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Institute of Logistics
Faculty of Security, Logistics and Management
Military University of Technology
in Warsaw

Universal design in transport

Uniwersalne projektowanie w transporcie

Beata Stasiak-Cieślak
cum@its.waw.pl, ORCID: 0000-0003-1548-3562
Automotive Services Center for Disabled People, Motor Transport Institute, Poland

Iwona Grabarek
iwona.grabarek@pw.edu.pl, ORCID: 0000-0002-4656-4093
Faculty of Transport, Warsaw University of Technology, Poland

Abstract. The article presented development directions in product, devices and service design related to ensuring broader accessibility for all users, with a particular focus on transportation. In this aspect, the requirements recorded in both national and international legal acts related to accessibility, including accessibility in transport, were reviewed. Compliance the analyzed regulations requires a human-centric approach to the design of means of transport, which in turn increases the likelihood of their wider use by people with various mobility needs.. However, this necessitates the designer's knowledge of the needs and limitations of end users. Special attention was paid to the concept of Universal Design (UD), based on the 7 principles formulated by Ronald Mace. Examples of technical solutions from the field of transportation innovation based on the principles of Universal Design were presented. The application of such an approach was also demonstrated in individual transportation – a vehicle accessible to drivers with limited lower limb mobility. In the summary, the authors emphasize that the devices available on the market are designed with wide customization possibilities in mind, without the need for extensive modifications. Therefore, most of these devices can be used by a wide range of people with disabilities, consistent with Universal Design principles.
Keywords: universal design, transport, accessibility, people with different needs, individual transport

Abstrakt. W artykule przedstawiano kierunki rozwoju w projektowaniu produktów, urządzeń i usług, które są związane z zapewnieniem szerszej dostępności dla wszystkich użytkowników, ze szczególnym uwzględnieniem transportu. W tym aspekcie dokonano przeglądu wymogów zapisanych w aktach prawnych zarówno krajowych, jak i międzynarodowych związanych z dostępnością, w tym dostępnością w transporcie. Spełnienie analizowanych przepisów wymaga humanocentrycznego podejścia w projektowaniu środków transportu, co w efekcie zwiększa prawdopodobieństwo ich szerszego wykorzystywania przez

osoby z różnymi potrzebami w przemieszczaniu się. Oznacza to jednak posiadanie przez projektanta wiedzy dotyczącej potrzeb i ograniczeń końcowych użytkowników. Szczególną uwagę poświęcono koncepcji projektowania uniwersalnego (UD), bazującego na 7 zasadach sformułowanych przez Ronalda Mace'a. Przedstawiono przykładowe rozwiązania techniczne z obszaru innowacji transportowych, bazujące na zasadach projektowania uniwersalnego. Aplikację takiego podejścia pokazano również w transporcie indywidualnym – pojeździe dostępnym dla kierowców z ograniczoną sprawnością kończyn dolnych. W podsumowaniu autorki podkreślają, że urządzenia dostępne na rynku projektuje się z myślą o szerokich możliwościach dostosowania bez konieczności przeprowadzania rozległych przeróbek. W związku z tym większość tych urządzeń może być używana przez szeroką gamę osób niepełnosprawnych, zgodnie z zasadami projektowania uniwersalnego.
Słowa kluczowe: projektowanie uniwersalne, transport, dostępność, osoby o różnych potrzebach, transport indywidualny

Introduction

The evolving needs of individuals and the decline in their abilities due to aging and health issues present significant challenges to transportation systems, colloquially known as transport. The increasing societal awareness and understanding of individual rights mean that designers and transportation organizers are confronted with a considerable task: ensuring accessibility. Accessibility is defined as „a characteristic of the environment (physical space, digital reality, information and communication systems, products, services, including transport), which enables people with functional (physical, cognitive) limitations to use it on an equal basis with others." For many individuals, accessibility is essential for leading independent lives and participating in the social and economic aspects of society, whether at the national level, within local communities, schools, or workplaces. Establishing the opportunity for independent mobility necessitates the provision of an appropriate system of locomotion and transportation. The concept of transportation means, i.e., technical aids for enabling the active movement of disabled individuals, was introduced by Professor Kabsch (Kabsch, 2011) to distinguish between transportation means that facilitate standing and walking and those that replace walking (e.g., „personal" wheelchairs). When discussing the accessibility of transportation, it's crucial to consider not only the technical means of transportation but also the transportation infrastructure (Borucka, 2013), which is closely linked to communication and information technology availability. Undoubtedly, the concept of „transport accessibility" is extensive and necessitates a tailored approach to design (Grabarek, Choromański, 2014). This approach should primarily prioritize human-centricity and sensitivity to the diverse needs of product and service recipients. In recent years, numerous design philosophies have emerged, all of which, despite their varying names, place the end-user at the forefront of their focus. While they may adhere to detailed principles, they do not significantly differ. Of course, it's not always feasible for designers to satisfy all recipients. The concepts of various design approaches are outlined in Table 1.

Table 1. Types of design

ERGONOMIC DESIGN	It focuses on designing products and environments that are comfortable, efficient and safe for people. It adapts objects to the user and not the other way around.
UNIVERSAL DESIGN	Designing products and environments to be accessible to all people, to the greatest possible extent, without the need for adaptation or specialized design (Mace, 1985)
USER CENTERED DESIGN	An iterative design process in which designers focus on users and their needs at every stage of the design process (Norman, Drapher, 1986).
DESIGN FOR ALL	Designed for human diversity, social inclusion and equality (designforalleurope.org).
INCLUSIVE DESIGN	A creation process that draws from human diversity. It involves people with different perspectives in product design and learns from them how to tailor specific solutions to them.

Source: Own work

Each of these approaches focuses on people, their diversity, safety, comfort, and the usability of the proposed products. Understanding the needs, limitations, and expectations of users is crucial (Hryciów, 2022; Gorzelańczyk et al., 2023). This knowledge can be acquired by involving them in the design process at every stage. Universal Design, now frequently mentioned in the media, documents, and publications, aims to create a product that is universally accessible. The question arises: is this task feasible? Inclusive design takes it a step further, aiming to create a product usable by everyone. This approach seems to be more realistic (Steinfeld, Maisel, 2012; Steinfeld 2011). Basically, each of the mentioned designs has a chance to ensure accessibility, remembering that "*..we deal with people as they are, not as they should be, so the objective is to adapt the product to the user and not the other way around, and the goal of design is to achieve the best possible matching of devices to the largest possible group of people*" (Pheasant, 2006). Everything that was not created by nature was designed (Norman, 2018).

The term "people with special needs" refers to individuals who, due to their characteristics or circumstances, require additional measures to overcome barriers that impede or hinder their participation in various aspects of life, including equal access to transportation. These individuals encompass not only those with disabilities but also dependents, the elderly, and parents with strollers.

Literature review on the topic

The literature review primarily focuses on examples related to UD in public transportation. Therefore, it is pertinent to cite material indicating that UD serves as a means to combat social exclusion by developing products and environments that are easily usable by all individuals to the greatest extent possible, without necessitating technical adaptations. According to the author, innovations and advancements in mobility technologies typically lead to increased mobility. Certain technologies, serving as niches, hold the potential to positively contribute to the advancement of UD. Technologies facilitating autonomous motorized modes of transportation within mixed traffic systems have significant potential to enhance mobility for all individuals. These advancements can extend mobility, currently accessible only to drivers, to a broader population (Aarhaug, 2023).

In the realm of mobility, the concept of UD has primarily been applied to public transportation (Audirac, 2008; Aarhaug, 2023). Bjerkan (2022) asserts that half of transport articles are based on cases involving public transportation.

The literature also addresses the perspective of contemporary European Union transport policy concerning passengers with reduced mobility, citing a case study focused on enhancing accessibility in Warsaw. The accessibility of public transportation is emerging as a prominent issue, particularly for public transport designers. This matter is also addressed by the European Commission, which has identified three fundamental passenger rights closely tied to accessibility:

- Non-discrimination;
- Accurate, up-to-date, and readily available information;
- Immediate and proportional assistance (Zając, 2016).

Legal requirements ensuring accessibility

The analysis of regulations offers an overview of the implementation of UD principles, encompassing both public and individual transportation. Selected legal provisions ensure the full participation of individuals with disabilities in social and professional spheres, serving as a crucial element in combating discrimination against marginalized social groups. The authors concentrated on several key provisions, beginning with the foundational legal document - the Constitution of the Republic of Poland, continuing with the Strategy for People with Disabilities, and concluding with EU recommendations regarding Universal Design.

The Constitution of the Republic of Poland (Journal of Laws of 1997, No. 78, item 483) contains very significant provisions aimed at counteracting discrimination:

„Article 32. Everyone is equal before the law. Everyone has the right to equal treatment by public authorities. No one may be discriminated against in political, social or economic life for any reason".

The rights guaranteed in the Constitution were also enshrined in the Charter of Rights of Persons with Disabilities adopted on August 1, 1997. The provisions therein pertain to accessibility comprehensively. In alignment with the principles of sustainable transport development, individuals with special needs in public spaces, including the elderly, constitute an essential group of passengers deserving special and systematic consideration.

The Government Accessibility Plus Program 2018-2025 is a strategic document aimed at ensuring equal opportunities for participation in public life for all members of society. The key activities initiated during the Program's implementation may include:

- The enactment of the Act of July 19, 2019, on ensuring accessibility for persons with special needs (Journal of Laws of 2019, item 1696), delineating the obligations of public entities concerning accessibility.
- The implementation of the Act of April 4, 2019, on the digital accessibility of websites and mobile applications of public entities (Journal of Laws of 2019, item 848), compelling public sector entities to enhance the accessibility of their websites and mobile applications based on common accessibility standards.
- Establishment of the Accessibility Fund, designed to provide financially attractive loans for adapting public buildings and multi-family housing structures to meet the needs of individuals with special needs.
- Amendment to the Regulation of the Minister of Infrastructure of April 12, 2002, on technical conditions and the location of buildings (Journal of Laws of 2019, item 1065), aiming to incorporate accessibility conditions more comprehensively into the provisions of construction law.

The Act of July 19, 2019, concerning ensuring accessibility for individuals with special needs (Journal of Laws of 2019, item 1696), delineates the fundamental requirements for ensuring accessibility. For the first time, the term "person with special needs" was defined as an individual who, due to certain circumstances, must take measures to mitigate functional barriers to participate in various aspects of life on an equal footing with others. This legislation established the legal and organizational framework for introducing the concept of accessibility in Poland, imposing obligations on public entities to guarantee accessibility.

The Strategy for People with Disabilities 2021–2030 outlines, among other objectives, comprehensive support for the individual mobility of individuals with disabilities. The document provides extensive information regarding the mandatory analysis of legal provisions and implementing measures aimed at enhancing accessibility for individuals with disabilities, particularly in the realm of transportation.

The Act of December 16, 2010, concerning public collective transport (Journal of Laws 2011, No. 5, item 13, as subsequently amended), includes provisions crucial for the accommodation of disabled individuals in the transportation environment. *"Chapter 2 - "Sustainable development plan for public collective transport"*

Art. 12. 2. When developing a transport plan, the following should be taken into account in particular:

4) the needs for sustainable development of public collective transport, in particular the needs of disabled people and people with reduced mobility, in the field of transport services;

Chapter 3 - "Organizing public collective transport"

Art. 21. 1. When awarding a public contract for the provision of public collective transport, the specification of essential terms of the contract may include in particular quality standards and universal availability of the services provided, including:

2) technical solutions used in transport means, in particular to ensure environmental protection and convenient service for passengers, including disabled people and people with reduced mobility;

3) standard of equipment of transport means".

The transportation plan within a specified area is developed by the transportation organizer. Consequently, we can expect the organizer to comprehensively and precisely define the requirements for the accessibility of transportation services. These requirements should be outlined in the Specification of Essential Terms of Order (SIWZ) for the operation of a given route, and subsequently included in the contract with the carrier.

The provisions of European law emphasize the necessity of integrating the concept of UD into state policies. In 2001, the Committee of Ministers adopted a resolution (commonly referred to as the Tomar Resolution) concerning the incorporation of UD principles into the curricula of all professions (ResAP(2001)1). According to this resolution: *Universal Design issues should be incorporated into all types and levels of education that impact our physical environment. Society, and in particular all professions that constitute the construction environment, have an obligation and duty to ensure that it is universally accessible to everyone, including people with disabilities.*

In 2009, the Committee of Ministers of the Council of Europe issued a recommendation to member states regarding the attainment of full participation through UD (Recommendation CM/Rec (2009)8). Member States are encouraged to undertake initiatives aimed at implementing the principles of Universal Design across all aspects of social life, including transportation. Educational programs should emphasize the interrelations between individuals and the environments they inhabit. Design tasks should incorporate the involvement of end users, encompassing all individuals, including those with special needs. Projects should aim to address

the specific or collective needs of individuals with special needs, encompassing individuals with disabilities and individuals of varying ages.

Numerous international legal instruments defining changes in the treatment of individuals with disabilities exist and play a significant role in shaping the legislative frameworks of countries within the European Union. These instruments compel Member States to amend their internal regulations (Stasiak-Cieślak, 2022).

Principles of universal design in transport

The concept of Universal Design (UD) is based on 7 principles formulated by Ron Mace (Mace, 1985). In the realm of transportation design, it aims to eliminate architectural and communication barriers, encompassing both transportation infrastructure and vehicles, as well as information dissemination. The UD strategy necessitates comprehensive engagement in activities related to its planning, execution, and oversight. Clearly defined standards for stakeholder involvement in the implementation of ideas are crucial to encourage the widest possible participation. These principles play a strategic role in promoting fair decision-making. The implementation of UD requires active participation from groups of product users and individuals facing specific conditions.

The issue of public transportation availability should be viewed as a multifaceted phenomenon. Therefore, accessibility can be ensured through appropriate design and procedures that cater to the diverse needs of user groups (Zając, 2016; Brídziková, et al. 2020).

When implementing Universal Design, the following principles should be considered:

Equitable use: Ensuring that all users have access to the same rules of use without requiring specific accommodations for particular groups. The design should be functional and appealing to individuals of all abilities.

Example: The vehicle should be designed to serve the same purpose for every passenger, regardless of their individual needs or abilities.

Recommended: 100% low-floor rolling stock (Fig. 1).

Flexibility in use involves facilitating users to maintain accuracy and precision while accessing a particular service by offering a choice between different methods of utilization. A well-designed system should consider the preferences and abilities of diverse individuals. Flexibility in use entails accommodating various physical capabilities.

Example: Providing information about services through multiple modalities such as visual, auditory, and tactile means (Fig. 2).

Fig. 1. ARP E-Vehicles low-floor electric bus (Mrągowo)
Source: https://transinfo.pl/infobus/arp-e-vehicles-wygrywa-w-mragowie-dwa-elektrobusy-przyjada-z-bydgoszczy [23 September 2023]

Fig. 2. Vehicle equipped with electronic displays and voice information about the route and stops
Source: https://www.wtp.waw.pl/komunikacja-bez-barier/ [23 September 2023]

Simple and intuitive operation involves ensuring consistency with the user's expectations and intuition, prioritizing information based on its importance. The designed solution should be easy to understand, regardless of the user's experience, knowledge, language skills, or current level of concentration.

Example: A multi-function button located by the door in a vehicle. The user expects to use it to signal the desire to disembark and open the door when the vehicle is stationary at a stop (Fig. 3).

Fig. 3. Multifunction button
Source: https://www.wtp.waw.pl/komunikacja-bez-barier/ [23 September 2023]

Perceptible information involves employing diverse forms of communication, such as images, words, and touch. This principle entails ensuring the readability of information through appropriate size, contrast, and formatting of visual signs, as well as maintaining an adequate level of audibility for audio messages amidst environmental noise.

Example: Utilizing well-positioned, clear pictograms to convey recommended behavior. This could include information about making space available in the vehicle for individuals who require it more (Fig. 4).

Tolerance for error involves offering solutions that mitigate any potential errors made by the user. A well-crafted design shields the user from the repercussions of unintended actions.

Example: Furnishing information about the next stop on the route, ensuring that passengers do not mistakenly disembark at an unintended location (Fig. 5).

Fig. 4. Pictogram – place for a stroller with a child
Source: https://www.agumama.pl/jak-bezpiecznie-przewozic-wozek-w-autobusie/ [23 September 2023]

Fig. 5. Audiovisual information
Source: https://www.transport-publiczny.pl/wiadomosci/warszawa-jest-umowa-na-sto-nowych-wyswietlaczy-na-przystankach-tramwajowych-79731.html [23 September 2023]

Low physical effort;

Example: A low floor spanning the length of the vehicle or automatic doors can facilitate everyday tasks (Fig. 6)

Fig. 6. Low floor through the entire vehicle length
Source: https://sadeczanin.info/wiadomosci/nasz-czytelnik-kierowca-mpk-nie-pomogl-osobie-na-wozku-inwalidzkim-chociaz-ma-taki [23 September 2023]

Fig. 7. Ticket machine
Source: https://www.radiowroclaw.pl/articles/view/103673/W-legnickich-autobusach-pojawily-sie-biletomaty [23 September 2023]

Example: Door buttons positioned at a comfortable height, accommodating individuals of varying heights, including shorter individuals. This principle is rooted in ergonomics and necessitates tailoring the design to fit the space occupied by users. The width of communication spaces should be determined by the dimensions and manoeuvrability of the largest wheelchairs used by individuals with mobility disabilities, while the height should accommodate the tallest individuals (Fig. 7) (Connell, 1997).

It is crucial to incorporate pertinent topics concerning disability, accessibility, and universal design into education to enhance the knowledge and skills of future professionals. By doing so, prospective employees will gain awareness of accessibility barriers and become better equipped to address them. Universal Design principles can be applied across various environments, products, services, and teaching methods.

Universal design in individual transport

The goal of implementing UD principles is to simplify life for everyone, regardless of age and functional limitations. Both able-bodied and disabled people thus gain widely available products, devices and services. The use of UD causes us to analyse the requirements and involvement of the user himself at all stages of the project. In UD, it becomes important to look for solutions that are characterized by variability over time, the so-called adaptability to the changing needs of the user. An example would be adaptive devices that can be personalized to the user's needs.

As part of this study, the authors undertook the challenge of delineating the scope of UD in individual transportation, considering both the vehicle and the devices used within it. A relevant example is an adaptive (mechanical) device known as a pull/push bar. This device can be utilized by most drivers with disabilities. Additionally, in temporary situations such as temporary mobility impairment of an able-bodied person, the device can also be utilized by non-disabled individuals. The acceleration function is activated by the «pull» movement, while the braking function is activated by the «push» movement. An example of this type of solution is illustrated below, where the device is installed between the steering wheel and the automatic transmission stick.

The Carospeed Classic (Fig. 8) is a universal device designed to facilitate intuitive operation of the accelerator and brake pedals. It is offered in three variants: a standard model with basic acceleration and braking functions, a model with integrated turn signals, and a model with integrated electrical functions including wipers, washers, horn, high and low beams, and cruise control settings. The device is aesthetically styled to complement the interior of the car and can be installed in most vehicles. It is recommended for use with automatic transmissions only. Most adaptation companies offer installation of this type of adaptation solution.

Fig. 8. Carospeed Classic
Source: https://emico.pl/oferta/dostosowanie-samochodu/reczne-sterowanie-gazem-i-hamulecm/braunability/braunability-carospeed-classic.html [23 September 2023]

Devices designed in accordance with Universal Design principles do not necessitate modifications or the introduction of additional solutions for individuals at risk of exclusion. UD does not preclude the use of additional supporting devices, such as cameras or motion sensors. Referring to the 7 principles of Ud, the authors characterized the device presented above as follows:

- Equitable use: a device is useful for individuals with diverse physical abilities, including both paraplegics and quadriplegics.
- Flexibility of use: a device accommodates a wide range of individual user skills.
- Simple and intuitive operation: The device is easy to use, regardless of the user's experience.
- Perceptible information: a device requires only brief training for proper use.
- Error tolerance: a device minimizes risks and negative consequences of accidental operation to ensure road traffic safety.
- Low physical effort: a device may incorporate electrotechnical support, and the user can also utilize support within the car.
- Size and space for approach and use: device's appropriate size and the space available in the vehicle consider the user's mobility.

According to the authors of the study, the exemplary adaptive device presented is designed to cater to each user. This device is expected to fulfil the needs of the

majority of individuals with mobility disabilities. Designing products and devices of this nature within the realm of Universal Design also extends to adaptive devices used in vehicles, while adhering to certain fundamental principles. Therefore, in accordance with Universal Design (UD), the adaptive device should be functional, user-friendly, and beneficial to all. Accessibility, as understood in this context within UD, places significant demands on designers, which must be met, at the very least considering legal and economic aspects.

Conclusions

The article aimed to explore key issues surrounding new trends in product and service development, particularly in the realm of individual transportation within the context of UD. Drawing from relevant literature, it emphasized the importance of understanding the needs and limitations of individuals with special needs and integrating this knowledge into design processes. By defining the scope of UD in individual transportation, considering both the vehicle and the devices used within it, the study contributes to filling a research niche in the field.

Analysis of the research material suggests that employing UD principles in transportation design can enhance the likelihood of broader utilization, not only among individuals with disabilities. In line with EU directives and recommendations, public infrastructure and rolling stock should be tailored to the needs of individuals with limited mobility, encompassing those with impaired mobility, vision, and hearing. It is imperative for vehicles and public infrastructure to be functional, cohesive, and user-friendly, achieved through the application of UD principles.

Adaptive devices for individuals with disabilities are typically customized to the user's specific needs. However, many devices on the market are designed for broad adaptability without the need for extensive modifications. Consequently, most of these devices can be utilized by a wide range of individuals with disabilities, aligning with principles akin to ergonomic design. Moreover, it's feasible to incorporate a universal approach into the characteristics of adaptive devices to ensure they meet the expectations of a broad user group.

Ultimately, both individualized and UD approaches are pertinent when centered around human-centric design principles.

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