

## SUPPORT SYSTEM OF MOUNTAIN TRAVELS FOR PEOPLE WITH DISABILITIES

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**Purpose:** The aim of the study is to increase the availability of the tourist offer in non-urbanized areas, including mountain tourist trails, for people with special needs resulting from the lack of full fitness.

**Design/methodology/approach:** Creating an integrated platform for planning, organization, supervision and support for the availability of the mountain travel offer for people with difficulties in physical functioning and a specialized off-road wheelchair for the implementation of the tourist offer

**Findings:** The development of a specialized off-road wheelchair for people with disabilities together with an IT support system for planning, navigation, and communication with the system operator and emergency services will increase the accessibility of non-urbanized areas, including tourist trails, for people with special needs.

**Social implications:** For people with disabilities, the proposed solution is to improve the quality of life, enable rehabilitation in a natural environment in a non-urbanized conditions, and the possibility of mountain tourism, and travel in green areas. A sense of contentment and satisfaction in active rehabilitation and integration in society.

**Originality/value:** The proposed solution for an integrated support system for people with disabilities based on the development of a specialized off-road wheelchair equipped with on-board computer with the functions of planning and navigating on routes, communication and calling for help in unplanned emergency situations. The paper is addressed to people with disabilities, organizations dealing with such people, decision makers in the field of investment planning and financing of such projects, research and development centers in construction of vehicles and IT systems.

**Keywords:** transport accessibility, disabled people, all-terrain wheelchair, non-urbanized areas, tourist routes.

**Category of the paper:** Research paper.

## 1. Introduction

Transport accessibility is one of the key aspects of human perception of the environment (Freiria et al., 2022) or (Ravensbergen et al., 2022). Nowadays, transport accessibility is the main product of the transport system, which determines the advantage of the location of a given area (region, city, or route) in relation to other areas. Transport accessibility affects the influx of both people and capital. The greater the availability, the better the potential conditions for demographic and economic development. It is one of the main factors in transport planning. It is directly related to the ease of reaching a specific goal (Kokhan et al., 2022).

Social exclusion in transport is the second most important mobility problem, along with accessibility to transport. Mobility is one of the main dimensions of social exclusion. Cox and Bartle (2020) as well as Priestley et al. (2016) show that insufficient access to transport prevents the society from fully meeting its social needs. Ensuring accessibility requires taking into account the needs of people with disabilities at the stage of planning and designing infrastructure or organizing other spheres of human activity, such as culture or travel. Making life easier for all members of society, including people with disabilities, avoids exclusion and gives equal opportunities to take advantage of these spheres.

The European Union estimates that people with disabilities may constitute more than 80 million inhabitants of the EU, of which 46 million are women. Every fourth European has a family member with a disability. The population of the European Union is aging, and as a result, there will be more people with disabilities. According to the World Health Organization, disability affects more women, who are particularly vulnerable to it due to their longer life expectancy. According to the European Health Survey, Poland may be inhabited by 4.9 million to even 7.7 million people with disabilities depending on the adopted criterion, which is the so-called biological disability, i.e., a declaration of a given person regarding the limited ability to perform activities due to health problems (European Disability Strategy 2010-2020).

It is estimated that up to 30% of the society may have permanent or temporary limitations in mobility or perception, with manual and cognitive difficulties, the elderly, physically weaker, and having difficulty moving. Polish society is changing - it is getting older. Currently, almost 9 million people over 60 live in Poland. According to forecasts, in 2030 there will be 10.7 million of them and they will constitute nearly 30% of the population (Accessibility Plus call, 2022).

Jaroš (2022), Kenyon et al. (2002), Mackett and Thoreau (2015) analyzed the aspect of social exclusion is extremely important within the framework of sustainable development policy. People with motor disabilities are now largely socially excluded from communicating with nature on tourist routes. With regard to the project in question, it should be noted that there are shortcomings in the adaptation of tourist routes and the insufficient accessibility to properly

prepared prams, which, in a safe and easy-to-use manner, could level the chances of travel for people with mobility disabilities (Mattioli, 2014). At the same time, the carts available on the market are not available to everyone due to their high price. Therefore, the idea of the project is not only to prepare the right application and improvements to trolleys, but also to launch the entire logistics base, including trolley rentals. In this way, the financial barrier to using travel will also be removed (Preston, Rajé, 2007).

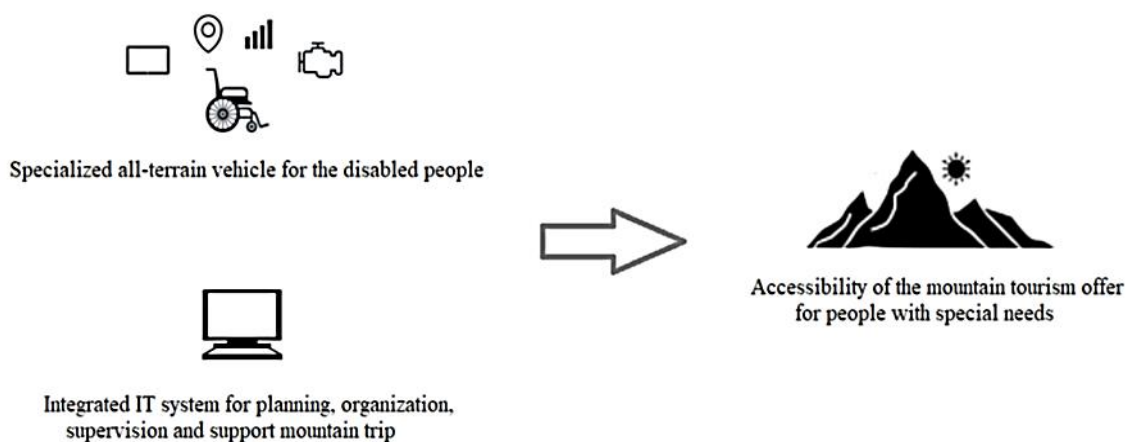
Rational improvements, including compensation and assistive technologies, will be the main task of the project. This is a direct removal of barriers and, most importantly, facilitating independent living and participation in social life. Due to the universal and modular design, which enables the replacement of the electrically assisted manual drive part with an electric one controlled by a manipulator, the target group can be defined as broadly as possible. People with difficulties in moving in flat terrain will be able to use hiking trails with inclinations, uneven surfaces, insufficiently legible markings, etc. It can therefore be indicated that the beneficiaries of such a solution will be people moving with the help of assistive equipment, such as crutches, canes, walkers, prostheses, wheelchairs, but also people with hearing impairment, manual and cognitive difficulties (e.g. after a stroke, suffering from Alzheimer's disease), pregnant women, and physically weaker, e.g. the elderly and experiencing difficulties in moving (e.g. as a result of an injury or illness). Therefore, the solutions proposed in the project will be addressed not only to people with the status of a disabled person, but also to people for whom it is very difficult to move around or orient themselves in the field. Both the infrastructure and the means of transport should take into account the social needs and the amateur nature of people who will design and built vehicles. It should be remembered that people with disabilities and seniors constitute a significant part of society (Siebert, 2012; Hill et al., 2014; Cavallone et al., 2022; Goodlin et al., 2022).

The paper presents the objectives and the results planned to be achieved from the project “Integrated platform for planning, organization, supervision and support for the availability of the mountain travel offer for people with difficulties in physical functioning and a specialized off-road vehicle for the implementation of the tourist offer – Mountains Without Barriers”. The idea of project in schematic form is presented in the figure 1.

## **2. Project assumptions**

The main assumption of the project is to develop an integrated IT system, mobile solutions, and wheelchair construction elements that meet the expectations and requirements of people with functional physical and cognitive difficulties, for whom the implementation of mountain travel is currently significantly difficult or even impossible. The experiences of people with disabilities and their assistants to people who support them (guardians) create assumptions and

guidelines that should be met by the solutions being developed. In addition, the beneficiaries of the project results will be directly people with special needs resulting from a lack of full fitness. Thus, the creation of construction and technological solutions increasing the accessibility of the tourist and cultural offer (including access to national parks, nature reserves, nature monuments or historic buildings) in public space in a non-urbanized environment resulted in the involvement of an entity associating people with special needs, the Borderland without barriers foundation. It is to constitute a consultative body in the field of construction and technological solutions implemented and to engage in work in the field of acquiring knowledge and exchanging experiences about the area of mountain travel for the disabled. In addition, it will allow for the implementation of functional tests of the developed solutions from the perspective of people with special needs resulting from the lack of full efficiency.



**Figure 1.** Idea of the implemented Mountains without barriers project.

Source: Own work.

Another assumption of the project is to ensure the safety of mountain travel for people, including people with disabilities, with the use of solutions developed in the construction of wheelchairs and designated routes on hiking trails or forest roads. As part of the wheelchair modification of the structure for mountain travel, it is required to implement technical solutions that facilitate the control of the wheelchair, such as the uphill start assistant and the downhill assistant preventing the vehicle from accelerating above the set descent speed. In addition, the applied additional electronic modules allow the assessment of the position of the trolley and information for the driver or the reaction of the drive unit to a possible loss of stability in terms of movement on / from the hill. The aspect of maintaining the safety of mountain travel also applies to the stage of determining routes for the implementation of the trip, as well as the stage of navigation on it. Thus, parameterization of the course of tourist routes and forest roads is required to determine the route sections in the routing algorithm that meet, among others, conditions of permissible inclinations for journeys with the developed specialist wheelchair. The assumptions of the project assumed the necessity to parameterize selected popular tourist routes and forest roads in order to determine the parameters of the route's inclination, its gauge, evenness and type of surface, as well as possible restrictions on the accessibility of the route.

In order to increase the accessibility of mountain travel and to support people with reduced physical fitness, rehabilitation in a non-urbanized environment surrounded by nature, the assumption was made to support the traveler through the use of a pro-ecological drive unit powered by electricity. However, it is to be a kind of boost in propelling the wheelchair in terms of the route, forcing the disabled person to perform rehabilitation exercises through the work of the upper or lower extremities. In other words, it is the possibility of active rehabilitation in fresh air, surrounded by nature.

Another assumption of the project is the creation of the idea of creating mobile rental of specialized wheelchairs that allow the implementation of mountain travel on the basis of rental with support for the implementation of the route without incurring the costs of purchasing a specialized wheelchair. The possibility of using the developed solutions of a specialized wheelchair and IT systems of travel support in the field of mountain travel will allow for a significant increase in the accessibility of the tourist offer, and thus the accessibility of disabled people to areas of the non-urbanized environment, the natural environment. An example of the concept of mobile rental companies according to the Borderland Without Barriers Foundation is presented in Figure 2.



**Figure 2.** An example of the concept of mobile rentals.

Source: Adopted from the Borderland Without Barriers Foundation.

In addition, it was assumed that in the implementation of the integrated IT system for planning, organization, supervision, and support of mountain trips carried out by people with functional, physical, and cognitive difficulties, open data sources such as Open Street Map, State Forest Data Bank and algorithms based on Open Trip Planner will be used. The mobile tool will run on the open Android operating system. The developed results of assisting solutions and modern methods of user interaction with the device and interface will refer to the Guidelines for the accessibility of websites, in terms of equal opportunities and nondiscrimination, including accessibility for people with disabilities.

### 3. Expected results

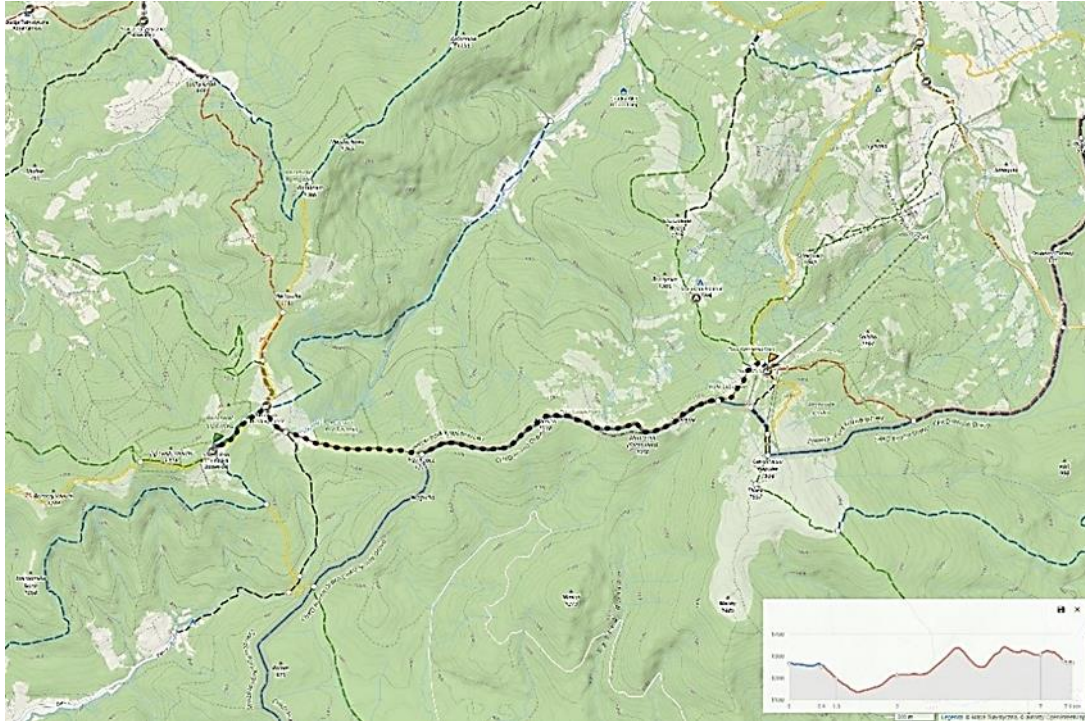
The expected result of the project is the development of an integrated system of planning, organization, supervision, and support for the implementation of the mountain travel offer by people with special needs resulting from the lack of full fitness. The integrated support system uses electronic and information technologies, mobile tools, and design solutions to modify existing wheelchairs, including adapting the drive system to conditions in non-urbanized areas.

The expected result of the project in the form of a full support system for mountain travel for people with functional, physical, and cognitive difficulties includes the following functionalities:

- Planning routes on hiking trails and forest roads.
- Online visualization of realized displacements.
- Navigation on the route being carried out.
- Generating voice messages.
- Monitoring the parameters of the wheelchair's operation.
- Tracking the position, speed, and location of the wheelchair.
- SOS Help calls for people with disabilities.
- Adaptation of the wheelchair structure for the disabled.
- Equipping the wheelchair with replacement power sources.
- Steering a wheelchair with a joystick.

Planning of mountain routes requires the development of a multimedia travel planner tool in the project that allows for the designation of a route along the existing tourist routes, forest roads, and public roads by indicating the starting point (the starting point for the implementation of the mountain travel offer), the destination point (the end of the trip), and intermediate points. Their indication by the user of the planner or the operator of the mobile system of specialized wheelchair rentals will allow one to define the location of service points for the disabled in order to support the basic life functions and to replace or recharge the power source of the wheelchair drive unit. A key element in planning a mountain trip is the necessity to designate a route taking into account the possibility of traveling along forest roads (due to forestry works, some sections may be closed), the altitude profiles of hiking trails or forest roads. Thus, as part of the development and implementation of route search criteria, in addition to the common search criteria, the fastest route or the shortest route, a route planning criterion will be introduced to minimize changes in the altitude profile and the possibility of taking into account the need to recharge or replace the power source of the drive unit at defined service points in mountain areas.

An example of planning routes on tourist routes in the *mapa-turystyczna.pl* planner is shown in Figure 3. The place where the trip starts – PTTK shelter in the Hala Lipowska, the place where the trip ends – PTTK shelter in the Hala Miziowa, the route through Hala Rysianka, Trzy Kopce, Hala Cebulowa.



**Figure 3.** An example of route planning using the *mapa-turystyczna.pl* planner.

Source: Own work.

Online visualization of realized movements requires the development of a graphic visualization tool for the location of people implementing mountain travel offers, indicating the parameters of the trip, its duration, energy consumption (battery charge status), the envisaged further route, its course and duration. The visualization tool will allow economic entities providing mountain travel offers to monitor the location of rented wheelchairs and, moreover, to provide information about the routes to be provided to emergency services, including the Tatra Volunteer Rescue Service and the Volunteer Mountain Rescue Service. The archiving of the routes implemented and then the analysis in terms of the use of the mobile system of specialized wheelchair mileage rentals, will allow further increasing the availability of tourist offers in individual mountain areas, where the conditions will allow for travel by people with special needs resulting from the lack of full fitness.

Navigating the route in mountainous areas requires the development of a mobile device that allows people to navigate using specialized wheelchairs. The developed solution mounted on the trolley structure will be based on the Raspberry Pi platform and will ensure communication using cellular data transmission (modem). In addition, the developed mobile device will be equipped with a GPS receiver to determine the location, and the control and control of the device will be carried out by handling the graphic interface of the touch display and voice

messages sent by people using the device. The functionality of navigating due to people with functional physical and cognitive difficulties requires the design and implementation of an application interface, related to WCAG 2.1 according to the principles of perceivability, functionality, comprehensibility, and compatibility.

The delivery of messages for disabled vehicle users requires the development of additional mobile device functionality in the project, allowing for the sending of additional information on the implementation of routes in the form of messages, e.g., about the closure of hiking trails or forest roads, the current weather situation, the possibility of sudden weather phenomena or rules of behavior in certain situations. In addition, it can provide wheelchair users with information about current places where they are located, among others. entrances to national parks, nature reserves in the vicinity of natural monuments, historic buildings, or viewpoints. The presentation of the message will take place on the display of the mobile device and through voice information. The possibility of transmitting messages to pram users in mountain areas will be available to the economic entity responsible for the organization of the mountain travel offer, as well as the TOPR and GOPR rescue services.

Monitoring the operating parameters of a wheelchair (a vehicle for the disabled) in terms of the drive system will allow planning or identification of the need to replace the power source (battery) or recharge it during the trip. The electronic system performing the monitoring functions will be a mobile device mounted on the trolley structure and equipped with an additional module for estimating the energy consumption (mobile electricity meter). Information on the available energy for the propulsion unit allows for securing the route implementation, thus reaching the destination of the journey, or the need to provide recharging on the route by replacing the power source (battery). Providing the required level of electricity for the wheelchair drive unit is crucial for the safety of people with limited physical and cognitive functionality, especially in non-urbanized areas, including hiking trails and forest roads.

Tracking the location, speed, and location of the wheelchair will ensure the safety of disabled people using the mountain travel offer. The additional MEMS modules implemented in the trolley structure allow for the assessment of the trolley's position (possibility of overturning), and with the use of a mobile device, they will transmit a message to the driver or force the drive unit to react (emergency stop) to a possible loss of stability in terms of moving uphill and in the opposite direction. In addition, the use of electronic control of the trolley's braking system will allow you to perform the functions of hill start assistant and hill descent assistant. Also, it will prevent acceleration of the trolley above the set descent speed. For people with limited physical and cognitive functionality, it is crucial to develop solutions that allow them to ensure travel comfort and safety while implementing the mountain travel offer.



SOS help calls for people with disabilities required to develop a mobile device in the design that allows for an independent (voice) call for help from a person with functional physical and cognitive difficulties implementing the mountain travel offer and an automatic call for help through the mobile application due to the lack of contact with a disabled person (no response to voice or graphic messages) or overturning the wheelchair based on the signals sent from the MEMS modules installed in the wheelchair structure. The automatic SOS emergency message will provide information on the type of event, time of its occurrence, and location in the form of geographic coordinates. Information will be provided directly to the economic entity responsible for organizing the mountain travel offer, as to well as the TOPR and GOPR emergency services.

Adaptation of the wheelchair structure for people with disabilities (with varying degrees of limitation in physical and cognitive functioning) requires the development of a modular structure in the project that allows for a simple and quick change of modules that perform driving functions, control the direction of movement, type of seat, and secure a person traveling in a wheelchair. For people with special needs, including individual needs, resulting from a lack of full fitness, the key is to adapt the construction of specialized wheel-chairs, allowing them to ensure the safety and comfort of travel during the implementation of the mountain travel offer. Adapting the vehicle to people who are just starting their adventure with mountain travel. The current constructions are dedicated to people who lead a sports lifestyle.

As part of the implementation of the first research task in the Mountains Without Barriers project, incl. specifying the requirements for the solutions created together with the "Borderland without barriers" foundation and in the presence of GOPR assistance, tests of the existing vehicle for disabled people owned by the above mentioned foundation were carried out by Hala Lipowska, Hala Rysianka, Trzy Kopce, Hala Cebulowa, Hala Miziowa are shown in Figure 4.

Controlling the wheelchair with the use of a joystick requires the development of a manipulator module in the design that allows to control the movement of the wheelchair by the movement of the hand of the person on the wheelchair. However, this requires the introduction of an additional system for independent control of the drive wheels. However, this solution prevents the interaction of the electric drive unit and drive modules using human muscle force.



**Figure 4.** Tests of a three-wheeled vehicle for disabled people on the route at 23-24 July 2022.

Source: Own photo.

Equipping a wheelchair with replacement power sources requires the development of an intuitive and easy-to-use system for replacing the power source of the drive unit (battery) and the possibility of connecting a charger powered from the power grid as well as charging with the use of alternative energy sources, photovoltaic panels. An intuitive and easy-to-use system for people with limited physical and cognitive functionality is crucial when implementing the mountain travel offer.

Additional system functionalities required to be developed in the project include: support in the organization of the mountain travel offer for specialist wheelchair rentals and the possibility of specifying requirements for the designation of hiking trails and forest roads as well as the construction of specialized wheelchairs for travel in non-urbanized areas.

## 4. Conclusions

The expected result of the project will be to increase the accessibility of the tourist offer in non-urbanized areas for people with special needs, including individual ones, resulting from the lack of full fitness. The results will be achieved through the development, implementation, and verification of solutions aimed at changing the approach to mountain travel as a field of travel intended only for people with full fitness towards people who require additional support in its implementation. Using innovative technical solutions, including route planning systems, its visualization, navigation, communication, and monitoring that support mountain travel, it is possible to improve the comfort of movement of people with special needs.

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