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Modeling the accessibility of public transport to people with disabilities in the GTFS standard

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In this paper, the possibility of using the GTFS standard to describe the public transport (PT) stop infrastructure in Poland, was evaluated. It was also proposed to expand the existing GTFS file of the ZTM (PT authority) in Poznań to include a detailed description of a selected two-level tram stop. A testbed equipped with open source software was built and used for this purpose. The study showed that despite the fact that in Poland, PT organizers and operators do not provide detailed information on its accessibility to people with disabilities, the preparation of such information is possible, while modifications to the data generated so far may be required, especially regarding the stops. However, the preparation and updating of this data on a nationwide scale may pose a problem.

1. Introduction

1.1. The importance of passenger information to people with disabilities

Passenger information is a vital component of public transport (PT) systems. Its ease of use, including its legibility, affects the ability to use PT, both at the trip planning stage as well as during trips. As a result, good accessibility to passenger information can increase the perceived attractiveness of a PT system, while lack of access is a detrimental factor that can lead to transport related social exclusion, see eg. [1, 6, 7, 18–20, 22, 23].

People with disabilities or other special needs (e.g. those who travel with heavy, large hand luggage) are a group for whom accessibility to digital passenger information is of particular importance [15]. At the same time, this group is internally very diverse, as there are many types of disabilities, in many cases conjugated, which impose different types of limitations related to the ability to move or obtain and process information necessary to travel [3, 17]. As a result, people with disabilities may need to use dedicated travel planners (see eg. [5]) that should be compatible with other devices used by these people [4]. The information needs regarding these planners may be different from those of general-purpose planners. Hence, it is important for organizers and carriers to make data available in open standards, as this facilitates the use of solutions best suited to people with disabilities.

There are two main open PT information exchange standards that enable users to model key information relevant to people with disabilities – the General Transit Feed Specification (GTFS) and Network Timetable Exchange (NeTEx). The differences of these standards' approach to modeling accessibility to people with disabilities are presented in paper [2]. This paper focuses specifically on the GTFS standard.

1.2. The features of the GTFS standard in terms of describing the accessibility of PT system to people with disabilities

The static version of the GTFS standard [10] assumes that the data are stored in text files, that are tables, interrelated by key fields. All files describing a given PT system are packed into a single zip archive. Table 1 shows the advantages and disadvantages of using this standard. One of its most important features is its flexibility. As a result, stake-

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holders can develop it independently and adjust the level of detail in the description of the PT system to suit their own needs. At the same time, this variation can vary within the dataset itself, i.e. it is possible, for instance, to describe some parts of the system with greater detail than others. Unfortunately, this flexibility might also cause compatibility issues between different IT systems using the standard, especially if one goes beyond the officially approved parts of the specification (that is being continuously developed).

Table 1. Advantages and disadvantages of using GTFS

Advantages	Disadvantages
Popular and versatile: – worldwide deployments – supported by many IT solution providers, including popular travel planners – turnkey open source solutions can reduce the implementation cost	The EU promotes NeTEx: – but there is potential for conversion between standards (within their data modeling capabilities)
Flexible: – may be developed/customized independently – the level of description can be adjusted to meet modeling needs, including differentiation within a single dataset	Flexible: – cross-compatibility problems between different solutions – "GTFS support" does not necessarily mean full support for people with disabilities
Easy to use: – low entry threshold; for small sets, data can be prepared using basic office software (spreadsheet, notepad)	Directed at presenting the timetable to passengers: – potentially problematic communication between other entities participating in the pt system
Open: – no user fees	Universal: – modeling features may include structures that are not provided for or banned in a country's regulatory framework

GTFS specification [10] analysis points to several possible levels of accessibility descriptions of the PT system to people with disabilities:

1. basic
2. advanced
3. extended – proposals of changes in the specification
4. independent expansions.

The basic level of accessibility description consists of the wheelchair_accessible fields in the trips.txt file and wheelchair_boarding in the stops.txt file. These fields can be used to indicate whether a given route is served by a vehicle adapted for people with reduced mobility and whether a given stop is adapted for people with such disabilities. The classification itself should be based on the rules adopted by the organization. In addition, there is a tts_stops_name field in the stops.txt file, where the name of a given stop can be stored for text-to-speech readers.

The advanced level of accessibility description provides a more detailed description of stations and complex interchanges. For this purpose, the stops.txt file is expanded, which, in addition to information on the location of stop posts, includes information on other points, such as station entrances and generic points that allow modeling the path to the stop. The parameters of paths, such as their type (e.g., stairs, elevator) and attributes (number of steps, path name on signposts), are described in the pathways.txt file. In addition, the levels.txt file can be used, which indicates the level at which the point is located, such as –1/0/1.

The proposed changes to the GTFS specification range from extensions of the description at an advanced level, such as the addition of facilities like a ticket machine or information point, to the addition of other categories of information that are relevant to people with disabilities. These could include rules for accessing the service (GTFS eligibility), detailed descriptions of vehicles (GTFS vehicles), or the service provider's ability to offer assistance to people with disabilities – e.g., in-vehicle only or "door-to-door" (GTFS capabilities).

Independent extensions include, for example, GTFS+, developed by the Metropolitan Transportation Commission for the San Francisco Bay Area, which allows stops to be described not only in terms of accessibility to people with limited mobility, but also to people with visual or hearing impairments. Another extension is the Extended GTFS Route Types, which provides more options for describing the nature of service on a given line, including, for example, the mobility service for people with disabilities, i.e. Special Needs Service or Mobility Bus for Registered Disabled.

In addition, an extension GTFS-PathwayUpdates is provided, which allows real-time notification of accessibility changes, such as elevator failures.

1.3. Coverage of digital passenger information including PT accessibility data for people with disabilities in Poland

An analysis of open GTFS sets available in Poland conducted in the work [24] indicated that only 14 of them contained basic information on accessibility to people with disabilities. Only two of them included information on both vehicle and bus stop accessibility. A study [2] of nationwide databases that contained information on bus stops, namely the Topographic Objects Database (BDOT10k) and OpenStreetMap (OSM), indicated that only 0.7‰ included any accessibility information.

The authors of the present study extended these analyses to regional databases of PT stops and other sources. Analyses of databases from the Lower Silesian, Lesser Poland, Świętokrzyskie and Greater Poland

provinces also indicated a lack of acquisition of accessibility data. This information was however widely available on PortalPasażera [12] (PassengerPortal) operated by PKP PLK (Polish railway infrastructure manager). The site provided both static information about accessibility and temporary changes to it in the form of a verbal description in three language versions. However, this information rarely appeared elsewhere. In the case of trip planners, the authors managed to find it only on the Bilkom service [8] (one of Polish trip planning services developed by PKP Informatyka). The access to the aforementioned data was possible only for the largest train stations and was achieved by navigating to the PKP portal [13], available only in Polish language version, where one had to additionally click on the "see facilities..." option. As a result, people with disabilities may find it difficult to obtain such information, especially if they have more confidence in other IT solutions for trip planning.

Data describing accessibility for people with disabilities is also sometimes available in various studies, such as [16]. However, it is very inconvenient to use this kind of reports to plan daily trips.

1.4. Purpose and scope of work

The purpose of this paper is to assess the feasibility of using the GTFS standard at an advanced level to describe the tram stop infrastructure of Poznan's public transport system. At the time of writing, the city's GTFS file contained only basic information on vehicle availability.

2. Materials and methods

The GTFS file for analysis and modification was downloaded from the organizer's website, i.e. ZTM Poznan [14]. The authors proposed a six-step procedure to expand it with an advanced description of accessibility, i.e.:

1. Expanding the structure of the stops.txt file.
2. Initial creation and completion of pathways.txt and levels.txt files.
3. Construction of the graph model of the station or node.
4. Adding new points in the stops.txt file.
5. Defining the parameters of paths connecting points within a station or node.
6. Preparing the pathways.txt file and exporting the results.

It was assumed that only open source software would be used at each stage. Hence, the workstation was equipped with GIS software (QGIS), a notepad (Notepad++) and a spreadsheet (LibreOffice Calc). A dedicated GTFS station builder tool [9] was also used, to create pathways.txt files.

3. Results and discussion

In the first step, the structure of the stops.txt file was expanded. The source GTFS file did not contain a location_type field. It was added, and then each object that was originally in the dataset was given a value of 0 (a stop or platform type object). These objects had to be assigned parent_stations that group together the stops or platforms. In the case of the analyzed source, this was most easily accomplished by using the data contained in the stop_code field, where a post in a stop group was identified using a string. A stop group was defined by a string of 2 to 6 characters, and then two digits denoted a specific stop. It is worth mentioning that this approach ensured the correctness of the grouping in the case analyzed which also could be done using a spreadsheet. However, this is not a universal approach, as not every GTFS source can use the stop_code field in this way. Due to optional nature of this field, there may be sources that do not use it at all. In such situations, other clustering approaches may be considered, such as those based on the similarity of stop names or mutual distribution in space, i.e. using the DBSCAN (Density-based spatial clustering of applications with noise) algorithm, for example.

After assigning stops to groups, their centers of gravity were determined using GIS tools, which constituted new objects – parent stations (location_type = 1).

In the second step, pathways.txt and levels.txt files were initially created. In the former case, it was just defining the fields according to the GTFS specification. In the case of levels.txt, typical traffic levels were added. In this one, an additional level "unk" (unknown, presumably 0 – on the surface) was added, which was initially assigned to all objects in stops.txt.

The next step was to build a graph model. For the purpose of this work, the example of the two-level tram stop "Piaśnicka/Rynek" in Poznań was used (see Fig. 1–3). In the case of this location, tram traffic runs in two directions on level –1 (underground). In contrast, all 6 entrances to the stop are located on level 0 (on the surface). 4 entrances are stairs, and 2 are elevators. It is impossible to change the direction of movement (transition between platforms) on level –1 – each time the level must be changed.

The stop itself was modeled as a graph with 12 vertices and 17 edges (see Fig. 5). Four of these were generic nodes, which divided the routes between the entrances and the platform into a staircase section and a flat section. It should be noted that this is not the only possible way of modeling. It can be both less accurate (no use of generic points, and therefore no division of the section) and more accurate (separate

modeling of each section of stairs, an example of which is also shown in Fig. 5).

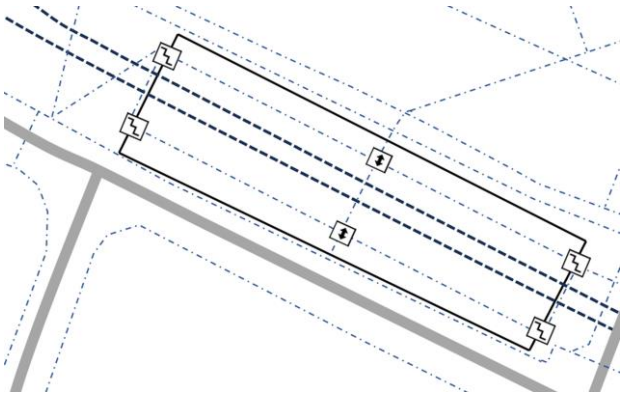

Fig. 1. A diagram of Piaśnicka/Rynek tram stop. Source: own work based on OSM [11]

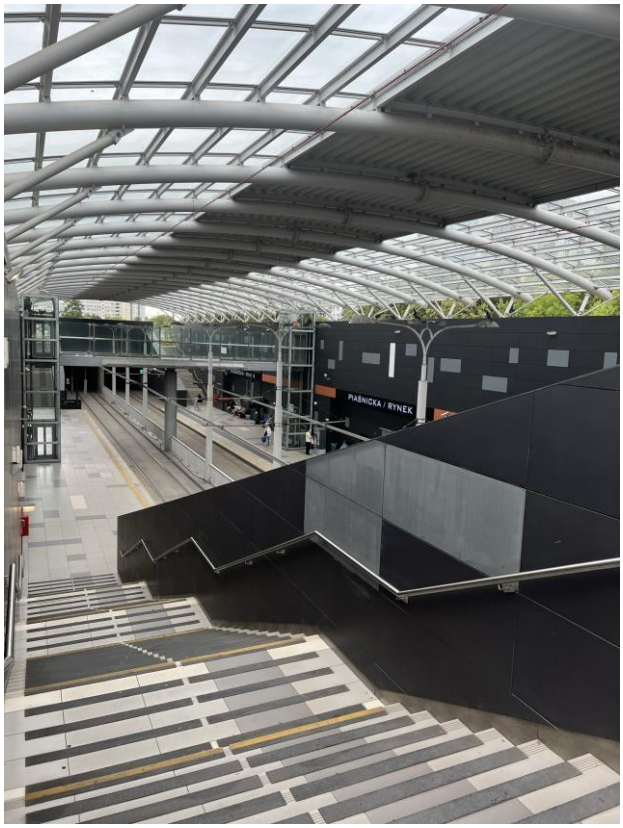

Fig. 2. Interior view of the Piaśnicka/Rynek tram stop

The fifth stage involved a physical inventory of the stop, including counting the number of steps, assessing the directionality of the pathways, measuring their widths and lengths and elevator travel times, and recording the names of the entrances. This allowed, in step six, the final preparation of the pathways.txt file in the GTFS station builder tool (see Fig. 6). The results were evaluated manually, and positively tested with the GTFS validator.

Fig. 3. An example of marking the entrance to the Piaśnicka/ Rynek tram stop

In the fourth step, new objects were added to the stops.txt file using the QGIS tool (see Fig. 4).

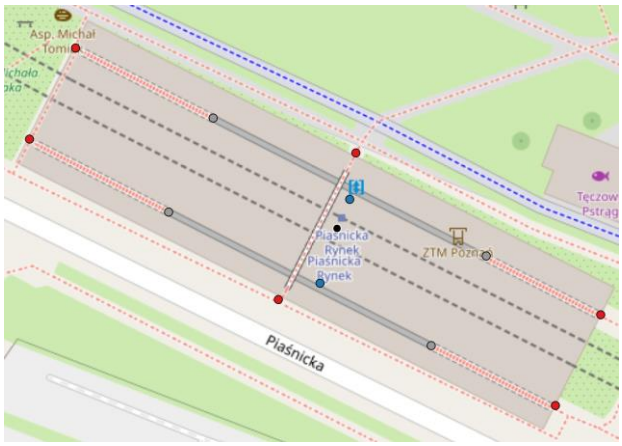

Fig. 4. The effect of adding extra points to stops.txt for the Piaśnicka/Rynek stop. Point color: black – station; blue – platforms; red – entrances; gray – generic nodes. Source of the map layer: OSM [11]

4. Conclusions

The analysis showed that it is possible to add information regarding the accessibility to people with disabilities at an advanced level for the Poznan GTFS set. However, from the information obtained from ZTM Poznań, it appears that implementing such a level of accessibility to the officially published GTFS files requires changes to the IT solutions currently used by the organization. It should be noted that the solution prepared by the authors may no longer work when any changes are made to the stops.txt file (e.g. a new stop is added). Moreover, GTFS station builder did not export the stop_code field, which was actively used in GTFS ZTM Poznań, which would also require some programming work.

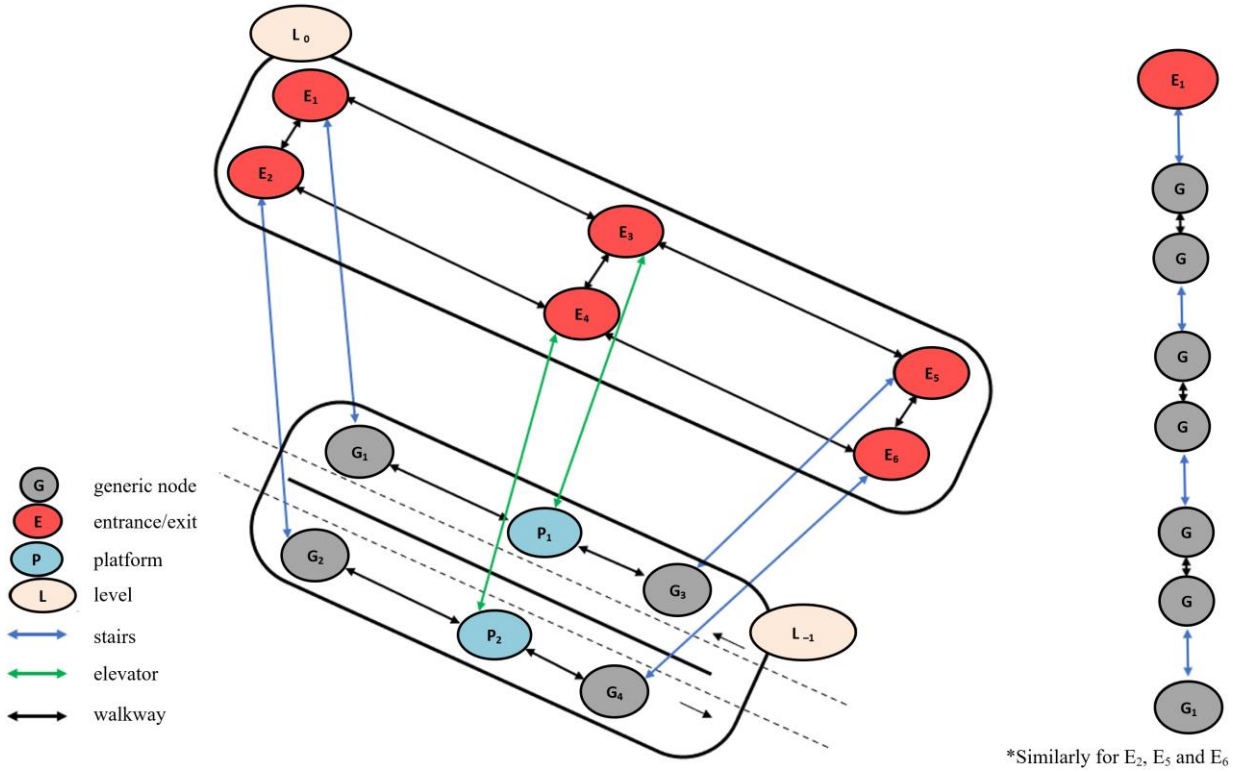

Fig. 5. A graph model of the Piaśnicka/Rynek stop. An example of a detailed description of one of the entrances is shown on the right.

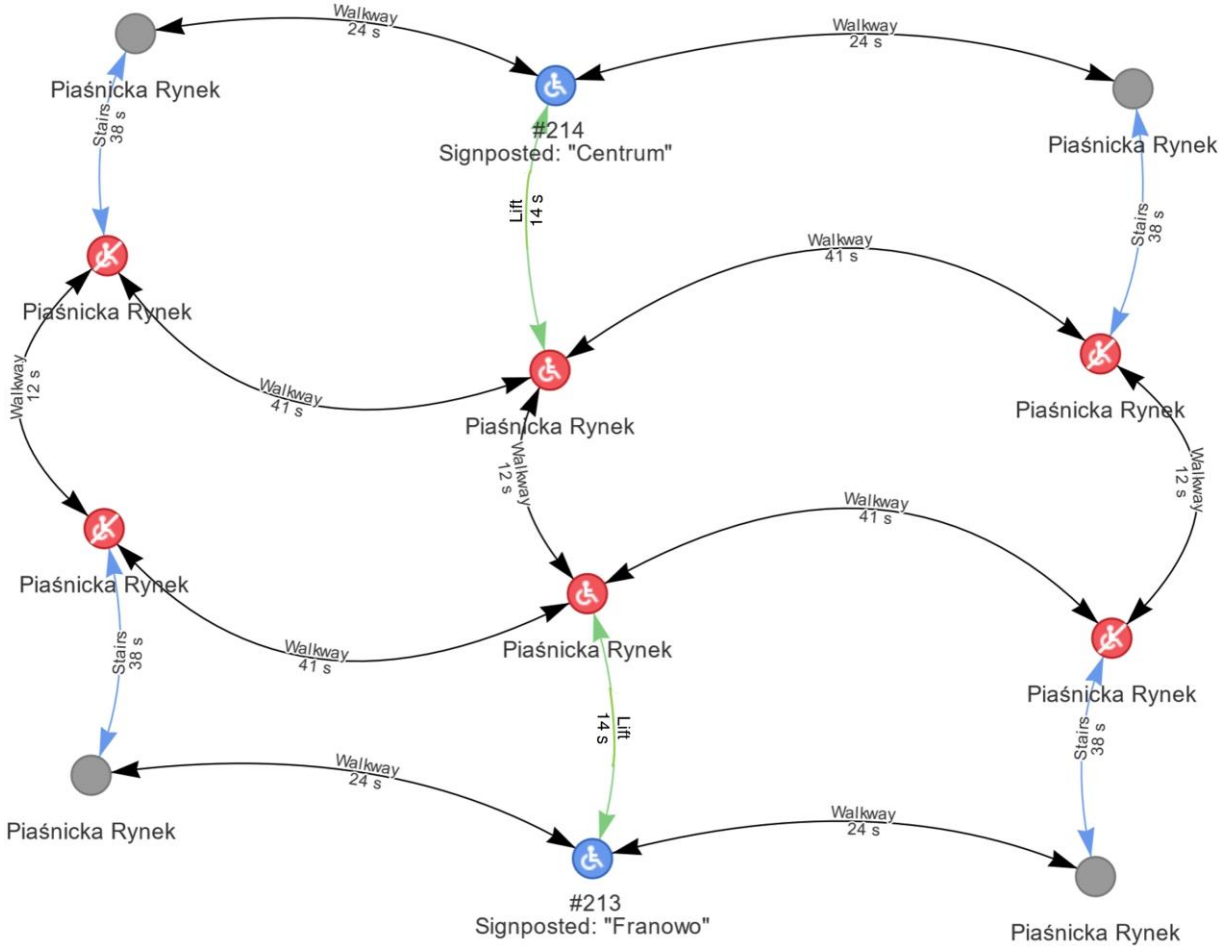

Fig. 6. A screenshot from GTFS Station Builder [9] with a model of the Piaśnicka/Rynek stop

The third stage raised the issue of modeling accuracy. It should conform to an accepted standard and, on the one hand, meet the needs of people with disabilities, and on the other hand, make modeling as simple as possible. In the latter case, it may be helpful to use Building Information Modeling (BIM) design documentation, if it is available for the site. In the literature, there are known cases of graph construction and travel planning based on such acquired data, cf. e.g. [21]. However, it would be necessary to conduct relevant studies strictly pertaining to transportation infrastructure facilities. The development of tools to convert data from BIM to GTFS may also be required. Alternatively, one could consider using data from the OSM portal [11] where, for some facilities, information on entrances or internal paths is also available.

The issue of accuracy in modeling accessibility for people with disabilities is also important on a national scale. Nationwide data sets, which were available at the time of preparing this work, contained only minimal information on this topic. The issues that need to be resolved are the definition of modeling standards, as well as the rules for updating these data and the sources of financing for inventory works. It should be noted that this data should be open and easily portable to both GTFS and NeTEx standards to maximize accessibility for people with disabilities.

In the case considered in this paper, the indication of such facilities as a ticket machine or information point was abandoned as was the use of other proposals for extensions to the standard. At the time the paper was prepared, the GTFS station builder tool did not support these extensions. Popular travel planners would also have a problem with this data. So the advantage of having the additional data immediately taken into account by the tools using them would be eliminated in this way. This raises the issue of what should come first – the data made available or the availability of travel planners. According to the authors, solving this issue requires further research work, and both directions have potential. The current lack of data accessibility in Poland means that travel planners dedicated to people with disabilities may not be widely used. However, one might assume that making data more widely available will increase the demand for solutions that use it. However, one risk is that some groups of people with disabilities are too few in number to make it commercially viable to build solutions for them, even on a nationwide scale. Government intervention, such as grants or the establishment of an organizational unit responsible for filling such niches, may be appropriate in these cases. In order to reduce costs, investment in the development of open source solutions could be considered here, so that a common route-finding engine tailored to the needs of a particular disability in different solutions could be maintained. Similarly, research should be conducted regarding the extent of data necessary for a complete yet relatively simple description of the public transport system from the perspective of each type of disability and their combination. Again, measures may be required to support and standardize the acquisition of information on a nationwide basis, including the expected level of modeling detail. Hence, for example further research work should also be conducted on assessing the reasons for the poor propagation of accessibility data for people with disabilities found in the PortalPasażera. The reason for this could be both insufficient openness of this data and the previously mentioned possibility that other IT developers are not interested in better serving this customer group due to economic unprofitability.

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