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Constructions of platform edges of urban transport in complex cases

Abstract: The work is a continuation of the first part of 2017, where the contribution to the development of the optimal solution of horizontal and vertical distance between the platform edge and the tram threshold in Wrocław was presented. The general argumentation for the development of collective rail transport in cities was described, and the basic features of an attractive public transport system were also discussed. The historical and ongoing works were collected focusing on the location of the wagon floor in relation to the platform, taking into account selected foreign regulations. Presented are solutions that can be used in Wrocław conditions, describing more complex cases, complementing the first part: the possibility of expanding the carbody above the platform edge, tram and bus platforms or stops for tram-trains. The principles of creating an example algorithm for the proper selection of the edge structure of the platform have been proposed. The paper concludes with a summary and conclusions for both parts of the work.

Keywords: Urban transport; Tramway; Platform; Tramway and bus stop

Introduction

Creating dedicated infrastructure for a given type of public transport (bus, tram, metro) becomes relatively easy, provided that appropriate standards are developed. These standards consist of several aspects and factors that are contributed by various stakeholders, hence the modifications of the guidelines are often observed when implementing subsequent investment tasks, or contradictory positions and needs. The classic antagonisms in urban mass transport include, among others:

- location of stops far/close to each other (transport management, acceleration of vehicle traffic/residents, elderly people, passengers with reduced mobility - PRM),
- creating closed/open tracks, especially green ones (transport management, to obtain an additional lane or the so-called life lane/inhabitants, users of neighboring buildings, to improve the vibroacoustic climate),
- purchase of small part/large part or completely low-floor vehicles (carrier, reduction of purchase costs/passengers, especially the elderly and PRM),
- construction and maintenance of platform edges with large/short distances to the vehicle sill (infrastructure manager, allowing very high wear and neglect of maintenance works/passengers, especially the elderly and PRM; profit on replacement of passengers and improvement of safety), etc.

The above partial statement shows that unless potential passengers receive support from agencies and institutions (e.g. the European Union), non-governmental organizations, or engineering associations, their postulates will probably be ignored and their needs will be neglected. This procedure ends with the currently observed retreat from the use of public transport, the most visible sign of which is the constantly growing number of car journeys, associated with the increasing number of cars per 1000 inhabitants, which at 571 has already exceeded the European average of 505 in Poland (data for 2016) [16].

The newly built urban transport networks, especially based on the French model, are characterized by very far-reaching attention to the needs of passengers. Regardless of the provisions of the act [21], practically all transport authorities determined more stringent values for vertical and horizontal gaps between the platform edges and vehicle sills, which most often fall within the range of 25-35mm [2]. The sizes of these gaps result from the conducted scientific research and consultations with the participation of interested parties, mainly the disabled, where, during tests on the model of a stop and a vehicle, the mutual position of which can be changed, an interview was collected among users regarding the ease of overcoming a given value of the gap [7]. Maintenance indications and recommendations for the network manager follow only from the values determined in this way. This is the opposite philosophy of conduct than that commonly used in Poland, where most often network managers establish large-scale gaps based on unlikely combinations of events and outdated regulations [17, 18, 25]. For example, in the guidelines of Tramwaje Śląskie [13], the assumption of a 50mm horizontal and 100mm vertical gap is dictated by the assumption that the following will occur simultaneously: maximum wear of wheels, rails, shock absorbers, the car will be heavily loaded, the door leaves will drop and the platform will be icy. Compared to the analogous national guidelines, the values adopted in the quoted document [13] do not stand out in a negative way.

The comparison of the French and Polish approaches proves the departure from various assumptions: in the French model, these will be the needs of as many passengers as possible, to whom the technical maintenance standards are adjusted, in the Polish model - passengers have to adapt to maintenance carelessness and the lack of standardization of the dimensions of cars and platforms, therefore, despite investments in infrastructure and purchases of new wagons in Poland, no qualitative improvement in boarding conditions is visible. I try to explain these differences with the fact that in France more often new infrastructure is built and new rolling stock is purchased, while in Poland the infrastructure of public transport is modernized to a large extent and multi-generation rolling stock is used. This translation seems inappropriate and controversial because there are positive patterns in overcoming the inconvenient situation in which Poland is currently located. For example, Switzerland, since the introduction of the law [21], has started a large-scale investment process, consisting in adapting the entire transport infrastructure of the country (including railways, trams, and buses) to uniform standards, which results in a wide-ranging modernization program based on detailed cantonal guidelines, e.g. [1, 11, 19]. Selected technical solutions are described below, which allow for the construction of a compromise, but safe and convenient for passengers infrastructure of stops, with emphasis on the modernization aspect.

Possibility of widening the vehicle body above the platform

The trams currently purchased in new networks most often have a box width of 2.65 m. This is an answer to several technical and operational issues:

– allows placing four seats in a row while maintaining the standard aisle width along the car,
– increases the capacity of the car and/or improves travel comfort,
– follows the trend of a continuous increase in the average height and average body weight of passengers.

Sometimes matching the platforms to the widened vehicle boxes is a long and costly process. There is, however, a compromise solution which, after adjusting the gauge on the route sections and interchanges, allows the use of the existing platforms, which in turn allows for a gradual, not sudden resignation from narrower wagons of previous generations. This solution is based on the observation of the human anatomy, which in the front view is much narrower from the feet to the knees than from the pelvis to the shoulders. Following this outline for a seated silhouette, the wagon body retains its former width (e.g. 2.30 or 2.40 m) at the platform height, smoothly widening to around the line of the lower edge of the windows, while as many seats as possible at the sides of the wagon. Examples of vehicles constructed in this way are shown in Figures **1 - 3**. Photo **1** shows the Vossloh 6N2 Tramlink, delivered to Rostock since 2014, the width of which increases from 2.30 to 2.65 m, and which is adapted to work with low platforms because its threshold is 290 mm above the railhead level [20]. Similar trams are to be delivered to Dresden: the prototype is to appear on the tracks already in 2020, and the series vehicles - from 2023.

1. Vossloh Tramlink 6N2 for Rostock, total width 2.65 m, at the platform height - 2.30 m, adapted to platforms 290 mm above the railhead level

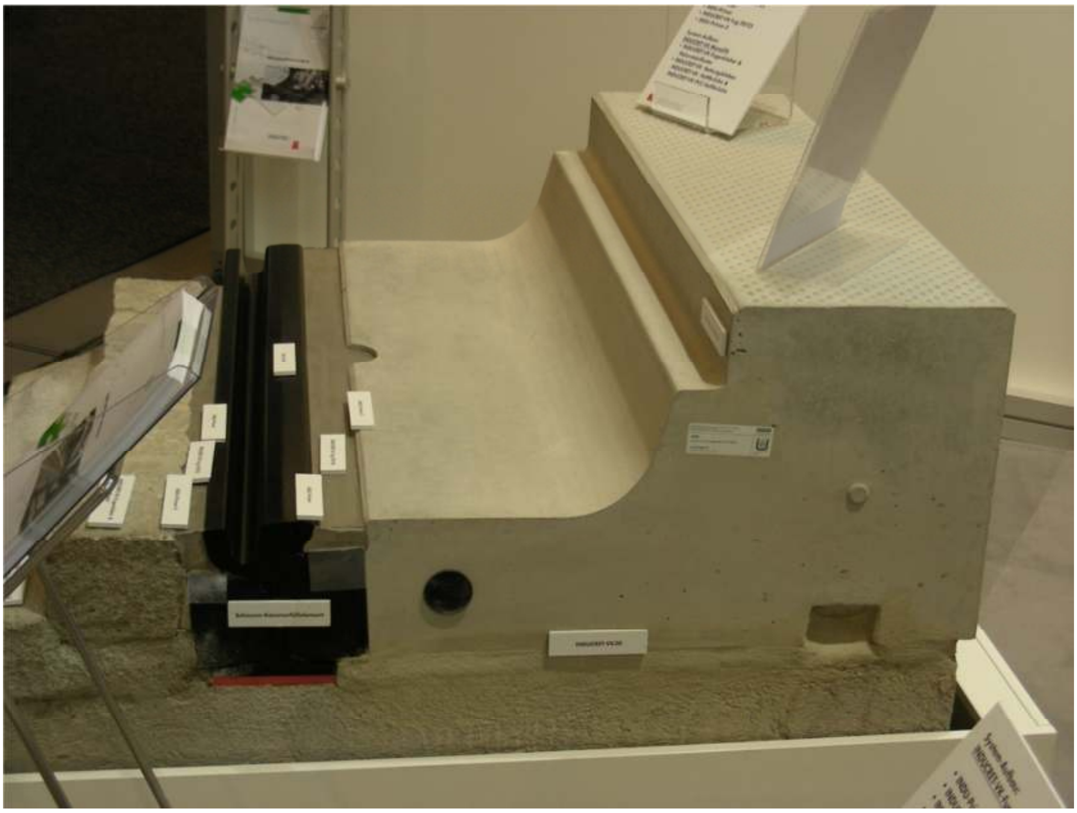
Photo **2** shows a view of the Vossloh Kiepe/HeiterBlick Vamos GTZ8-B from Bielefeld, running since 2011. Like Tramlink, it is adapted to platforms specific to 2.30 m wide trucks, but the maximum width of the box is 2.65 m [15]. The difference, however, is that the GTZ8-B is entirely high-floor, with an entrance height of 920mm above the railhead level, although access is also possible from low platforms, on four extendable steps, as shown in photo **3**. The solution described in the above examples is a compromise in terms of both rolling stock and infrastructure: a wagon is obtained with a slightly smaller floor area than indicated by the outline of the body, but the need to move platform edges away from the track axis is no longer required.

2. GTZ8-B Vamos city rail train for Bielefeld, total width 2.65 m, at platform height - 2.30 m, adapted to platforms 920 mm above the railhead level

3. View of the unfolded steps of the wagon described in figure **2**

Bus and combined platforms

The issue of building appropriate platform edges for trams was discussed in detail in the first part of the work. The general conclusion resulting from these considerations is that the conditions for the safe and comfortable boarding of passengers are met while maintaining appropriate, small values of the vertical and horizontal gaps. While in rail transport the vehicle path is highly repeatable and independent of the vehicle driver, in bus transport the driver is responsible for the correct, parallel, and possibly close to the edge placing the vehicle at the platform. The structures of platform edges have been known for some time, especially in the form of specially shaped prefabricates, which facilitate this task. In terms of differences in cross-section, they are divided into two main groups: oblique edges, the plane of which is in contact with the bus wheel is not vertical, but inclined towards the platform plane, and curved edges, in which the lower part is rounded, usually in the shape a quarter of a circle and a step receding the boarding edge from the edge of the prefabricated element by a few cms. An example of the second solution, adapted to the tram and bus platforms is shown in the photo **4**. In both cases, the specific shape of the leading edge is to enable the bus wheel to reach the platform tangentially, while preventing damage to the chassis or body at the stop. Even such a shape of the edge does not guarantee the correct use of the stop; the geometry of the entry and exit zones is also of great importance. Stops located along the sidewalk, or constituting islands near the bus lane or along the PAT, can be approached at a very small angle, thanks to which the lateral forces acting on the vehicle at the moment of contact with the platform are relatively small. Meanwhile, even placing the correct shape and height of the edge in a short stop bay will cause the approach angle to be very large.



4. Combibord - a combined prefabricated element for a tram and bus platform, allowing the bus wheel to reach the edge of the platform without damaging the car

Then the drivers, not wanting to be accused of damaging the vehicle, stop at a considerable horizontal distance from the edge, which completely eliminates the sense of using dedicated solutions. On the other hand, the issue of the height of the edge of the bus platform is simplified insofar as practically all today's vehicles are equipped with adjustable suspension, thanks to which they are able to perform a "kneeling" when changing passengers, consisting in lowering one side of the car. As a result, it is possible to adopt standard edge heights of 18, 21 or 24 cm [3], i.e. values smaller than considered convenient for trams.

Many stops within the network area are adapted to accept both trams and buses. The issue of the proper shaping of the platform edge and the selection of its height, discussed in the previous chapter, becomes more complicated. The analysis of European trends leads to the conclusion that two groups of solutions are used here. The first of them are platforms with a compromise height. Since they are most often built according to the bus standard, they turn out to be too low for convenient access to the tram by about 8-10 cm. Only recent Swiss proposals [1, 11, 12, 19] indicate that the problem is solved by an edge with a height of 28 cm above the railhead level. For a tram with a threshold height of 300mm, the difference is only 20mm, and buses at these stops are not to lower the suspension. Examples of structures built according to these guidelines are already in use, but for too short a time to speak of binding conclusions. The second group of solutions are platforms in which the stopping points of the tram and bus are separate, but connected by a ramp or the width of the platform into one whole, then the edge heights fit closely to the floor in the vehicle. An example of such a solution is shown in photo **5**, where a short bus lane has been created within the tram stop.

5. Kassel, Leipzigerplatz - example of adjacent, independent platform edges for a bus (in the center of the photo) and a tram (not visible, on the left)

Designs in which the bus travels along the same track along the platform are more common, only stops at the beginning or end of a stop with a slightly lowered edge. These solutions also include such spatial arrangements in which trams stop at one edge of the two-edge platform, and buses stop at the other. The difference in height may be compensated by the inclined arrangement of the platform plane or the difference of the grade line of the track and the roadway. An example of a set of two-edge platforms, constituting the central transfer junction in Gera, is shown in photo **6**. A special feature of the node is the left-hand traffic of buses, excluding other road traffic, which may be confusing for people unfamiliar with the specificity of the system.

6. Gera, Heinirichstrasse - interchange junction with left-hand bus traffic, so that transfers between buses and trams take place across the width of the platform

Platforms for double-system trams

The selection of the correct positioning of the platform edge for a double-system tram largely depends on the adopted model, e.g. mixed traffic, separated in time, or taking the line exclusively. Possible options are described, among others in [14], however, as a consequence, they boil down to adopting one of the typical solutions, as long as there is only one traffic model in a given network. After a period of quite dynamic development after 2000, there are currently no plans to build new double-system trams, while the existing systems are consistently expanded. A network not far from Poland, where the second cooperation model has recently been introduced, is the tram in Chemnitz. The newest rolling stock acquisitions, Citylink wagons from 2016, are equipped for better cooperation with various platforms, with doors with a threshold height of 405 and 570 mm above the railhead level [23]. Thanks to this, the carriages work well with the standard, medium-sized railway platform with a height of 55 cm by simply sliding the horizontal threshold, but the introduction of new cars to the city tracks forced changes within the tram stops. Some of them have been rebuilt to combine two different heights: along one edge, with the use of dedicated concrete prefabricates [24]. Variobord and Variobord S elements can create spatially complex systems, allowing for additional bus traffic, integrating guide strips for the visually impaired and the blind, the so-called tiles with knobs or transition profiles to a zero-height curb at a pedestrian crossing Typical edge heights in the system are 240 and 380mm as shown in Figure **7**.

7. Stadler Citylink trams at the Stadlerplatz stop in Chemnitz. Visible use of two Variobord heights

Stops construction algorithm

In countries where the safety and comfort of passengers is a high priority, municipal infrastructure boards do not assign to designers and contractors of renovation, modernization, or construction of new sections the task of standardizing the rules for building and equipping public transport stops. In many cases, apart from the indication of the desired and allowable gaps between the vehicle and the platform described in the previous chapters, they more or less explicitly indicate the correct algorithm for obtaining the best solution in a given spatial situation. Variant considerations are such issues as:

– whether the street with tram tracks is one-way or two-way,
– whether the track is located along the road axis or next to the road,
– is there enough space for a classic stop island in the street view, or is a Viennese stop, a stop with a raised boarding lane, or an anti-gulf available?,
– whether it is justified to use a two-edge platform, assuming that only two-way trams run,
– whether the stop is located on a curve, considering the situations of concave and convex platforms and completely or partially along the curve of the track,
– whether due to the small width of the platform it will be possible to equip the shelter with sidewalls, and the stop with seats,
– whether the stop can maintain the correct height along its entire length, or only partially, due to the height correlation of the sidewalk with the platform and the roadway,
– where it should be located and what dimensions should the space on the platform be free from obstacles, to enable free access to vehicles for passengers with reduced mobility [4, 5].

Most often, the starting point is to achieve a full-length platform with a height adapted to the vehicle, situated on a straight line, and any deviation from this assumption is treated as a compromise and must be properly justified. These concessions tend to be arranged in a specific order, which determines the degree to which they are distant from the assumed optimal solution. It seems that, especially in Polish conditions, with the great freedom and variability of standards for the construction and equipment of stops, the introduction of similar algorithms would bring positive results.

Summary and conclusions

Both international organizations, governments, and citizens are increasingly aware of the fact that road transport contributes to the premature death of thousands of people each year, poses a significant burden on the environment, and is associated with a significant amount of the so-called external costs. In connection with the fact that around half of humanity lives in urban areas and that the mobility of societies continues to increase, it becomes imperative to effectively develop efficient, ecological means of transport and look for further alternatives. Unfavorable trends are aggravated by various kinds of external phenomena; for example, in Poland, one of the factors with the strongest impact on the load on transport networks is spatial chaos, manifested by the emergence of new housing estates on cheap but randomly located land, instead of more intensive use of areas already served by public transport and equipped with media.

In times of calling for the dynamic development of electromobility, it is often forgotten that we have known very efficient forms of urban electric transport for decades. These are mainly trams, various types of railways, including city railways, and trolleybuses. They are primarily characterized by high reliability and efficiency, which is the result of long-term, evolutionary development. Regardless of the geographic location, all cities leading in the world rankings of "most living places" are characterized by a well-functioning, developed system of electric mass transport. Interestingly, the presence of the metro is not a necessary condition in this ranking. Polish cities also have a chance to get higher and higher positions in similar rankings, mainly under the conditions of improving spatial development and public transport, because other important factors, such as education, health care, culture, and greenery, remain at a decent level. It is very important that the quality of the offered transport services is kept at such a high level that passengers voluntarily give up traveling by car in favor of public transport.

The key ways by which a significant improvement can be achieved in this field are the best possible interplay between infrastructure and vehicles, high availability of infrastructure, minimization of wasted time when changing passengers and waiting for an enabling signal, high commercial speed and broadly understood travel comfort. It should be expected that as part of the improvement of the aforementioned factors, the outlays for maintenance and upkeep will noticeably increase, which in the long term will bring significant profits and benefits, including financial savings. For this purpose, it will be necessary to shift the investment and management model from the reasoning according to the criterion of "100% purchase price" to the comprehensive method of assessing the cost of purchase, operation and removal of a given structure, the so-called Life Cycle Cost (LCC), about which more and more foreign and domestic jobs are created, for example [8].

Technical measures that provide passengers with reduced mobility with autonomous access to public transport are being implemented particularly intensively in developed Western countries. Contrary to popular opinion, they do not only concern new infrastructure, which is particularly evident in the example of France [10] but also focus on the modernization and adaptation of the existing infrastructure, as in Switzerland. Especially the latter example can be a role model for Poland. Unfortunately, while Switzerland has launched an effective legislative procedure at the central and local levels, in Poland the main obstacle to any changes is outdated, inadequate to today's situation and inconsistent regulations, including [25]. Without far-reaching changes in this respect, it is difficult to expect that the quality of domestic investments will be equal to that of foreign ones, despite considerable financial outlays.

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