PubTrans4All

Public Transportation - Accessibility for All

Deliverable 4.4
Vehicle based BAS prototype design and evaluation

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1. Executive Summary & Introduction

The deliverable 4.4 will describe the decision making process of the development and the outlook for the evaluation of the vehicle based boarding assistance system prototype created as part of the project PubTrans4All. It will include sections on the selecting of the features to be included in the system, the process used to design and build the prototype and the deployment planning and preparation.

The result of the previous work led to the decision that the most important step towards an accessible rail system at the moment is the development of a boarding assistance system (BAS) for existing UIC wagons. These cars are still in use in large number all over Europe. As described in deliverable 3.1, due to design limitations it is not possible to retrofit these types of vehicles in order to use existing BAS. So at the moment only platform based BAS can be used for wheel chair users. For all other types of vehicles some kind of BAS exists (lifts for high speed trains, ramps for low floor trains). The aim of further research in this project was to develop a BAS that can be used for installation in UIC wagons.

The technical and operational frames for the new BAS are explained in this deliverable. The different decision and evaluation criteria are evaluated from the passengers', the operators' and the manufacturers' perspective described in deliverable 2.1.

The results shown in deliverable 3.1 demonstrate that the layout of older UIC coaches and modern high speed trains that are designed for wheelchair users and other PRMs in general is similar. UIC coaches have small doors with a width of 800mm, while in modern trains the door with is increased to 900mm. The difference is that there are already lift solutions for a door width of 900mm but none for narrower doors. The UIC coach has doors located at the end of the coaches. Because of the folding or sliding steps and vicinity of the buffers as well as other constraints, there is no space under the steps for the installation of a BAS. Additionally, the space at the coach end is occupied by mechanisms of the head doors leading to the next coach, fire fighting equipment, some electrical components etc. Typical for these coaches is that the passageway is in the majority of cases at one side outside the longitudinal centre line of the vehicle because of the neighbouring toilet cabins adapted for people with handicaps and persons with reduced mobility. Finally, there are usually only two potential positions left which could be used for stowing the BAS.

The lifts usually consist of a solid steel frame with a swivel arm and a vertical lifting column. The upstroke is generated by a hydraulic cylinder or an electrical spindle drive. The divided platform is attached to the frame and usually manually folded and unfolded. The lifts are operated and supervised by a trained operator. The turning radius is adaptable to the individual requirements (180° or 270°) of the vehicle. Furthermore, it is possible to board and alight the lift platform from the side which is helpful on very width limited platforms. Swivel lifts can be used in very narrow doors due to the very slim bracket which minimizes the door width only marginally.

2. Methodological approach

The deliverable 4.4 is a summary of all investigations described in the previous deliverables and it describes the decision making process used in choosing the actual developed prototype.

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

The assessment of the importance of the different criteria was performed according to the following scheme:

1 Very important („must have“)

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

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

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

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

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

The assessment for the usability of the prototype was performed according to the following scheme:

1 ……. Very good usability

2 ……. Good usability

3 ……. Merely usable

4 ……. Not usable

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

3. General requirements for a (new) boarding assistance system (BAS)

3.1. Specific users' requirements

Table 1 describes the importance of offering a BAS to the different potential user groups based on the criteria described in deliverable 2.1.

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

User group	importance
Power wheel chairs	1
Manual 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. 1: 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; thus all the frame conditions for visual and hearing impaired must be considered.

3.2. Specific operators' requirements

The prototype system will be compared against the evaluation criteria and this comparison will define which criterion is fulfilled at which rate. The operators' assessment is based on satisfaction level based on their experiences as described in deliverable 2.1.

The criteria for a new BAS are specified in deliverable 2.1. It shows that the system must be standardized for most of the different types of vehicles in use. The operational time to run the BAS shall be reduced to a minimum in order not to delay dwell time. Furthermore, the BAS shall be stowed in the vehicle without limiting space (**Fehler! Verweisquelle konnte nicht gefunden werden.**). Moreover, the system shall be easily exchangeable in case of defects. Spare parts need to be available for the life cycle of the vehicles, which is about 35 years.

The findings of the survey in deliverable 2.1 clearly show that for operators providing regional, InterCity and long distance service; short and medium term investments are not economical. Therefore, a long term view is required which intends to provide a technical accessibility solution in order to improve the accessibility for all travellers.

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

- Reliability of BAS

  The BAS must work reliably, and in case of malfunction it must not influence the passenger-flow. In case of failure it must be ready to be operated manually. Since the BAS shall be a standardized solution for the whole of Europe it needs to be assured that the BAS will work under all (extreme) weather conditions such as snow, ice, gravel, heat, dust, water and rain to mention only a few. (Tab. 2)

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 case of breakdown	1
Vandalism protection	1

Tab. 2: Criteria for reliability and operational quality

- Operational quality

  The BAS should be operable independently and automatically. The customer should also be able to operate the BAS except when due to legal considerations (putting somebody at risk) it can only be operated by train personnel. (Tab. 3)

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. 3: 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 in danger.

- Costs

  The BAS needs to be almost 100% reliable. Low life-cycle cost and a long life cycle are also required. All costs for the required personnel and general costs (material etc.) for manufacturing, implementation and operation are valuated as “very important”. Only the effort for special personnel and special tools for maintenance is valuated as “important”.

- Manufacturing cost / installation

  In order to be able to produce the system at a low cost it must be standardized; which means it needs to fit in all the different vehicles and it needs to be able to be re-equipped and refurbished. Interference with static need and conversion work on the vehicle shall be reduced to a minimum in order to keep the stability around this vehicle area, transfer pressure, loads and pulling-forces to a minimum and not to make cuts in the wagon bearing structure in order to keep conformity of the wagon with regulations.

Effort and cost criteria	importance
Required personnel for operation	1
Required personnel for maintenance	2
Special technical tool required	2
Manufacturing costs (BAS price)*	1
Structure intervention costs	1
Maintenance costs	1
Cuts in the wagon bearing structure not necessary (conformity of the wagon structure preserved)	1

*Two BAS are needed, one for left another for right side of the wagon

Tab. 4: importance of following criteria: manufacturing, implementation, operation and maintenance

- Safety risk and warning devices

  The BAS has an influence on the homologation process of the vehicle. In order not to endanger passengers and to provide a safe operation for the customer, only trained personnel shall operate the BAS.

  The BAS must fulfil all relevant safety criteria, especially if the system should work automatically. E.g., fall protections, emergency stop, optical and acoustical safety features are “must haves” (Tab. 5). A surveillance system using an integrated, advanced sensor system shall contribute to the safe operation. Sonic and visual alarms need to avoid complications.

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. 5: safety criteria

* For automatic systems: 1

- Environmental – friendly

criteria	importance
energy consumption*	3*
recyclability	3

Tab. 6: sustainable criteria

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

- Design / aesthetics

  In general aesthetic is rated merely important. Based on the customers' request there should however be more focus on this subject (Tab. 7). The visibility of the BAS scores high though.

criteria	importance
aesthetics	3
visibility	2

Tab. 7: aesthetic criteria

3.3. General technical and operational requirements

The main technical and operational requirements and limitations are obtained on site or provided by the operator. This information is based on the work in deliverable 3.1. At this stage no assessment is made whether criteria are fulfilled or not. It will be done after testing the system in detail.

The BAS needs to work reliably, and in case of malfunction it must not influence passenger-flow; and it needs to be ready to operate manually in case of failure. As a standardized solution is going to be the goal, it also needs to be assured that the BAS will work in (extreme) weather conditions such as snow, ice, gravel, heat, dust, water and rain to mention only a few.

A standardized boarding assistance system needs to fulfil the following technical and value boundary (Tab. 8).

Frame condition	limit
Total duration → preparation, use, stowing	< 2 min
Station 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	2 persons, 2x75 kg
Relative angle platform-vehicle*	< ± 13,2% or 7,5°

Tab. 8: Technical and operational frame conditions

* transverse gradient of platform and super elevation of track

TSI-PRM[1] 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 details here).

3.4. Detailed technical requirements for a BAS for UIC wagons

As described below in the chapter “decision making process” the consortium decided to focus on a BAS that can be implemented into UIC wagons. Therefore, at this point all technical requirements that have been identified especially for the implementation into UIC wagons will be described in detail. This information is based on the work in deliverable 3.1.

Characteristic	Value	Comment
Carrying capacity	300kg	Covers 99% of wheelchair users, see chapter 2.2.4.7 of D3.1
Minimum clear width of lift	720mm	Covers 96% of

[1] TSI-PRM: Technical Specifications for Interoperability – persons with reduced mobility

Platform		wheelchair users, see chapter 2.2.4.7 of D3.1
Minimum platform length	1200mm	
Maximum working height difference vehicle floor-platform	1300mm	
Distance from the side of the coach when the lift platform is in lowered position:	as small as possible, but not less than 75 mm	The lowest foldable stair required to be lifted up before descending of the lift platform.
Boarding/alighting parallel to the vehicle	recommended	Alternatively, exit sideways through lay down of the side fenders (required for narrow platforms)
Handrail bound to the platform on one side, should be at the height of	650 to 1100mm from platform level	
Integrated folding seat for categories of users other than wheelchair users	Recommended	
Finger pressure for activation of control buttons	≤ 5N	
Manual force to operate the lift by staff	≤ 200N	For example for emergency mechanical activation.
Manual force to operate the lift by staff at movement start	≤ 250N	Allowed only for short period at the start. For example for emergency mechanical activation.
Vertical speed in the operation	≤ 0.15 m/s	Movement should be smooth
Operating speed variation: empty-maximum loaded	±10%	
Speed of any point of BAS without load	≤ 0.2 m/s	Up to 0,6m/s is allowed by EN 1756-2 only in the case where security measures (proximity sensors or similar) are present to recognize obstacles and stop the movement. To meet

		TSI PRM, maximum speed without load no more than 0,3m/s is recommended.
Acceleration during operation with load in any direction and at any point of the lift platform	≤0.3 g	
Tilting speed of the lift platform	≤ 4°/s	In case of automatic adaptation to the relative angle between vehicle and platform, for example at superelevated track by platforms in curves.
Automatic roll-off protection height	≥100mm	The barrier in front and at rear side of the wheelchair lift platform should be automatically erected during lift operation.
Lateral side guards height:	≥25mm min ≥50mm preferred	Prevention of the wheelchair side roll-off from the lift platform
End of travel mechanical limitation devices	yes	
Prevention of any unauthorized operation in the absence of the operator	yes	Locking and unlocking by a key or a code or similar.
Overload protection of the main power electrical circuit		Fuse, an overload cut-out or similar
In stowed position BAS must be safe against uncontrolled displacements. Mechanical securing devices dimensioning according to the accelerations:	$a_{longitudinal}$=5g $a_{lateral}$=1.5g $a_{vertical}$=1g	These accelerations can arise in the exceptional case of occasionally buffing impact at coach staying in yard (without passenger) (UIC 566)
Activation possible only at:	V = 0 km/h.	
Activation of the BAS should introduce activation of the coach brake system.	yes	Movement of the train during BAS usage must be prevented
Minimum safety coefficient against yield strength	2.1	
The lift platform surface should be smooth and must have slip-	yes	Slip resistance according to EN ISO

resistant surface		14122-2.
Easy removal of ice and snow must be possible	yes	
Gaps or holes in the platform area shall not accept a probe greater than:	15 mm diameter	
Illumination of the lift working zone	yes	
The warning devices should be fitted at edges that can come in contact with persons or injure passengers or personal.	yes	light / reflective stripes / reflective markings, visible at night also
Visual and audible warning signals during the lift movement must be activated	yes	
The operation control should be of type hold-to-run.	yes	Lift shall stop moving and remain motionless after the control is released.
Movement no more than 100mm for any part of the lift platform after release of the control is tolerable to slow lift down	yes	Mechanical drives with self-braking capability or with independent direct acting brakes, or hydraulic systems with normally closed valves etc. should be used.
Controls shall be designed to avoid unintentional lift actions.	yes	Recessed or covered buttons, two hand controls, etc.
One control position is recommended	yes	Conflicts of commands must be avoided
In any case of breakdown, it is acceptable that platform may decrease with controlled speed:	≤ 0,165 m / s	For example in hose or pipe failure by hydraulic systems or similar.
Safety devices shall preferably operate through active positive action.	yes	
A stop in overload protection should be present at overload more than	25%	
An emergency stop button within reach of the user should	yes	Release of the emergency stop

be present		button should only be possible by the personnel
Additional protecting measures such as obstacle detector, foot entrapment protection etc.	recommended	Although control of hold-to-run principle is used additional measures are recommended
During lift platform closing the risks of crushing or shearing of the arms or head must be avoided.	yes	Limitation of the closing force, security cut-off, etc.
Other technical details not covered in this table preferably should be based on:	TSI PRM, EN 1756-2, RVAR	

Tab. 9: applicability of a BAS in different vehicles

4. Decision making process

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

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

In the first step, current and future plans of the different railway systems over the whole of Europe have been analyzed in order to identify the biggest gaps. The result concerning which railway systems require the development of a new BAS is summarized in (Tab. 9).

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

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

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

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

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

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

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

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

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

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

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

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

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

A lift system under very limited frame condition means many restrictions and compromises. In regard to user requirements, wheelchair users are the only passengers for whom a technical solution is an absolute must. For many other groups it would be very nice to have some technical devices; but if there is no chance, than other solutions are acceptable. As

other solutions, special services at the entrance door are recommended within this project. There already exist good examples in different European countries which can be advanced.

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

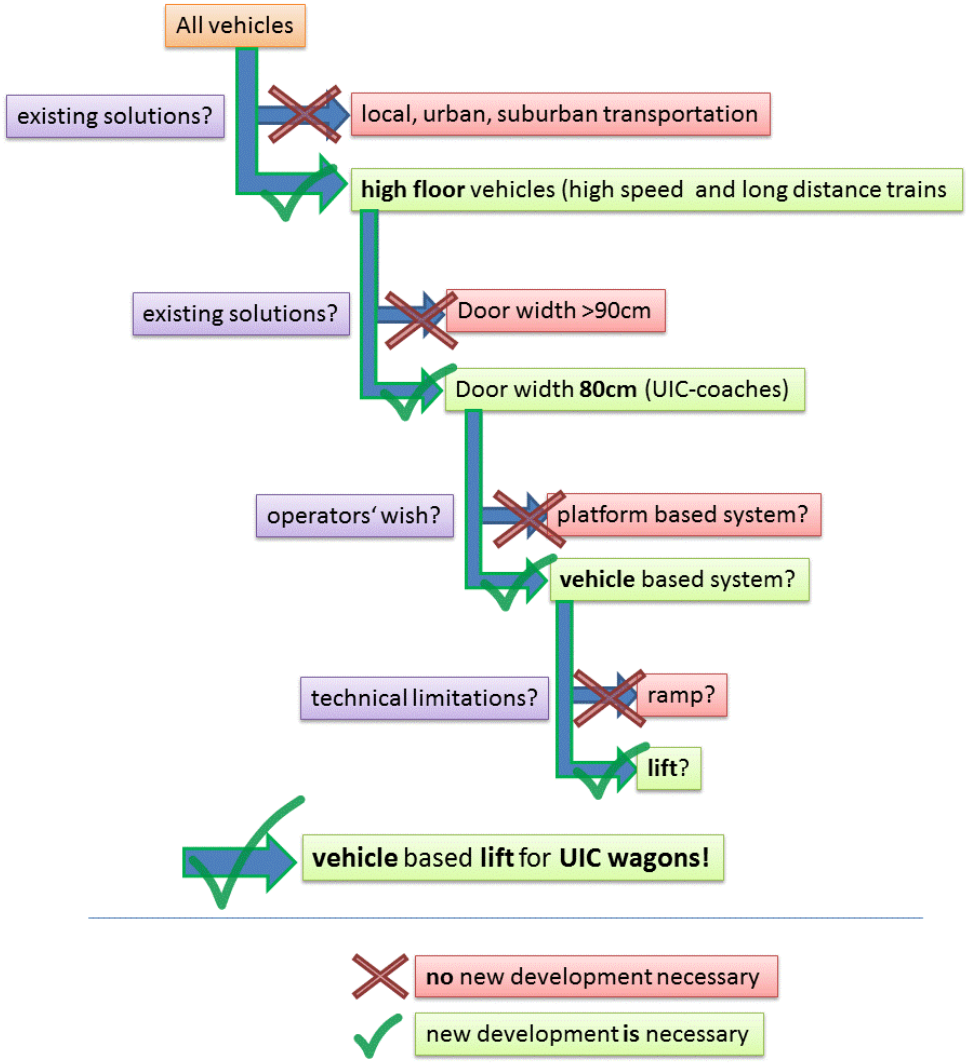

Figure 1: Decision making process

5. Conclusions

Providing accessible rail transport to all passengers is nowadays a must. This is because of different national and European regulations but also because of ethical questions. That means every person must be able to use a public means of transportation. In light of this, the entrance to railway vehicles and the whole boarding process is a big challenge and causes huge difficulties.

In order to be able to provide accessible boarding to all passengers, the consortium tried to define the biggest gaps that must be closed.

For mid and long term thinking the results can be summarized as follows: Because level boarding is in the process of being or will be offered soon for all types of local, urban and suburban traffic; no systems are required. At this point, only horizontal gaps need to be bridged. Therefore, enough technical solutions already exist. In the rare case that level boarding is not possible, existing technical solutions can be used.

For all high floor vehicles with an entrance door width of at least 90cm, enough technical solutions such as different lifts exist. A new development is neither meaningful nor necessary.

The intensive investigations of the consortium led to the result that for the huge number of UIC-wagons which are running and will be running within the next decades all over Europe no vehicle based BAS yet exists. There are too many design limitations.

Due to the fact that UIC-wagons will still form the backbone in many European railway networks within the next decades; it is absolutely necessary to develop a BAS for this operation.

Due to the different limitations resulting from the vehicle construction, it is also necessary to make several compromises. But the developed compromise allows about 99% of all actual wheel chair users to board a UIC-coach. In combination with a good personnel service at the entrance, which is also recommended in this project, the UIC wagons can also become accessible for nearly all passengers.

6. Publications

- *Referring to deliverable 4.4 publications are in preparation but not yet published.*

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