of little importance to the operators. A reason for this opinion could be that a BAS only consumes a small amount of energy compared to the

whole train and its electric systems and that it is expected that a BAS needs to last as long as possible, possibly as long as the trains life-cycle, so that recyclability is not a concern.



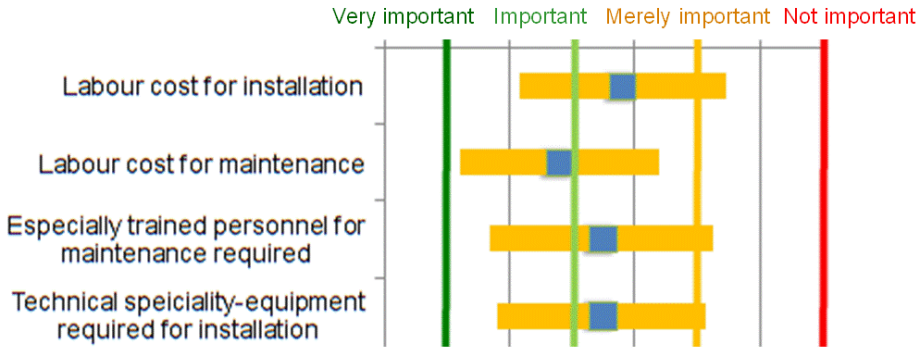

**Pic. 66: Purchase decision-criteria for a new boarding assistance system – energy consumption and recyclability**

### 5.3.3 Installation and Maintenance

The required personnel for the installation of the BAS is considered as merely or not important by operators (see Pic. 67).

Maintenance performed by trained personnel is regarded as important, as well as the need for training and speciality equipment (see Pic. 67).

In general, operators request little personnel intensity, little specialisation of personnel and speciality equipment, for maintenance work – the less the better.



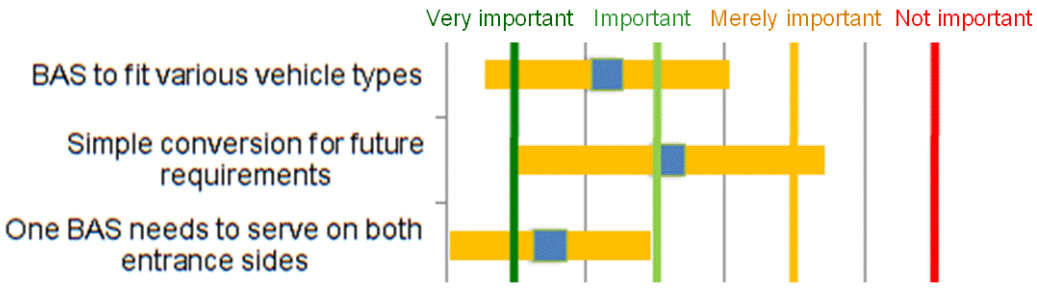

**Pic. 67: Purchase decision-criteria for a new boarding assistance system – installation and maintenance**

### 5.3.4 Universality of a System (see Pic. 68)

Importers rate a universal application of a BAS **very highly** in order to make use of the same system on **different train-types**, which goes hand in hand with the original idea to create a universal solution.

The question of usability of one BAS on both sides of the vehicle is still open it seems that operators have misunderstood that question.

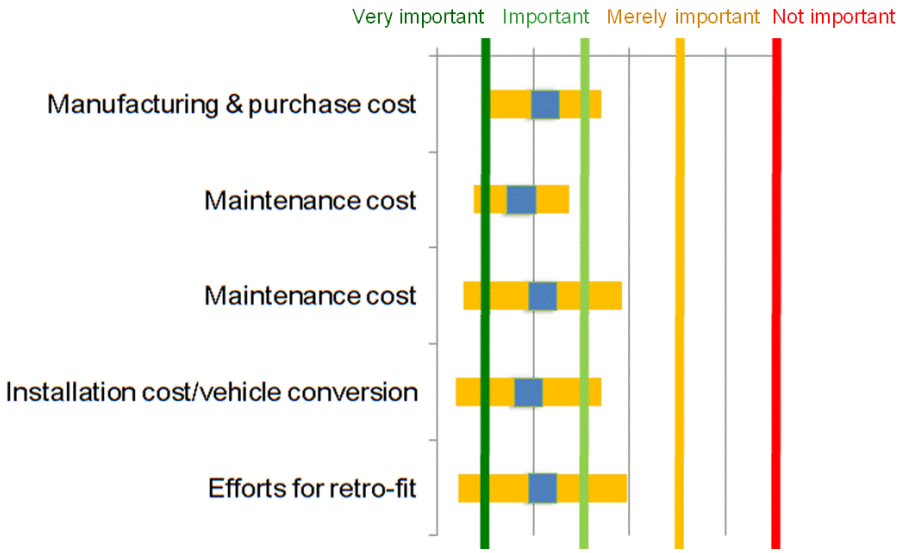
Slight tendencies show that it is important or merely important that a BAS can be retro fitted according to future requirements.




**Pic. 68: Purchase decision-criteria for a new boarding assistance system – universality**

### 5.3.5 Installation Cost (Pic. 69)

Installation costs are a contributing factor within the purchase decision-making process for or against a purchase. Purchase and Maintenance cost and cost for changing the vehicle-structure are regarded as important and very important.

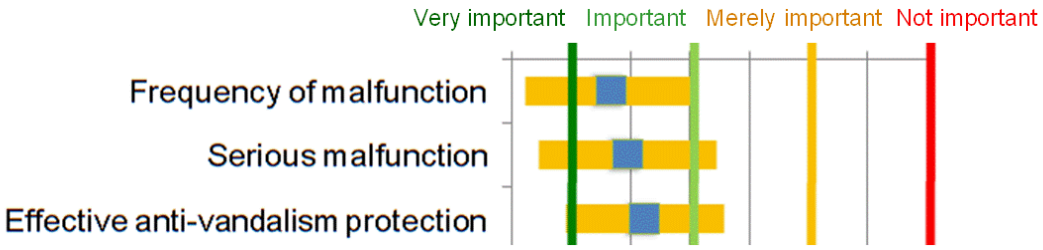



**Pic. 69: Purchase decision-criteria for a new boarding assistance system – efforts and costs**

### 5.3.6 Reliability – Protection against Vandalism

Reliability of the BAS has a very high status amongst operators. Important criteria are the number of potential malfunctions their impact and severity (see Pic. 70).

Also protection against vandalism is important and very important of operators these days and a must have for a BAS (see Pic. 70).



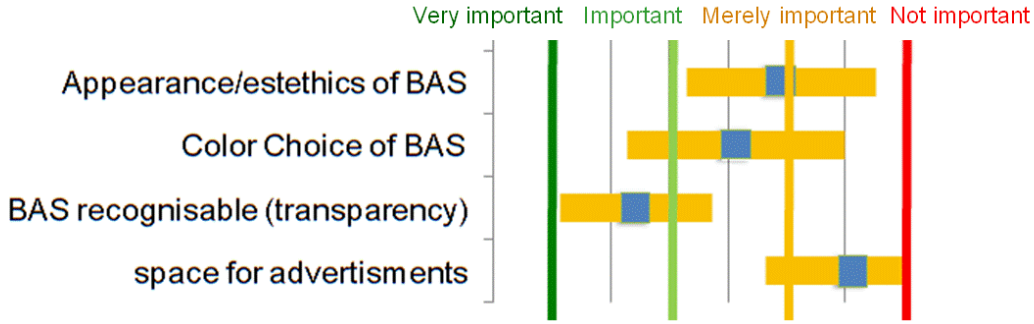

**Pic. 70: purchase decision-criteria for a new boarding assistance system – reliability**

### 5.3.7 Design and Appearance of a BAS (see Pic. 71)

The aesthetics and colour of a BAS is rated of minor importance. Nevertheless, the design of the BAS shall blend in with the vehicle or have an inviting appearance, and use a contrast colour though. This subject was mentioned within personal face-to-face interviews with operators.

A BAS needs to be clearly visible with no hidden corners and the user shall not get the feeling of being "arrested"when using the BAS.

Using visible parts of the BAS for marketing, e.g. advertisements, is not important to operators.




**Pic. 71: Purchase decision-criteria for a new boarding assistance system – visual design**

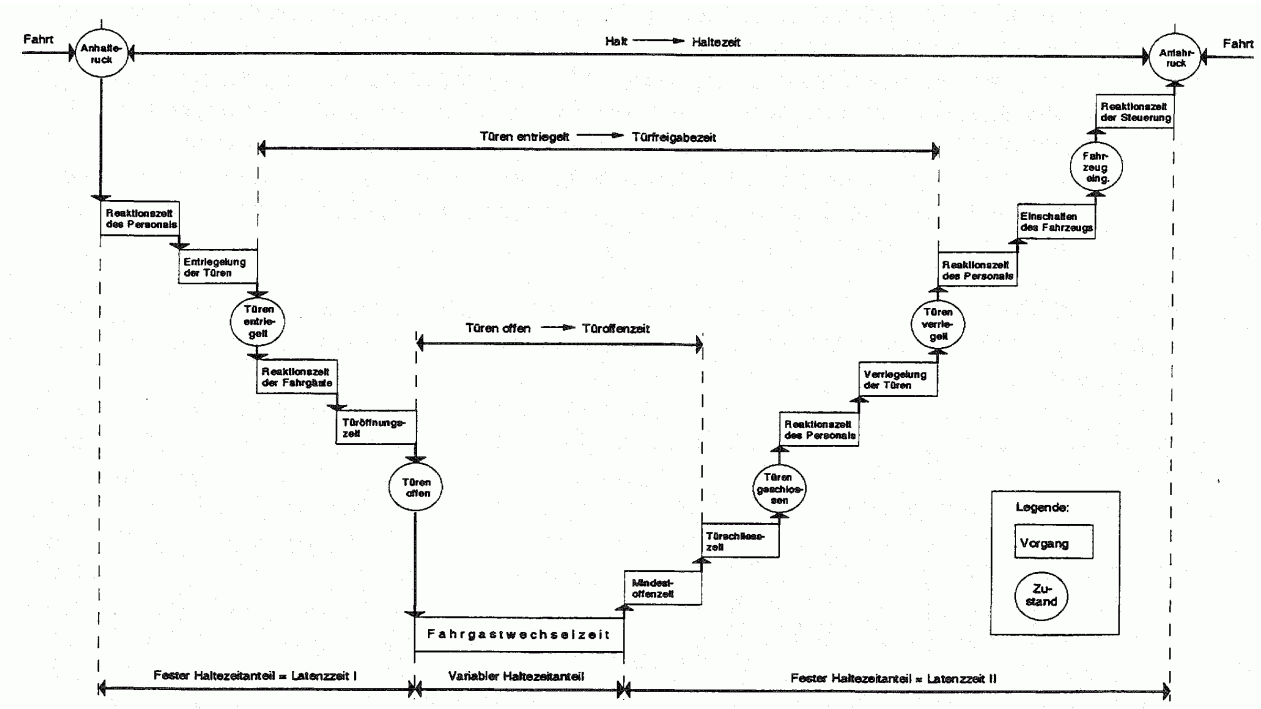
## 5.4 Operational Environment

Available time is influenced by operational service-quality, which directly relates with its operational environment. The operational environment is covering the available dwell periods and its impact on the stability of the schedule if at risk.

### 5.4.1 Dwell-time at the Station

Dwell times consist of a variety of components, of which passenger flow/change is only one part. The available time for the exchange of passengers is also the available time, which can be used for the operation of the BAS.

Pic. 72 shows the different phases of the dwell-time. There are 10 to 20 seconds available when a regional or long distance train is stopping at the station (without considering the duration passenger change). These 10 to 20 seconds need to be deducted from the scheduled dwell time, which reduces the available time for the change passenger flow and exchange of passengers.




**Pic. 72: components of dwell time (Weidmann 1994)**

The minimum dwell time is usually 1 minute amongst most operators. In Scandinavia, it is even 3 minutes. Differences are seen between regional and main stations. Main stations provide more time for the use of a BAS, as a main station typically sees more travellers and therefore a higher passenger flow (see Tab. 1).

Average dwell times vary between 1 to 4 minutes at main-stations and 1-2 minutes at stations in between depending on the operator (SBB Switzerland). SJ in Sweden is using between 3 and 5 minutes dwell times. In Bulgaria, the average dwell time is between 1 and 5 minutes at main-station, and 1 - 2 minutes at stations in between. The general dwell-time amongst all passenger ranges from 1 to 5 minutes.

Within local traffic the scheduled dwell times are shorter, e.g. between 1 and 3 minutes at main stations and between 30 seconds and 1 minute at stations in between. In Bulgaria dwell times are lying in between 1 and 3 minutes in local traffic, whereas in Sweden it is 1 to 5 minutes.

| | Min. Dwell Time | Max. Dwell Time | Target Time |
|---|---|---|---|
| Regional Stations - Long Distance | 1 min | 5 min | 1-2 min |
| Main Stations - Long Distance | 1 min | 5 min | 1-2 min |
| Regional Station - Local Service | 0,5 min | 3 min | 0,5-1 min |
| Main Stations - Local Service | 1 min | 5 min | 1-2 min |

**Tab. 1: Lower and upper limits for the dwell time – comparison of different European operators**

If a BAS should be operated at all stations and for all travellers, the required time for its operation needs to be co-ordinated with the minimum dwell-time.

If the use of the BAS only aims at particular stations, a shorter period can be added on top of the dwell time, which is used up again by the reserves calculated into the schedule. A maximum of 30% to 50% of the reserves shall be used, as they are still used for irregularities within the schedule during operation.

### 5.4.2 Timely Reserves within train schedules

Reserves within the train schedule are necessary to compensate for operational irregularities and delays and are usually calculated as a percentage of the travel time. Amongst European operators, these are between 6% and 12%. Higher amounts could be required on heavily frequented lines, as these delays have a direct impact on the total schedule.

Usable reserve times are about 2-6% of the total time between platform (depart) and platform (arrival) which is 15 to 30 minutes on average, so that a period of 20 minutes would mean 1 minute of reserve time at the maximum.

### 5.4.3 Acceptable Operational Time for a BAS

Most European train networks have different dwell times at each station with dwell times between 1 minute and more. A stop time of one minute is well positioned between two minutes and more, so 2 minutes for the operation of a BAS are acceptable.

Therefore, various areas of application and levels of qualities in regards to the duration of an operational cycle of a BAS need to be designed (see Tab. 2).

| **Quality-Level** | **Operat.-cycle** | **Application** |
|---|---|---|
| **1** | 1 min | **all stations** / **all passenger groups** |
| **2** | 2 min | Stations with **2 minutes dwell time** or more / **all passengers**<br>**all stations** / **selected user groups** |
| **3** | 3 min<br>or more | Stations with **3 min dwell time** or more / **all passengers**<br>**all Stations** / selected user-group |

**Tab. 2: duration of an operational cycle of a BAS**

Ideally, an operational cycle should not be longer than 1 minute. In that case, the BAS could be used at all stations. In practice, 1 min for a full cycle is rather tight time-wise, so quality level 2 should be at least aimed, which means 2 minutes for the cycle but no longer unless demanded by the passenger flow.

Quality level 2 enables its operation amongst the majority of stations for all passengers and at all stations for selected user groups.

### 5.4.4 Minimum- and Maximum Measurements

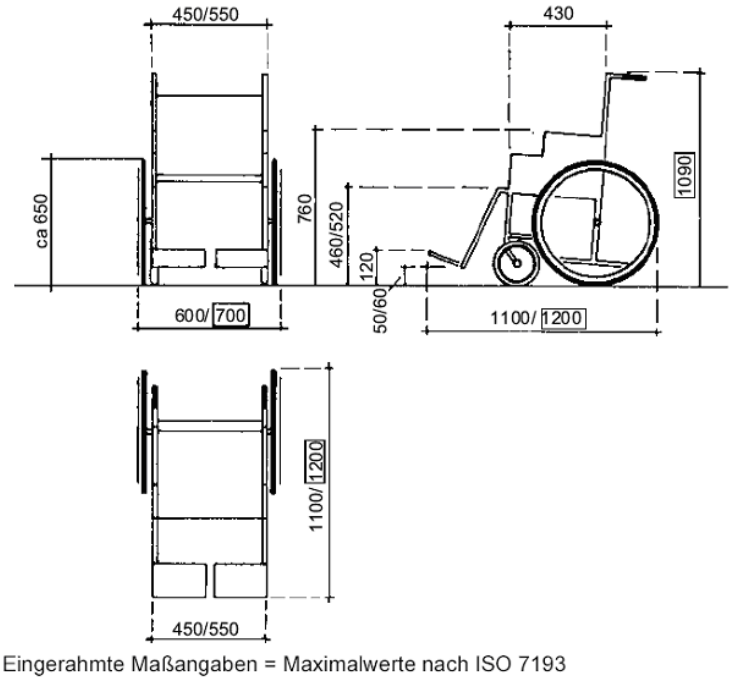
ISO 7193 is the basis that specifies wheelchair measurements along the limits in terms of size, and needs to be compared with ISO specifications as long as the maximum measurements are not increasing those shown in Pic. 73.

Total Length: 1200 mm

Total Width: 700 mm

Total Height: 1090 mm

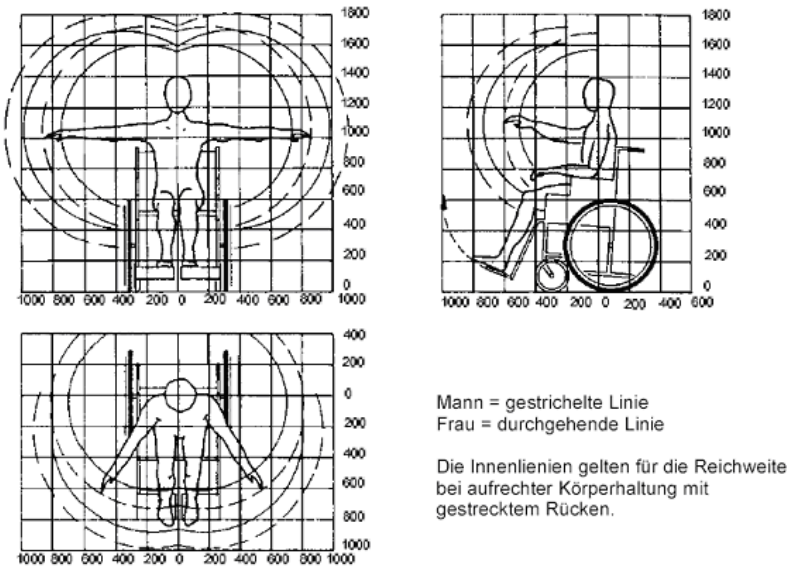
An occupied wheelchair is usually 50mm longer than an unoccupied wheelchair, as specified in the standard.




**Pic. 73: wheel chair dimensions according ISO 7193**

Pic. 73 is showing the dimensions of the most common wheelchair for adults which is 1100 mm to 1200 mm in length, and 600 mm to 700 mm in width (see ISO 7193).

Pic. 74: Occupied Wheelchair – grip circle is showing the reachable distance for a wheelchair-occupant when needing to operate devices independently.




**Pic. 74: Occupied Wheelchair – grip circle**

The smallest turning circle of a wheelchair according to ISO is 1500mm (1800 being a more common number today with power wheelchairs) including footrest. The centre of mass is located at a height of approximately 660mm above ground level.

The current ISO 7193 is only referring to wheelchair intended for indoor use and dated back to 1985. Annex M of TSI PRM, referring to ISO 7193, represents engineering limits for transportable wheelchairs, e.g. the total weight of a wheelchair including passenger and luggage being only 200kg, whereas this limit is moving into the direction of 300kg nowadays (heavy electric wheelchairs)

Accommodating for turning circles of 1800mm represent a tremendous, if not impossible, challenge for manufacturers. BAS in use nowadays do have load capacity of 300kg. Manufacturers have accommodated to this need by making their experiences in public transportation (Bus Directive 2001/85 see chapter 5), community transport (minibuses) and private motor vehicles.

In due time ISO 7193 will be renewed by a new version which has been developed and reviewed by an international working group.

In real life, the majority of wheelchairs that are used within the area of transportation are designed for outdoor use, as specified in the following CEN standards:

- CEN 12183 - Manual wheelchairs
- CEN12184 – Power Wheelchairs
- Class A – Indoor
- Class B - Indoor, with some outdoor capability
- Class C – Outdoor, with obstacle climbing ability

Wheelchairs nowadays are classified by operating environment – not by mass. Wheelchair selection/prescription is done according to user requirements.

### 5.4.5 Platform construction

In Europe, platform heights are ranging between 550mm and 760mm, which vary as well outside these dimensions on a wide scale amongst the different nations and their rail infrastructure.

- Platform construction
    - Earth platform

No Platform edges do exist on earth platforms, it is made of gravel, sand and asphalt, covering as well the body of the tracks and space in-between them.

- Plattform with concrete components

  Built on a concrete fundament, pre-fabricated elements are use to build the platform tailor-made according to the track geometry, filled with earth behind the elements and on top of the fundament. This approach is widely used, as it is a flexible way to accommodate the platform according to requirements in terms of required heights.

- Pre-fabricated concrete/steel construction

  Large pre-fabricated concrete/steel elements are being delivered, which enable a quick building time when a new station is built or when rebuilding an existing station. This approach can be used with all types of platforms, limitations occur in case of an angled track geometry though.

- Steel constructions

  They are mainly used for operational platforms used by the operating personnel.

- Platform width [TSI PRM]

  The minimum platform width without hindrances needs is always the larger measurement of the dimensions covered within the following information. It is not including the width that is needed for the common passenger-flow:

  Width of the endangered area plus the width of a walking strips per side 800 mm (total 1600 mm) each

  - 2500 mm for an outside platform, 3300mm for middle platform

  1600 mm need to be kept clear of obstacles larger than 1000 mm in width. The clearance between platform and obstacle needs to be 1600mm at least, between obstacle and danger zone at least 800mm. longer obstacles in size require more clearance accordingly.

**Pic. 75: Obstacle on the Platform**

**Pic. 76: Obstacle on the Platform**

1500mm clearance is requested when operating a BAS around the area of the boarding device, regardless if the BAS is platform- or vehicle base.

- Gradient of platforms

  The gradient of a platform depends on its drainage system, and the layout and routing of gradient of tracks. Island- and Middle-Platforms without roofs usually have a gradient of 2-3% towards the centre of the platform, whereas platforms built with roofs use a gradient of 1% towards the tracks.

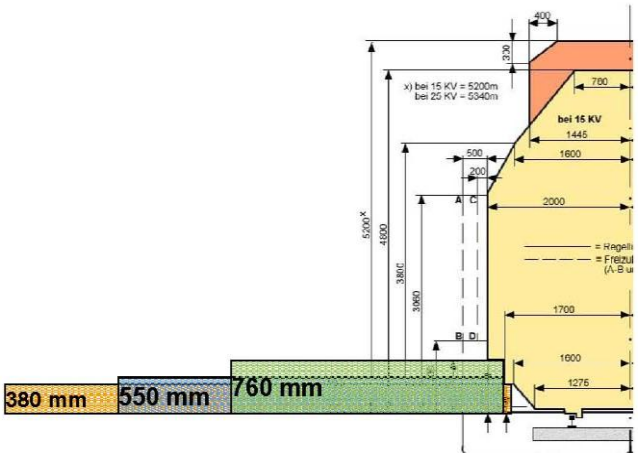
- Platform height

  550mm and 760 mm with a tolerance of -35 mm/ + 0 are acceptable. Only in stations with curved tracks under a radius of 500m, it is allowed to cross these limits.

  Within the European railway system there is a number of different platform heights, which, in addition depends on its use for local or long-distance services, e.g. 760mm for high-speed trains in the UK as well as 915mm also in the UK for intercontinental trains such as Eurostar (London-Paris and London-Brussels).

  In Austria for example, the best-case scenario is when the platform and the floor-level is the same, which is only the case with low floor trains and new platforms for level boarding. The worst-case scenario in Austria is the combination between old platforms and classic old-type wagons with up to 110cm of distance that needs to be overcome.

- 380 mm
- **550 mm (EU-Standard)**
- **760 mm (EU-Standard)**
- 840 mm (NL)
- 915 mm (GB)
- 960 mm




**Pic. 77: platform levels in Europe - clearance**

- Distance between Vehicle and Platform - Gap

  New platforms are being built based on the defined clearance gauge of 550mm or 760mm height. Here the minimum structure gauge has to be taken into account (see Pic. 77). The formula used in TSI PRM calculates the maximum dimension of the gap in reference to the track radius.

  The formula does not cover the impacts of

  - tracks drift apart slightly
  - super elevation
  - switches und crossings
  - statically gradient of the vehicle
  - constructional and maintenance tolerances

Each single impact on the dimension of a gap needs to be evaluated separately on its own. The European train network shows a range of distances, depending on their alignment and regulations that are in effect.

As the lowest stair is not always located at platform level, the maximum distance measured diagonally is 35cm (see Pic. 78)


**Pic. 78: vertical gap and diagonal distance (left), "Harrington Hump" (right)**

The "Harrington Hump" as shown in Pic. 78 (right) in the used in the United Kingdom, is a prefabricated hump to raise low platforms at low use stations and can be fitted elsewhere. It does not give level access though and does not deal with horizontal the gap.

The UK by May 2010 provides Step-free access at 148 stations and is running smaller schemes at 1300 other stations, having the intention to achieve 81% by 2015. Current challenges are to overcome gaps and steps, barrier-free access for old platforms used for mixed ["Accessibility within Public Transport - A Natural Must Have?" PubTrans4All Conference, Vienna, Austria, May 2010, John Bengough, Head of Domestic Policy, Rail Standards & Safety, Department for Transport, Great Britain]

## 5.5 Legal Framework

- TSI PRM regulations [TSI PRM]

If the horizontal gap in exceeds 75mm and the vertical gap more than 50mm, a BAS for wheelchair users is required.

Operators, management of the infrastructure and train stations need to decide, in which area of the platform the BAS will be used, and ensure its feasibility. This specific area must be compatible with other platforms. For each BAS an area of 1500mm is required, measured from the platform.

Operational guidelines need to ensure trained professionally trained personnel handles a BAS and provide assistance as required.

# 6 Requirements from the manufacturers' perspective

## 6.1 Fringe Conditions/Constraints

- Requirements according to TSI PRM [TSI PRM]

  According to the TSI, a BAS needs central positioning over an area of 660mm to 660mm, and carry a load of up 300kg.

- Requirements on Ramps

  The surface needs a slip-resistant, nonslip surface, a platform of a clear width of 760mm including 20mm side plates with round edges and a contrast colour in order to prevent wheels slipping from the platform with a maximum retention of 18% (10,2°).

- Requirements on (electro-) hydraulic lifts

  A nonslip surface and a clear platform-width of 720mm. 25mm roll-stop plates need to be fitted to the side of the platform, in order to prevent wheelchairs from tumbling over the boarders during operation. The access area needs to be equipped with a mechanical safety - roll stop, enabling the wheelchair to access the platform, and preventing an electric wheelchair from falling off the platform. No single part of the lift may move more than 150 mm/s, and up to 300 mm/s when deploying the platform and disembarking the customer. The vertical acceleration is limited with 0,3g.

### 6.1.1 Costs

- Cost of material
- Operational cost

  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.

### 6.1.2 Construction Concept

- Durable Design
- Universal Design

  A universal design takes all specific needs of all user groups in consideration and handles them effectively by making the BAS useable for everybody, without adapting the product specifically to a certain need only.

In order to fulfil the demands a universal design requires, a number of principles need to be considered.

  - Wide-range of usability
  - Flexibility when in use
  - Ease of use, intuitive
  - Tactile recognisable information
  - Tolerances for mistakes
  - Low physical efforts
  - Accessibility and space for usage

- Proven design
- Easy implementation into the vehicle

  The system needs to fit in almost every vehicle, and needs to be able to be re-equipped and refurbished. Interference with statics need and conversion work on the vehicle shall be reduced to a minimum in order to keep the stability around this vehicle area, and transfer pressure, loads and pulling-forces to a minimum, and keep the stiffness of the shell in order to keep comfort and crashworthiness.

- Low mass
- Aggregates / motors
  - Mechanism
  - Power unit
  - Emergency use
  - Operation

### 6.1.3 Integration of the BAS

- Size
- Minimum build-size

### 6.1.4 Attractiveness

- Technical attractiveness

- Requirements and demands from manufacturers
- The BAS shall be easily installed, and cover a wide range of vehicles. Clear interfaces with the vehicle structure to prevent weakening of the vehicle-structure.
- Operator´s Requests

  The system needs to have the same concept regardless throughout, independently from the type of train. The operational time to run the BAS shall be reduced to a minimum, in order not to delay dwell times, and shall be stowed in the vehicle without limiting space. Furthermore, the system shall be easily exchangeable in case of defects, and spare parts need to be available for the lift time of the vehicle, which is 35 years.
- Requests by the users

- No discrimination
  - Usage by as many groups as possible

### 6.1.5 Ergonomics

- Ergonomics
- Comfort
- Ease of use

  The BAS shall be easy to use, and not demand intensive training for personnel.
  - Emergency Use
  - Door Operation
  - Manuals
  - Feature Buttons
  - Operational concept

    The operational concept needs to be co-ordinated with organisations representing the various user-groups.

### 6.1.6 Safety

The BAS does have 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.

- Door Operation
- Safety Switches
- Protection of Other travellers
- Integrating the drivers` role
- Surveillance

  A video surveillance system shall contribute to the safe operation, using an integrated, advanced sensor system. Sonic and visual alarms need to avoid complications,

- Emergency concept

  The system needs to serve as an evacuation system in an emergency in order to evacuate passengers, also in a tunnel.

- Manual backup system

  Provided by manual operation and manual force – e.g. handle to operate cylinders for ground to floor operation (boarding) floor to ground operation (alighting).

### 6.1.7 Feasibility

- Weight
- Integration into the vehicle
- Legal restrictions
  - Norms
    - Standards for buildings / construction
    - Standards for operations
    - Standards for accessibility

      These standards specify minimum dimensional requirements such as platform size, lifting speed and maximum lifting capacity.

    - Fire prevention standards
    - Environmental Standards Normen für Umweltbedingungen
  - Work guidelines
  - Laws

- Homologation
  - Country - specific needs

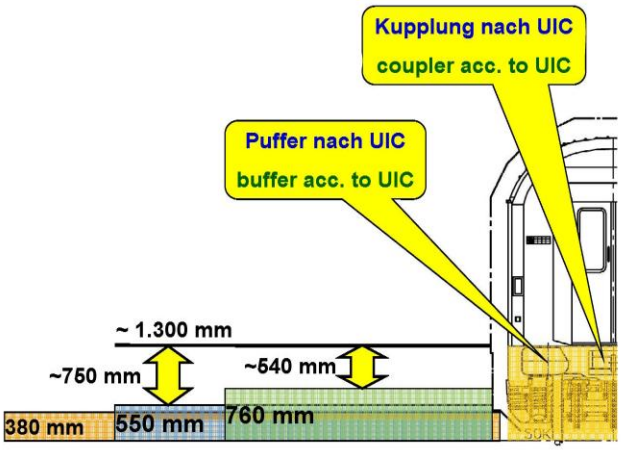
## 6.2 Technical boundary conditions – vehicle based restrictions

- Floor Level

  Depends on the construction-type of the vehicle and is classified into two types:

  - **High floor vehicle**
    High-floor vehicle flooring is located at 1300mm above track surface. The height is depending on the positioning of the buffers and construction and design of the powered bogie. This design is mainly used at existing long-distance trains (see Pic. 79 and Pic. 80).

**Pic. 79: High floor access**




**Pic. 80: floor level in high floor vehicles**

- **Low-floor vehicles**

  Due to the use of single wheels, and a non-continuous flooring system, level boarding at floor level is possible. This technique is mainly used in local public transportation (see Pic. 81).

**Pic. 81: Low floor access**

- Access Doors

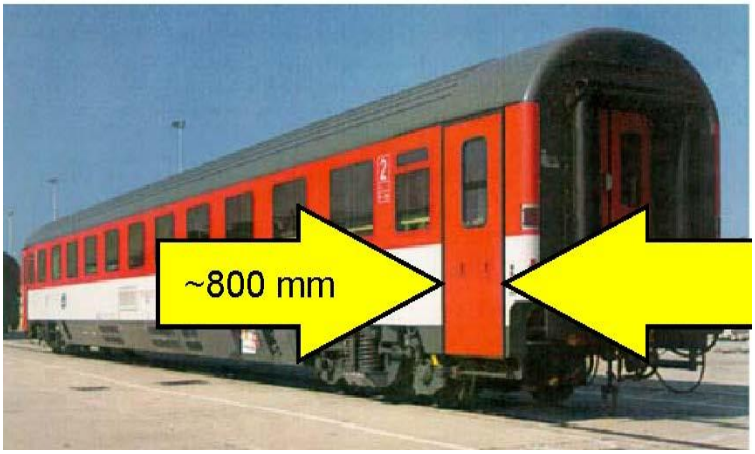
  Türen für den Einstieg von Reisenden von außen müssen in geöffnetem Zustand eine nutzbare lichte Weite von mindestens 800 mm aufweisen und in Kontrast zum Rest des Wagenkastens stehen.

  A train access door requires a minimum width of 800mm and sufficient contrast.

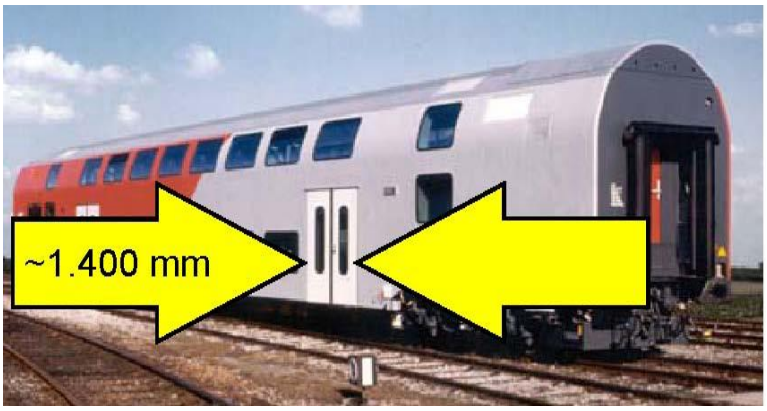
  The operation of the door must be performed by the train-personnel or „half"-automatic by a push button activated by the passenger.

  Push buttons either needs to be located next or on to the door leaf, must have a contrast colour, and shall be operated with a maximum force of 20N. They shall also have tactile design.

  The feature buttons need to be located behind or next to the door cover, shall be operated with less than 20 N, and provide sufficient contrast.




**Pic. 82: door width of a typical long distance wagon**




**Pic. 83: door width local wagon (example)**

- Entrance stairs

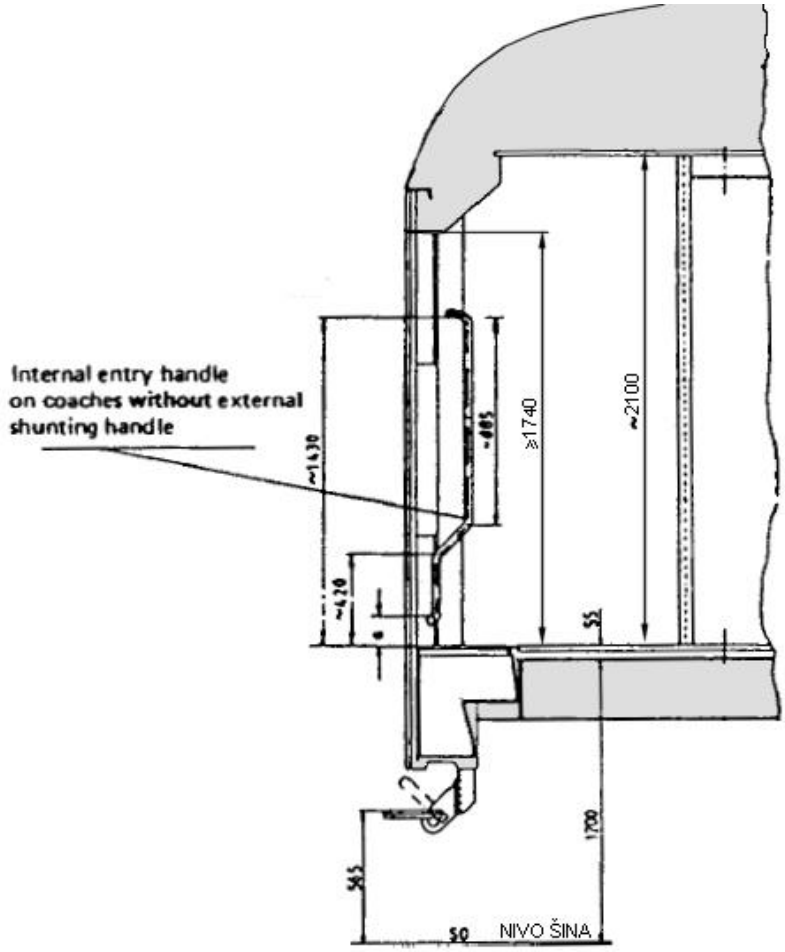
  In order to access the vestibule of a vehicle the entrance area shall only have four slip resistant stairs at the maximum, of which one of them can be located outside the wagon. Stairs need to accommodate the width of the door.

  The maximum height of stairs is 230mm and a depth of 190mm minimum.

  The first and third stair need to have a contrast against the floor, its maximum height is 230 mm, and 145 mm wide minimum.

- Clear floor to ground distance

  The area around the door and direct access area in-between the interface of wagon, often only have limited clearance, at least 1740mm needs to be available. This fact should be considered in combination with constructions that could provide level boarding (see Pic. 84).




**Pic. 84: Positioning of steps - Clear floor to ground distance**

- Handrails

  Which are installed on the vehicle have diameter between 30 mm and 40 mm and have contrasting colour. Minimum clear distance to other obstacles and areas are 45 mm, and the minimum inner radius is 50 mm.

  Door openings with two stairs require handrails on both sides mounted between 800 mm and 900 mm above the first step.

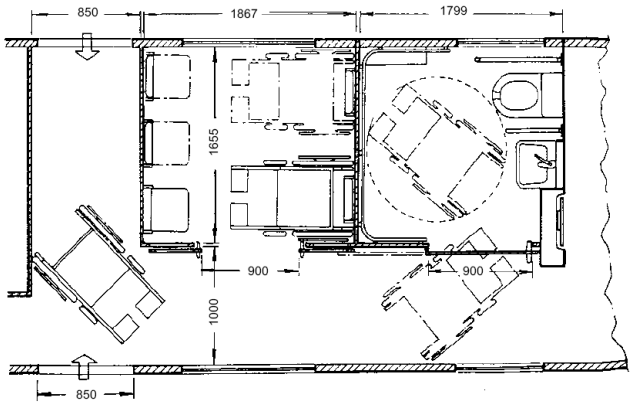
- Lightning

  Must cover 80% of the access area and lighten with 75 Lux.

- Structure clearance in the vehicle

  Clear room in 1000 mm high require 450 mm width (in-between 1000 mm and 1950 mm, minimum 550 mm.)

The accessible wheelchair place for example for requires wheelchair-friendly door-widths of 800mm wide and 1450 high to enable a turning circle of the wheelchair of 1500mm minimum (see Pic. 85).




**Pic. 85: required space for wheelchairs inside the vehicle**

# 7 Standards, regional law

## 7.1 TSI PRM

TSI PRM covers construction, design and infrastructure etc of railway vehicles as described in previous chapter.

An accessible train station needs either a vehicle- or platform based BAS to board wheelchair users.

Official Journey of European Commission (TSI PRM) within conventional Trans European railway-system and high speed traffic (K 2007, 6633), March 2008

## 7.2 UIC-Codex

UIC literature covers the accessibility of train vehicles. They have the status of proposals. UIC will use TSI PRM and its European norms for their new codex. UIC-KODEX 565-3, 2nd edition March 2003

## 7.3 National and European Norms

There are several national Norms in Europe, as well as European norms, regulating accessible buildings, vehicles, technical mobility aids etc. Due to its variety, the following will give some overview:

- ECE 2001/85 Bus directive (e.g. Annex Vll)
- RVAR Rail vehicle Accessibility Regulations (U.K.)
- TSI PRM Technical Standards Interoperability - Persons with Reduced Mobility, (*Annex M, wheelchair specs.)*
- Rail Vehicle Accessibility Regulations 1998
- Disability Discrimination Act 1995
- Disability Discrimination Act 2005
- TSI PRM Annex M, ISO 7193 (indoor-chairs),
- EN 12184 Annex A (electric wheelchairs),
- ISO 7176-19 (ISO 10542), design Requirements for use in Transportation

- Code VVR Netherlands (incorporating ISO 7176-19 & ISO 10542)
- DIN 75078 Germany
- ÖNORM B 1600 (Barrierer free Buildings – basic planning), 1601 handicapped and elderly people, V 2100 Technical aids for visually impaired people, ,
- ÖNORM B 1601 Baulichkeiten für behinderte und alte Menschen – Planungsgrundsätze
- ÖNORM Technische Hilfen für sehbehinderte und blinde Menschen – Taktile Markierungen an Anmeldetableaus für Fußgänger
- ÖNORM V 2100 Technische Hilfen für sehbehinderte und blinde Menschen – Akustische und tastbare Hilfssignale an Verkehrslichtsignalanlagen
- ÖNORM V 2100 Technische Hilfen für sehbehinderte und blinde Menschen – Taktile Bodeninformationen

# 8 Evaluation criteria catalogue

The following chapters are showing all relevant parameters discussed in earlier in this work, the „must haves“ and „nice to haves“. Three main criteria had been identified (features rated as not important, are not shown herein). The evaluation criteria catalogue is a summary of all relevant parameters, criteria and frames that must be considered when designing a new BAS. All the details can be found in chapter 5.

All criteria are defined in three levels (see Tab. 3). All criteria that are not important – as found out in chapter 5 – are also shown in the catalogue.

| Score | Meaning |
|---|---|
| **1** | **Very important** („must have“) |
| **2+*** | **Important** („nice to have“– high customer value, BAS not necessarily needed, but a BAS is very welcome! |
| **2** | **important** („nice to have“ – high customer and operator value) |
| **3** | **Merely important** („nice to have“ – customer and operator´s value, but not necessarily needed) |

**Tab. 3: score card**

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

### 8.1.1 User groups

For the following user groups a BAS needs to be useable (Tab. 4): Rating of operators, manufacturers, users etc:

| User group | importance |
|---|---|
| Power wheel chairs | 1 |
| Manuel wheel chairs | 1 |
| Walking disabled | 2+ |

| | |
|---|---|
| Frail people | 2+ |
| Elderly | 2+ |
| Baby prams | 2+ |
| Passengers with luggage | 2 |
| pregnant | 2 |
| Diminutive people | 2 |
| Overweight people | 3 |
| children | 3 |
| Visually impaired* | 3* |
| Hearing impaired* | 3* |
| Passenger with extra luggage (e.g. bicycles) | 3 |

**Tab. 4: 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.

### 8.1.2 Operability

The question if a BAS should be operable independently or automatically, or through train personnel, is not answered yet, also due to legal reasons (putting somebody at risk!)

Due to cost operators, opt for an independent BAS with automatic functions. For the reason of comfort there is the demand for a system that can be operated y the users or which is working automatically, as long as it is assured that it does not put people on danger (Tab. 5).

| **operation, handling** | **importance** |
|---|---|
| Self operation of the system by the customers themselves or by companion)* | 2 |

| | |
|---|---|
| Automation of the system* | 2 |
| **Personnel autarkic operation*** | **2** |

**Tab. 5: 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.

### 8.1.3 Applicability

The BAS needs to be used on heavy rail, long–distance rail and high-speed, both. The impact of BAS on regional trains is not that intensive, as within regional traffic more and more low floor vehicles. It was found that it is not important to serve other local operators, such as underground, tramway etc (Tab. 6).

| **applicability, vehicles** | **importance** |
|---|---|
| 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. 6: applicability of a BAS in different vehicles**

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

### 8.1.4 Quality and reliability criteria

A BAS needs to work reliably, and in case of malfunction must not influence passenger-flow and needs to be ready to operate it manually in case of failure. As a standardised solution for the whole of Europe plays an important role, so it also needs to be assured that the BAS is working in (extreme) weather conditions such as Snow, Ice, Gravel, Heat, dust, water, and rain only to mention a few (Tab. 7).

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

**Tab. 7: Criteria of reliability and operational quality**

### 8.1.5 Safety criteria

The BAS must fulfil all relevant safety criteria, especially if the system should work automatically. E.g., fall protections, emergency stop, optical and acoustic safety features are "must haves" (Tab. 8).

| Safety criteria | importance |
|---|---|
| Safety features (acoustical, optical) | 1 |
| Fall protection | 1 |
| Emergency stop (for passenger)* | 2 |
| Contact detection | 1 |

| | |
|---|---|
| Applicability outside of stations | 2 |

**Tab. 8: safety criteria**

* For automatic systems: 1

### 8.1.6 Manufacturing, implementation, operation and maintenance

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" (Tab. 9).

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

**Tab. 9: importance of following criteria: manufacturing, implementation, operation and maintenance**

### 8.1.7 Sustainability

The topics „energy consumption" and "recyclability" are valuated as less important (Tab. 10).

| criteria | importance |
|---|---|
| energy consumption* | 3* |
| recyclability | 3 |

**Tab. 10: 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!

### 8.1.8 Universality criteria

It is „very important“ to find a standardized solution for a BAS that can be implemented into as many existing vehicles as possible (Tab. 11).

| criteria | importance |
|---|---|
| Implementation into different vehicles | 1 |
| retrofitting | 2 |

**Tab. 11: universality criteria**

### 8.1.9 Aesthetic

In general aestethics are rated merely important, based on the customers' request there should be more focus on this subject though (Tab. 12). The visibility of the platform is scoring high though.

| criteria | importance |
|---|---|
| aesthetics | 3 |
| visibility | 2 |

**Tab. 12: aesthetic criteria**

### 8.1.10 Technical and operational frame conditions

A standardised boarding assistance system needs to fulfil the following technical and value boundary (Tab. 13).

| Frame condition | limit |
|---|---|
| **Total duration** → preparation, use, stowing | **< 2 min** |
| **Platform width** | **> 130 cm** |
| **Vertical gap** platform - vehicle | **< 110 cm** |
| **Access door width** | **> 80 cm** |

| | |
|---|---|
| **Access door** resting height from the floor | **> 174cm** |
| **Capacity (wheelchair)** | 350kg |
| **Capacity - other persons** | 75kg/Person*8Persons/m² = **600kg/m²** |
| **Relative angle platform-vehicle*** | < ± **13,2%** or **7,5°** |

**Tab. 13: Technical and operational frame conditions**

* transverse gradient of platform and superelevation of track

TSI-PRM Standards need to be fulfilled as a minimum level of a "new" standard. It makes sense to use more severe standards and interpretation in order to develop a new standard (this is why the TSI has not been covered in all detail herein).

In addition to this, all relevant constructional limits, energy consumption, structural engineering, and wiring, which will be specified further in WP 3 and WP 4.

# 9 Evaluation criteria matrix

The following chapter provides an overview and a summary about all evaluation criteria. For details it is essential to consider the criteria as described in chapter 5. The following main evaluation criteria matrix gives an overview (Tab. 15)

Overview on importance including rating (Tab. 14).

| importance | meaning |
|---|---|
| **1** | **Very important** („must have“) |
| **2** | **important** („nice to have“ – high benefit for user and operator ) |
| **3** | **Less important** („nice to have“ – benefit for user and operator does exist, but is merely important) |

**Tab. 14: Importance of criteria including Score**

| Main criteria | Remark | importance |
|---|---|---|
| **User** | | |
| ***User with devices*** | wheelchair, walking frame, baby prams | **1-2** |
| ***Physical 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 of BAS*** | Prevention of malfunction | **1** |
| ***Operational quality*** | Short dwell time, defect must not have | **1-2** |

| | | |
|---|---|---|
| | influence on the train operation | |
| ***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*** | Keeping costs as low as possible | **1** |
| ***Manufacturing effort*** | The manufacturing effort needs to be low – especially when retro-fitting | **1-2** |
| **Safety** | | |
| ***Safety risks*** | No safety risks to be tolerated | **1** |
| ***Safety features*** | Optical and sonic signals | **1-2** |
| **Maintenance** | | |
| ***Maintenance effort*** | Number of personnel required, special tool required | **1** |
| ***Costs*** | | **2** |
| ***Sustainability*** | recyclability and energy consumption | **3** |
| **Aesthetics** | | |
| ***Optical design*** | Aesthetics is important for customer acceptance | **2-3** |
| *All regulations must be fulfilled (currently according to TSI-PRM) as a minimum standard. Some specifications in this document had been set-up as more severely.* | | |
| *Technical and operational specifications need to be fulfilled (see chapter 5)* | | |

**Tab. 15: evaluation criteria - overview**

# 10 Conclusio

The survey which has been summarized in this Deliverable 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. 80cm of door-width, and the lifting capacity of 350k 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.

# 11 Publications

- Improving Railway Vehicle Accessibility, Zilina 2010, EURO ŽEL 2010
- Improving Railway Vehicle Accessibility, Nis 2010, ŽELCON 2010
- Improving Railway Vehicle Accessibility, Lille 2011, WCRR (world congress of railway research

Further publications regarding to the deliverable 2.1 are planned within 2010 and 2011:

- International Railway Review
- FME Transactions (published by Faculty of Mechanical Engineering Belgrade)
- Der Nahverkehr
- ETR (Eisenbahn Technische Rundschau)
- Railway Interiors Journal
- Mobility
- Road and Rail Technology
- Eurail Magazine
- Railway Interiors Expo
- UIC technical conferences

# 12 List of Figures

# 13 List of Tables