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Analysis of the concept of an accessibility map for people with disabilities for the integrated transfer hub

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Abstract: Transportation accessibility for people with disabilities is the challenge of our time. In Poland, there are more than 3 million people with disabilities who have legal proof of disability. There are many more - from 4 to as many as 7 million. Thus, there is a need to actively include this group of people in social life, including in public transportation. This work presents issues related to the accessibility of integrated interchanges for people with special needs. The work also points to a key problem for transport system managers associated with the aggregation of knowledge necessary to implement the changes in transport infrastructure. Information about the needs of people with disabilities is, in turn, a prerequisite for proper universal design, which is already becoming noticeable in many areas of social and economic life. As technology evolves, so do the methods of obtaining information about the needs of people with disabilities. The difficulty here, however, is to develop tools that consider the degree of disability of the specific people from whom we would like to obtain information. The authors in the paper justify, on the one hand, measures that aim to eliminate the difficulties that a person with special needs may encounter when traveling by various means of transportation, and on the other hand, point to specific solutions and tools that are used to acquire knowledge that will consequently allow the precise adaptation of the current infrastructure to the needs precisely defined by these people. The aggregation of knowledge also has additional significance in increasing transportation accessibility for people with disabilities. It enables the informed design of new facilities and supporting infrastructure to consider the changing needs of people with disabilities.

Keywords: transport, disability, transfer hub, facilitation

1. Introduction

Disability is a limitation or lack of ability to perform activities in a manner or to the extent considered normal for a human being, resulting from damage and impairment of

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bodily functions. This definition was adopted in 1980 by the World Health Organization (WHO). The term "disability" is often used interchangeably with the term "invalidity". However, the scopes of the two concepts do not fully overlap, and disability is a broader concept that includes the activity aspect of life [17].

According to the WHO, people with disabilities are considered to be those who cannot independently, partially, or completely provide opportunities for average individual and social life as a result of congenital or acquired impairment of physical or mental faculties. The division of the effects of the disease into damage, incapacity, and limitation in roles has been adopted [2]. Damage refers to abnormalities in the structure and appearance of the body and the function of organs or systems, regardless of the cause; thus, it means a disorder at the organ level. Incapacity reflects the effects of damage on the performance of a person's activities and actions. On the other hand, role limitations are the consequences of damage and incapacity that affect interpersonal interactions and adaptation to the environment. [14]

Still, the term disability is not ideal, but no better term has been found so far. The term replaces many previously accepted terms, such as handicap, impairment, and infirmity, which have acquired a pejorative meaning. [21]

Until now, disability, as a consequence of illness or injury, was considered from a medical point of view. It was seen as an individual problem of a person requiring appropriate medical care to improve the health and functional state of the body [11]. Psychosocial aspects involving real-life situations of people with disabilities, such as removing barriers that limit their ability to participate in society, have not yet been fully addressed. These issues require changing social attitudes and respect for human rights [5].

Disability issues were also addressed in 1994 by the European Parliament's European Disability Forum, which defined a disabled person as "an individual in the fullness of their rights, who is in a situation that handicaps them as a result of environmental, economic and social barriers which, because of the impairments present in him, he cannot overcome in the same way as other people. These barriers are too often reinforced by depreciatory attitudes on the part of society" [1].

The International Classification of Disability (ICF) promulgated by WHO 2001 adopts a holistic model of disability, combining medical and social models. It encompasses the interrelationships between damage, limitation of activity, and impediment or limitation of participation in social life, determined by personal and environmental factors [3].

A person with a disability is thus viewed not only as an individual with medical problems requiring appropriate medical care but as a community member whose human rights apply to the same extent as the rest of society [25]. For this reason, numerous measures are being taken to ensure that people with special needs have access to public transportation and transportation infrastructure.

2. Purpose and scope of the study conducted

The article presents an analysis of accessibility to information about transportation infrastructure. It identifies examples of tools for people with disabilities to communicate with and report their needs to the transportation infrastructure manager. A disability is a limitation or lack of ability to perform activities in a manner or to the extent considered

normal for a human being, resulting from damage and impairment of bodily functions gps [20]. The analysis was performed for selected hubs divided by geographic coverage into international, national, regional, metropolitan, and local. A detailed description of this division is included in Table 1.

Table 1. Integrated transfer hubs by geographic coverage (source: own study)

Type of hubs	Description
International hub	A hub that handles significant domestic traffic with consideration of international traffic, enabling multimodal integration (bus transport, rail transport, urban transport, air transport).
Domestic hub	It covers a significant area of the province or neighboring provinces, enabling multimodal integration (bus transport, rail transport, air transport, urban transport). In some cases, they also handle a certain amount of international transportation.
Regional hub	It covers several counties (mainly neighboring counties) and allows the integration of rail, regional buses, city buses, and individual transport. In some cases, they also operate a certain amount of domestic transportation.
Metropolitan hub	Operates at least two lines commuting passengers from another municipality and at least 2,000 passengers per day, allowing integration of rail transportation with bus transportation or individual transportation or regional bus transportation with personal transportation; One line carrying passengers from another municipality and at least 1,000 passengers commuting by particular transport from another city; The infrastructure of the interchange consists of a railroad station or stop, a bus and streetcar station or stop, car parking and bicycle parking. These elements should be linked to each other and the external system by as short and efficient sections of roadways, bicycle routes, and sidewalks as possible.
Local hub	It covers most of the surrounding municipalities and allows the integration of rail transport with bus transport and individual or regional bus transport with personal transportation.

The article primarily aims to show the impact of creating awareness of the need to consider universal transportation infrastructure design on the ability of people with special needs to use transportation. Table 2 shows a sample analysis of the integrated transfer hub audit performed.

Using an empirical study of selected transportation infrastructure, the authors assess its accessibility for people with disabilities. As defined in Article 2 of the "Convention on the Rights of Persons with Disabilities", universal design should be understood as the creation of products, environments, programs, and services to be usable by all to the greatest extent possible, without the need for adaptation or specialized design. However, the results of audits at selected public transportation facilities indicate the need to adapt them to meet the above-mentioned formal requirement.

3. Definition of data/information acquisition

According to the Dictionary of Correct Polish Language, to acquire is to gain, achieve, gain something. However, the term is often equated with search. According to the Encyclopedic Dictionary of Information, Search Languages and Systems, information retrieval is understood as: "the selection from among a search set of information that has a given characteristic [...], is determined by the similarity relation of the document's search

Table 2. Analysis of the hub - Chorzow Market hub Center (source: own study)

Barrier category/ convenience	**Barrier/ Convenience**	**Parameter in general YES/NO**	**Accessibility parameter [0/1]**	**OTHERS/ REMARKS**
Limited Availability	Footpaths	YES	0	There is no traffic cost, only the edge of the verge, very narrow lanes
	Significant (unacceptable) access distance	NO		
	Passenger service equipment	YES	1	ITS - boards with sound information
	Area to properly serve people with disabilities	YES	1	
	Elements of a textured pavement marking or natural guidance system	YES	1	
	Parking	YES	1	
	Distance from parking	YES	1	Short distance
	Excessive glazing	YES	0	At bus stops
	Unmarked glazing	NO		
	Contrasting elements	YES	1	Signage for the visually impaired of yellow color
	Directional lines (e.g., arrows)	NO		lack of
	Roadway crossings	YES	1	
	Pictograms	YES	1	
	Automatic revolving doors	NO		
	Automatic sliding doors	NO		
	Moving walkways	NO		

characteristic to the search instruction, and is carried out following the search strategy of the system or the strategy adopted by the user." [4,10] The first part of this definition mentions the purpose of information retrieval - to select to get to the needed news [4,10]. Therefore, information retrieval should not be considered only as obtaining relevant materials. All the steps that lead to this should also be considered. Information acquisition thus includes [35]:

- active, purposeful search and collection of information,
- routine information gathering,
- incidental information acquisition.

All activities mentioned above can influence the acquisition of needed data, thus satisfying the user's information needs. Nowadays, there are many ways to get information. We find the necessary data in the resources of libraries and information centers or on the Internet [6]. Among other things, we have various catalogs, databases, and information systems. One can also use the services of info broker companies to obtain information. By enlisting the help of specialized workers, we count on their skills and workshops to find quality information in systems with limited access. However, it should be remembered that the most accurate information can often be obtained only after using several resources simultaneously. Users generally use the listed sources when there is a realized and specific

need. Activities are then oriented towards a purposeful and active search for information [8]. However, a person has many information needs. The user's work schedule and limited ability to focus attention cause one need to come to the fore. This is conducive to the so-called accidental acquisition of information. This phenomenon accompanies, among other things, the search for data to satisfy the user's primary need, a side effect of its acquisition. Accidental information acquisition occurs when a user searches for news that is not the immediate, primary purpose of the investigation. It causes the need at the center of interest to be replaced by another. This happens when the user encounters information that can satisfy his other needs. They then move to the foreground [9].

However, the user also finds information unexpectedly when engaged in other activities. Their search is not always intentional but is gathered occasionally, accidentally, and just in case. It should also not be forgotten that data acquired in this way may inspire him to do something he had not previously considered. The situations described are also conducive to accidental information acquisition. These ways allow us to distinguish the following types of information [12]:

- information capable of satisfying the need that is the main reason for deliberate and conscious search,
- information capable of satisfying the searcher's other information needs,
- information inadequate to meet any information needs of the searcher,
- potential information that can arouse new information needs.

Depending on the user's activities, accidental information acquisition is thus fostered by [35]:

- daily media use,
- aimless browsing of resources,
- conversations with friends, family, and others, often also accidentally met people
- inadvertently entering the wrong character from the keyboard (known as a typo),
- mistakes or ignorance (such as giving a different author's name),
- incorrect or vague definition of the search strategy,
- ignorance of the principles of constructing a proper query (selecting the wrong indexes or interface options),
- the strategy and nature of the information retriever,
- the quality and preparation of the sources used.

4. Barriers to data acquisition

The topic of information barriers is also related to information acquisition and access. Such a term was probably first used by Russian authors Vadim Alekseevič Poluškin and German Stepanovič Ždanov in the early 1970s. Other terms for these obstacles are also encountered in the literature. The most commonly mentioned are barriers to access to information, barriers to communication, and barriers to the flow of knowledge. Information barriers are obstacles that hinder, delay, or prevent the use of data. They are negative factors that affect users' information behavior and actions taken to find and use information. Thus, they prevent the user's needs from being met. These obstacles also interfere with the process of information flow from its creator to its recipient. Information barriers are related to access to data, as confirmed by Dietrich Eckart Haag's definition,

according to which they "appear [whenever] there is a discrepancy between the ideal and current availability of published information." Since the 1970s, i.e., since the term information barriers, many different typologies of this phenomenon have emerged. Dividing them is difficult, as they often influence and intertwine with each other. Among others, very general typologies have appeared in the literature, which divides information barriers into [28]:

- internal (subjective, micro barriers) - dependent on the user, his knowledge and skills,
- external (objective, macro barriers) - resulting from the user's environment.

A well-known division of information barriers is Thomas Daniel Wilson's typology. According to him, the satisfaction of information needs is influenced by positive and negative factors, which he called variables. He distinguished three groups of these variables, which have a positive or inhibitory effect on human information behavior [16]:

- characteristics of a person, including emotional variables - worldview, stereotypes, preferences, self-perception, educational variables,
- education and skills, work experience, level of knowledge of the search process, and demographic variables - age, gender, social background,
- social/interpersonal factors, which are related to one's professional role - the nature and requirements of professional work, related restrictions and privileges, norms and patterns of behavior applicable to a specific group, regulations related to a particular position,
- environmental factors, or economic variables - financial and time conditions, applicable laws, the issue of geographic distance to sources of information, and the characteristics of the source.

Marzena Swigon [42,43,44], using Thomas Daniel Wilson's typology, proposed a detailed typology of information barriers that includes many different types of obstacles. Barriers related to the information user - result from the nature of the person as an information user, can be caused by intellectual, educational, and psychological factors such as:

- barrier of unawareness - ignorance of the existence of information,
- the barrier of lack of knowledge - related to the deficit of general knowledge, with gaps in education,
- terminology barrier - difficulty in reading texts or using other sources (e.g., online help in computer programs, patents, documents of EU institutions) due to the presence of specialized terms, also associated with the barrier of lack of knowledge,
- the barrier of foreign languages - complete or insufficient knowledge of them,
- the barrier of inadequate preparation for information search through traditional sources, e.g., bibliographìe, catalogs, etc.,
- the barrier of inadequate preparation for information search through electronic information sources, e.g., CD-ROM databases, computer catalogs, the Internet,
- mental resistance to using computer databases, e.g., the Internet,
- mental resistance to asking librarians, information center staff, and lecturers for help in searching for information,
- passive attitude of self - lack of commitment, easy discouragement, premature discontinuation of search,
- lack of systematicity in searching and reviewing subject literature,
- lack of sufficient time,
- anxiety about using the library (fear of the library).

Some of the barriers in this group depend on the person, attitude, and priorities. In this case, their removal depends solely on the user himself. However, in this group, there are also such barriers, which may or may not rely on him but are indicative of a poor level of training in information retrieval. Mental resistance to using, for example, computer databases may also result from shortcomings in curricula. The terminology barrier and language barrier can also be considered. These are partly due to the education offered by the state. They may also depend on what language and field the user is looking for information in, as they will never be fluent in all languages [18].

a. Interpersonal barriers - occur if the source of the information is a person or if contact with another person is necessary to access the source of the data:
- users' mental reluctance to ask questions,
- lack of help from people who are direct or indirect sources of information: librarians and subject librarians, lecturers, and other staff/colleagues.

b. Environmental barriers - related to the user's broader environment:
- legal barriers - stem from the protection of intellectual and industrial property rights, e.g., copyright law, patent protection law, data protection, archival protection,
- financial barriers - related to the scarcity of financial resources necessary to obtain information, e.g., too high prices of books, fees for photocopying prints, interlibrary loans, costs of trips to other libraries, etc.,
- geographic barriers - distance to places where information sources are available, isolation from large research centers,
- political barriers - related to the current political situation in the country and the world,
- cultural barriers - related to differences in the cultures of countries and nations.

Financial barriers have always been an obstacle to acquiring materials [36]. Not surprisingly, they are considered one of the main impediments to obtaining information. In part, they may also be related to geographic barriers. If a user agrees to travel a distance to acquire specific data, they are constantly faced with the cost of traveling to the relevant facility. The financial and legal obstacles that arise also make it clear how much there is a need for organizations that would work for free and unhindered access to at least a small degree.

c. Barriers related to information sources:
- lack of sources - no specific title (books, journals, databases) or an insufficient number of copies,
- unfriendly regulations, e.g., restrictions on making photocopies of certain documents, making materials available only on-site, limiting the number of books on a reader's account,
- insufficient advertising of information sources, e.g., bibliographies, databases in information systems, full-text databases available through paid consortia, etc.,
- delays - related to the prolongation of domestic and foreign interlibrary loan processing times, as well as the need to hand over journals for binding, misplacement on the shelf, cataloging of acquisitions, placing orders for new publications, delivery of resources to the lending desk, etc.,
- lack of computers or the ability to operate electronic devices,
- inconvenient opening hours of libraries and information centers.

The barriers listed in this group do not depend on the user. Their main cause is primarily financial. It does not seem that these barriers will ever be overcome [19]. However, consideration could be given to finding sponsors, which would alleviate at least some of the financial problems and, thus, some of the barriers included in this group.

– Created by authors and publishers of indirect and direct information:
  - publication delays - long publishing cycle of journals, books, and other information,
  - difficulties in accessing unpublished materials, such as typescripts, master's theses, doctoral theses, materials from ongoing research, and information about such work,
  - overabundance of information - a huge number of titles of books, journals, and other sources - this phenomenon is particularly true of the Internet,
  - scarcity of information - applies to narrow specialties, topics not yet developed,
  - the barrier of lower quality of information - the information received is unreliable, unreliable, outdated, contains errors in the content/footnotes, etc.,
  - barrier of non-relevant information - the information obtained does not meet the need; it is valuable but deals with another issue, is too terse or too detailed relative to the user's needs,
  - unfriendly search tools - difficulties in using computer information and search systems caused by inadequate indexing, that is, the presence of subject headwords that are too general or too specific in the user's opinion. This includes problems with the graphical representation of information that is unclear to the user, e.g., the marking of document storage, etc., as well as difficulties with subject search, i.e., information-search language, and technical problems - related to outdated equipment, system hang-ups, long waiting for the search result (unfriendly computer catalogs or databases in information systems),
  - English language dominance - related to the predominance of English in various fields of knowledge and life,
  - information published in an unknown source, e.g., in an unpopular journal or work in another field of expertise; it is related to the phenomenon called information theory, the law of publication dispersion. Barriers from this group also do not depend on the user. This is because they result from the elaboration of information by others.

Over the past few years, urbanization and, consequently, megacities population have increased dramatically. The Smart City concept is becoming increasingly popular. It is one of the main topics of interest for governments worldwide, but there are also concerns about social inclusion. According to a study, nearly 12-16% of the population has a disability that limits mobility [32]. This represents an essential need for technology for people with disabilities as cities become larger and smarter. A city's smartness is judged not only by technology but also by how residents adapt to it. Data about transportation and its amenities must be recorded to provide an interactive and inclusive solution for everyone.

In traditional times, surveys, questionnaires, laws, and policies regarding people with disabilities. While the Disability Council was used to collect data on the facilities of people with disabilities, recent times require much more sophisticated and trustworthy solutions. Crowdsensing (or crowdsourcing) is one of the most common methods suitable for large-scale applications at integrated transfer hubs [34]. These applications obtain data as individual information according to their interest, location, and mission. The Internet of Things is the most visible way of effective crowdsourcing, which provides the basis for the foundation of a smart city connected to integrated transfer hubs [31].

5. The main methods of gathering knowledge about the needs of people with disabilities

Points of interest are places that should be noticed/indicated throughout the integrated transfer hubs. This is the information that a person with a disability shows the most interest in. The United States of America, for an accessible city for people with disabilities, divides urban infrastructure elements into two main categories: urban design elements, which include information about the external aspects of the infrastructure, and architectural design elements, which include the internal substructure [29]. Architectural design elements include the following: ramps, elevators, stairs, handrails, entrances, vestibules, doors, corridors, and restrooms. These elements are often present in indoor environments such as train stations and shopping malls.

Similarly, the main urban elements listed by the UN are obstacles, signage, street furniture, paths, curbs, pedestrian crossings, ramps, pedestrian crossings, and parking lots. Inaccessibility or misplacement of these elements are considered barriers for users with disabilities. These barriers restrict mobility, so they must be adequately identified as a concern. UN & Prandi and co-authors segmented infrastructure elements (barriers) into six main groups:

- integration gaps: this category includes gaps, steps, stairs, and other similar barriers,
- crosswalks: devices and obstacles associated with road crossings, such as pedestrian crossings, traffic lights, and audible lights,
- obstacles: elements that can block the path of traffic fall into this category,
- signs, fixed poles, trash cans, wires, fallen trees, and ongoing road works are types of obstacles,
- parking: information about parking lots and their characteristics, such as location, dimensions, and number; this category includes information about parking lots and their features, such as location, dimensions, number of parking spaces and egress areas,
- surfaces: properties such as uneven road surfaces, parking areas, and description of ramp surfaces are included in this category.
- paths: all types of sidewalks and their characteristics, such as width, grids, and guards, are included in this category.

For any infrastructure, data is essential to understand the needs of the area and its residents. Typically, the most common techniques for gathering information are based on observation and actual evidence. Surveys and questionnaires from stakeholders are also used to improve their situation [37]. Mackett identified several research methodologies that assess accessibility based on disability legislation and policy [23]. Nonetheless, these methods are considered ineffective and are gradually being pushed out. The time and costs associated with these procedures reduce the frequency of these methods, thus decreasing efficiency. In addition, these methods are not suitable for real-time dynamic information collection. Another problem with surveys and questionnaires is that these activities are problematic for people with disabilities. The limitations mentioned above encourage using active, autonomous, and flexible modes of data collection, which can be achieved through smart city models. Below are the different data types related to accessibility for people with disabilities and the different data collection methods [33].

a. Radiofrequency identification technology - RFID

Radio Frequency Identification-RFID technology is a widely used communication technology for collecting information. RFID location systems include RFID tags, readers, and data processing systems. Due to the integration of RFID reading capabilities and RFID tags in modern mobile devices, this technology is very useful in designing user-centered systems in indoor and outdoor environments. In addition, the minimal cost and ease of implementation of this technology provide the opportunity to integrate with cards made of plastic, such as ID cards, bank cards, electronic keys, and clothing tags, among others. Despite this technology's advantages, its use has several drawbacks [41]. The main challenge of using RFID in localization is multipath propagation, interference, and localization of multiple objects, which causes errors in localization accuracy, modification, or interference of RFID signals by unwanted signals, which is difficult to eliminate. The proposed project is challenging because an intermediary device between the two is needed. However, a suitable mechanism to incorporate a data processing system for RFID over a wide area is difficult to achieve. However, the technology may have applications in smaller facilities.

b. GPS sensors

The Global Positioning System (GPS) is a satellite-based navigation system considered the central technology for identifying the current location. Being free, GPS provides continuous positioning and real-time information using 24 operational satellites orbiting the Earth [15]. It is a unidirectional (passive) system in which signals can only be received, not transmitted. Advances in GPS technology provide user location and movement data more precisely than any other tool. Its affordability and availability on almost any smartphone give an advantage in acquiring real-time location and trajectory data. Using this data, the mobility pattern can be analyzed, and daily traffic can be predicted. GPS accuracy is still one of the main concerns raised [30]. However, recent advances in the development of satellite technology can provide positioning with an accuracy of up to 2 meters, which is already sufficient to track the movements of, for example, a wheelchair.

c. Crowd Sourcing

Enrique and Fernando state that "Crowdsourcing" is a type of participatory online activity in which an individual, institution, non-profit organization, or company proposes to a group of people of varying knowledge, heterogeneity, and numbers through a flexible, open invitation to undertake a specific task voluntarily. However, the activities should be mutually beneficial, regardless of the mode of participation. Individuals' participation is usually evaluated through economic incentives such as bonuses, coupons, and premium services, social recognition using tools such as reward points, contribution profiling, and user ratings, or motivational factors such as altruism [24]. The power of crowdsourcing has made it more widely applicable. The use of crowdsourcing along with ICT (information and communication technologies) is also being considered in the smart city model, which not only generates feedback from citizens but also increases the accountability of governing bodies and reduces adverse reactions to them. However, the accuracy and reliability of this method are always criticized. Because there is a high probability of data misinterpretation, a suitable mechanism should be developed to maintain the reliability of crowdsourced data. In addition, there is a high probability that the crowdsourcer will lose interest after a certain period in participating in a given task, so it should be adequately combined with some incentive mechanisms for the crowdsourcer.

6. Existing assistive technologies for people with disabilities

Various studies are being conducted to provide better crowdsourcing solutions, especially in improving the accessibility of integrated transfer hubs for people with disabilities [26]. Multiple approaches have been used to provide this functionality, which forms the basis for the development of countless application architectures, examples of which are indicated below:

a. System MPASS

The Mobile Pervasive Accessibility Social Sensing (mPASS) system features a personalized, handy interface built based on all users' special needs and requirements, including people with disabilities. The primary purpose of this system is to collect data through sensors(sensing) and crowdsourcing, present the output through various geospatial visualization systems, and offer users customized paths and routes according to their preferences.

b. EasyWheel

EasyWheel - The mobile social navigation system aims to support wheelchair users to become more independent by providing them with a safer, easier-to-use navigation system. The core concept behind the EasyWheel architecture revolves around three main components: Spatial Identification of points of interest, personalized, barrier-free routes, and communities. Spatial Identification allows adding or tagging a point/place of interest and additional information. The associated information pertains to infrastructure elements such as streets, pedestrian walkways, and photos of obstacles [7]. A personalized obstacle-free route provides an obstacle-free route and navigation for wheelchair users according to their obstacle type preferences. Finally, a social component connects all EasyWheel users and offers social interaction. The architecture of the EasyWheel application is based on the Model-View-Controller (MVC) concept, which allows for the separation of data, processing, and visualization. The need to use this concept stems from the need to provide users with the same data model and the possibility of offering additional, extensible functions to the application in the future. The scalability and modularity of the system are usually compromised in such an architecture due to the high interdependence between system modules. On the other hand, integration with Facebook to provide a social profile is an innovative incentive mechanism to encourage the user to contribute to the system, which is a strength of this architecture. Another noticeable component is the mapping module, where data is retrieved from databases bi-directionally.

c. WeMap

WeMAP is a mobility assistance application based on three approaches: integrated source, business source, and crowdsourcing. It aims to provide personalized mapping services for wheelchair users. Built on semantic, linked data technology, the application provides an easy data visualization solution for people with disabilities to plan their trips. Integrated information provided by local businesses and other sources is defined and integrated using data technology. Using and establishing a structure of related data can help identify and integrate information that is usually scattered and, in some circumstances, not easily accessible. In addition, an evaluation system has been introduced into the data classification system to verify the reliability of the data. Priority for evaluation is given to users with disabilities based on the assumption that their data is more reliable. The list included a set of points of interest based on a user's position within a 300-meter radius.

Once a user selects a point of interest, the system automatically searches and links the point's information to other open ontologies, which is the main feature of the WeMAP system.

d. Wegoto

Wegoto is a mobile approach to assessing and improving accessibility, explicitly designed for wheelchair users. This smartphone application uses different types of mobile sensor data, such as accelerometer, gyroscope, and GPS, and processes it using a particular algorithm. Information about the best available route is presented using GIS maps according to the category and capabilities of wheelchair users [27,39]. The Wegoto system records in real-time the user's GPS data, the front and rear inclination of the wheelchair, its track, speed, acceleration, and deceleration. In addition, special points of interest can be delivered to the system in various ways, which can be exported in different formats. However, the application requires specific smartphone devices with the availability of sensors such as accelerometers, gyroscopes, and GPS.

e. EasyGo

EasyGo is a disability-friendly mobile navigation system that provides a customized navigation solution for people with mobility disabilities based on their preferences [13]. The user-based crowdsourcing platform collects data on barriers and facilities, processes this data to generate relevant information, and provides customized routes with information about obstacles and facilities along the way [40]. The primary purpose of this system is:

- gathering barriers and facilities for people with disabilities available throughout the city,
- providing a customized route and navigation with information on obstacles and amenities in the area,
- creating a dataset of disability-related infrastructure elements and making them available as open access for all parties.

7. Summary

During the audits performed, several barriers related to transportation accessibility for people with special needs were identified due to reasons, organizational nature, technical nature, or the existing cubic infrastructure. Conclusions were formulated to eliminate incompatibilities and adapt transportation hubs to the needs of people with disabilities. The study results also indicate the need for greater awareness of those responsible for managing transportation infrastructure at various levels of its operation regarding universal design.

The results of the evaluation of an exemplary transportation hub presented in the paper, as well as tools for communicating the needs of people with disabilities in meeting the requirement of universal design, show a significant improvement in transportation accessibility for this group of people. However, fully adapting existing infrastructure to the relatively newly emerging concept of universal design is not always possible. Generalizing the study's results, the paper identified one of the most critical barriers to transportation accessibility for people with disabilities. This is the lack of complete, systematized knowledge and full awareness of those who design and manage transportation hubs about the needs of people with special needs. For this reason, there is a need for ongoing aggregation of data in the subject area using all available technical solutions.

Barriers identified in the course of the performed audits relate to transport accessibility for people with special needs, which are due to reasons, organizational nature, technical nature, or the existing cubic infrastructure. Conclusions were formulated to eliminate incompatibilities and adapt transportation hubs to the needs of people with disabilities. The study results also indicate the need for greater awareness of those responsible for managing transportation infrastructure at various levels of its operation regarding universal design. Collecting disability data is key to creating a complete picture of the impact of disability on the health and functioning of people with disabilities in society [22,38]. These data contribute to global decisions on development efforts, poverty reduction strategies, and humanitarian action. For example, the Disability Survey (MDS) model designed to survey the general population provides comprehensive information on the distribution of disability in a country or region. By collecting detailed and specific information about how people with varying degrees of disability lead their lives, it identifies unmet needs as well as barriers and inequalities [45]. The MDS helps member countries develop policies and services and provides data to monitor countries' progress in meeting their commitments to the Sustainable Development Goals and the Convention on the Rights of Persons with Disabilities.

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Analiza koncepcji mapy dostępności dla osób z niepełnosprawnościami dla zintegrowanego węzła przesiadkowego

Streszczenie. Dostępność transportowa dla osób z niepełnosprawnością jest wyzwaniem naszych czasów. W Polsce osób z niepełnosprawnościami, które mają prawne potwierdzenie niepełnosprawności, jest ponad 3 mln. W rzeczywistości jest ich dużo więcej – od 4 do nawet 7 mln. Zachodzi więc konieczność aktywnego włączenia tej grupy osób do życia społecznego, również w obszarze transportu publicznego. Niniejsza praca ma na celu przedstawienie problematyki związanej z dostępnością zintegrowanych węzłów przesiadkowych dla osób o szczególnych potrzebach. Praca wskazuje również na kluczowe dla zarządzających systemami transportowymi zagadnienie związanie oraz agregacją wiedzy koniecznej do wdrożenia niezbędnych zmian w infrastrukturze transportowej. Informacje o potrzebach osób z niepełnosprawnościami są z kolei warunkiem właściwego projektowania uniwersalnego, które staje się już zauważalne w wielu obszarach życia społecznego i gospodarczego. W miarę rozwoju technologicznego, zmieniają się również metody pozyskiwania informacji o potrzebach osób z niepełnosprawnościami. Trudnością tutaj jest jednak opracowanie narzędzi, które uwzględnią stopień niepełnosprawności konkretnych osób, od których informację chcielibyśmy uzyskać. Autorzy w pracy uzasadniają z jednej strony działania, które zmierzają do eliminacji utrudnień, z jakimi może się spotkać osoba ze szczególnymi potrzebami podczas podróży różnymi środkami transportu, z drugiej strony wskazują na pewne rozwiązania i narzędzia, które służą do pozyskiwania wiedzy, pozwalającej w konsekwencji na precyzyjne dostosowanie bieżącej infrastruktury do ściśle określonych prze te osoby potrzeb. Agregacja wiedzy ma także dodatkowe znaczenie w zakresie zwiększenia dostępności transportowej dla osób z niepełnosprawnością. Umożliwia ona świadome projektowanie nowych obiektów i infrastruktury towarzyszącej z uwzględnieniem zmieniających się potrzeb osób z niepełnosprawnościami.

Słowa kluczowe: transport, niepełnosprawność, węzeł przesiadkowy, ułatwienia