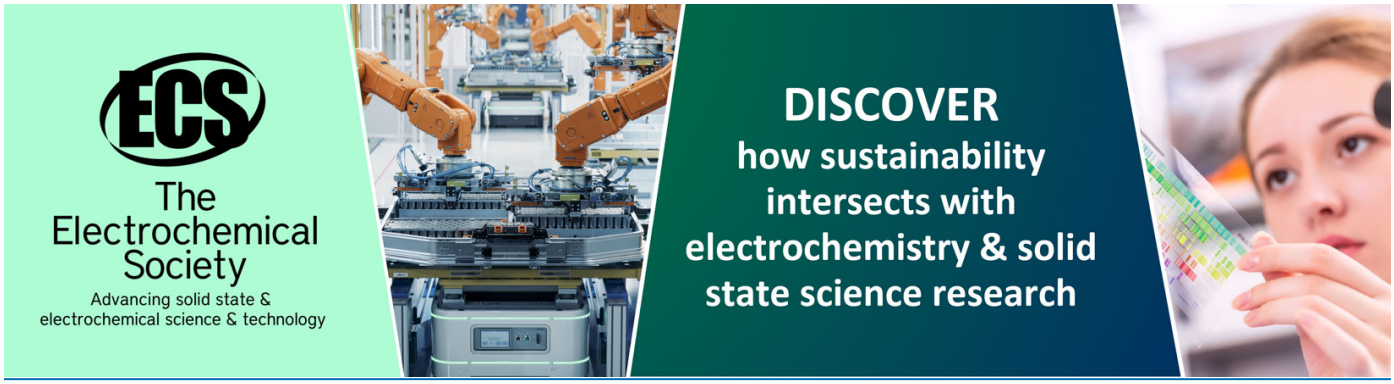
Composing a Conceptual Framework for an Inclusive Mobility System



IOP Conf. Series: Materials Science and Engineering **960** (2020) 032089 doi:10.1088/1757-899X/960/3/032089

Composing a Conceptual Framework for an Inclusive Mobility System

Tabea Fian [1], Georg Hauger [1]

[1] Technische Universität Wien, Centre of Transportation System Planning, Augasse 2-6, 1090 Wien, Austria

tabea.fian@tuwien.ac.at

Abstract. This paper addresses the question how a future mobility system can be available and accessible to all people in our society regardless whether they are disabled or not. The purpose of composing a conceptional framework is to point out how such an inclusive mobility system must therefore be designed and organised. The discussed research question is based on the "Seven Principles of Universal Design", the "UN Convention on the Rights of Persons with Disabilities" as well as on the UN goals on sustainable development (more specifically, Goal #9: Industry, Innovation and Infrastructure, Goal #10: Reduced Inequalities, Goal #11: Sustainable Cities and Communities). These theoretical principles on inclusion and inclusive design are transferred to the interdisciplinary concerns of spatial planning: From a transportation system planning point of view, a detailed set of mobility and accessibility requirements for people with disabilities is elaborated and described. Consequently, the identified accessibility and mobility requirements of individuals with disabilities are assigned to the roles and responsibilities of the following sectors: (1) government, (2) the private sector (economy and industry), (3) academia and (4) civil society and advocacy groups. This broad analytical approach allows to include and identify innovative solutions that constitute an inclusive mobility system by considering technology driven aspects as well as non-technological aspects. In this manner, eight inclusive components (so called *i components*) for the future design and organisation of an inclusive mobility system are formulated: i Car, i Environment, i Ride, i Assist, i Organize, i Code, i Image and i Funding.

1. Introduction

Article 13 of the Universal Declaration of Human Rights (UDHR) [1] guarantees freedom of movement. In order to develop an inclusive mobility system that works for all, the UN goals on sustainable development (Goal #9: Industry, Innovation and Infrastructure, Goal #10: Reduced Inequalities, Goal #11: Sustainable Cities and Communities) [2] as well as the UN Convention on the Rights of Persons with Disabilities [3] point out the necessity to meet fundamental mobility and accessibility requirements of all individuals regardless whether they are disabled or not.

1.1. Problem Statement

In Austria and many other countries of the OECD, the current organisation and design of mobility infrastructure, systems and services do not provide ubiquitous barrier-free and user-friendly access for the entire variety of (vulnerable) groups in society (e.g. children, the elderly and people with disabilities).

If future developments and innovations continue to overlook or disregard basic needs of marginalised groups and those who have limited transport accessibility today, existing mobility limitations and barriers will be amplified. Specific technological as well as social innovations and improvements are required along all stages of everyday trips (pre-trip, on-trip and post-trip).

1.2. Research Objective

For disabled people it is the humble target of an inclusive mobility system to be able to access and use the transportation system easily and confidently. The responding concept of accessibility for all is therefore being considered to a greater or smaller extent in certain mobility projects. Universal Design, Design For All or Universal Access are different approaches that mainly attempt to increase the exact same thing: accessibility for the largest possible range of groups in society.

However, these concepts do not address satisfactorily the specific mobility and accessibility requirements of individuals with disabilities nor the specific involvement and mutual responsibilities of key actors. In addition to Universal Design Principles, the development of an inclusive mobility system requires the respective competencies from politics, the private sector (economy and industry), academia as well as civil society and advocacy groups as the theoretical quadruple helix approach suggests [4]. Yet, it is a complex task to identify the relevant intersections between these players. The target of this paper is to provide an adequate framework for the development of such an inclusive mobility system by encompassing a wide range of accessibility and mobility requirements and assigning their realisation to specific sectors (government, the private sector (economy and industry), academia, civil society and advocacy groups). Transportation system planning approaches can derive key components that constitute a conceptual framework for an inclusive mobility system (see figure 1) by intersecting

- Universal Design Principles with [5]
- specific mobility and accessibility requirements and [6, 7]
- respective competencies and responsibilities of the involved sectors [8, 9, 10].

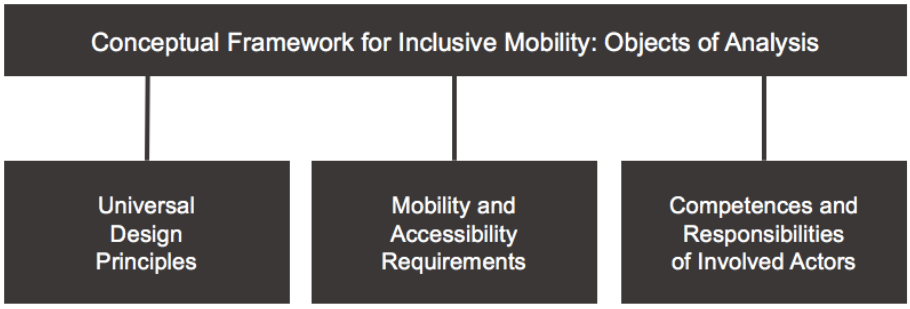


Figure 1. Objects of investigation for deriving a conceptual framework.

2. Methodical Approach

The methodical approach consists of a comprehensive qualitative thematic analysis of the three presented categories in figure 1. The following three subchapters provide a brief overview of the main results retrieved by the analysis. Thereupon, the key components for an inclusive mobility system are presented in chapter 3.

2.1. Universal Design Principles

The decisive idea for developing a conceptual framework for an inclusive mobility system is based on the Universal Design Principles. The Universal Design Principles aim to construct physical, learning and working environments that can be used by the widest possible range of people regardless of their age, gender, ability or disability. The key feature behind Universal Design is promoting access for individuals with disabilities, while it also benefits other groups in society. Universal Design operates by a set of seven principles defined to maximize accessibility for everyone [11]:

- Equitable Use: The design is useful and marketable to people with diverse abilities
- Flexibility in Use: The design accommodates a wide range of individual preferences and abilities
- Simple and Intuitive Use: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills or current concentration level
- Perceptible Information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
- Tolerance for Error: The design minimizes hazards and the adverse consequences of accidental or unintended actions
- Low Physical Effort: The design can be used efficiently and comfortably and with a minimum of fatigue
- Appropriate Size and Space for Approach and Use: Appropriate size and space is provided for approach, reach, manipulation and use regardless of user's body size, posture or mobility

In Table 1 the seven Universal Design Principles are represented in the context of an inclusive mobility system.

Table 1. Universal Design Principles in the context of inclusive mobility.

Universal Design Principle	Example (in the context of inclusive mobility)
1_Equitable Use	A ticket counter or info terminal may be raised or lowered to accommodate users of varying height or individuals using a wheelchair
2_Flexibility in Use	An avatar-based or captioned video as part of a digital passenger information system allows people to choose to listen or to read in order to understand content (ensuring the two-sense principle)
3_Simple and Intuitive Use	A corporate, easily legible and high-contrast design of guidance systems at traffic stations and traffic nodes (including acoustic, optic and tactile guidance systems)
4_Perceptible Information	Ensuring a combination of tactile and/or optical and/or acoustic elements in the design of information and navigation systems in compliance with the two-sense principle
5_Tolerance for Error	Access routes free of protruding objects which could not be detectable by an individual with visual impairment using a cane
6_Low Physical Effort	Appropriate door dimensions and automatic door operation (in vehicles as well as in traffic stations) in order to facilitate access
7_ Appropriate Size and Space	Appropriate design of vehicle interiors (e.g. including a variety of seating options such as enough space for people using a wheelchair or wider chairs for individuals who are taller and/or larger)

2.2. Specific mobility and accessibility requirements for individuals with disabilities

The comprehensive identification of mobility and accessibility requirements for individuals with disabilities is based on a thematic analysis of relevant Austrian standards (e.g. ÖNORM B1600, ÖNORM EN 115, ÖNORM A3012, ÖNORM V2105, ÖNORM A6015 etc.), ISO standards (e.g. ISO 3864-1) and the "Guidelines for barrier-free public transport" by the Austrian Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology [6]. Mobility and accessibility requirements involve every stage of the travel experience (i.e. pre-trip, on-trip, post-trip) and include elements that are provided by technology, the built environment and human interaction (as represented in table 2).

Table 2. Structuring mobility and accessibility requirements.

Technology (in the context of inclusive mobility)	**Built Environment** (in the context of inclusive mobility)	**Human** (in the context of inclusive mobility)
• Design of digital passenger information and navigation systems that can be accessed and presented with electronic devices • Design of vehicles and vehicle components (exterior and interior) • Interactions between technologies, the built environment and humans	• Design of traffic stations and nodes (access routes, waiting rooms, POIs, parking spaces etc.) • Design of guidance systems (tactile, optic and acoustic) and analogue information systems (e.g. signs) at traffic stations and traffic nodes	• Provision of personal assistance for individuals with disabilities • Inclusive guidelines for operational organisation (company strategy) • Public awareness raising for inclusion

2.3. Respective competencies and responsibilities of the involved sectors

Governmental, academic, industrial and economical as well as societal roles and responsibilities [8, 9, 10] in the context of inclusive mobility are presented in table 3.

Table 3. Roles and responsibilities of the involved sectors.

Government	**Private Sector**	**Academia**	**Civil Society & Advocacy Groups**
• Setting an overall direction of policy • Coordination of environmental, economic and social externalities • Coordination of transport, land-use and economic goals • Communicating with public about transport system operation • Balancing the needs of different transport systems and users • Provision of public goods and services (which are not profitable) • Defining basic standards of operations and rules of movement • Funding the provision and upkeep of infrastructure • Supporting the adoption of transport innovations (funding innovation and research)	• Service models and business opportunities • New technologies, applications and equipment • Organisation of the transport chain (routing of passengers through the transport system using a mix of transport services and infrastructures) • Operation of transport services (bus services, rail services, barge and maritime services, airline services, trucking as well as passenger services at transport nodes) • Operation and organisation of transport infrastructure (transport nodes and transport links) • Demand and application-oriented (basic) research	• Knowledge- and application-oriented (basic) research • Addressing socially, economically, ecologically and technologically relevant issues • New technologies, applications and equipment	• Consuming transport goods and services • Respecting rules of movement • NPO and NGO activities to address specific needs and to advocate minority aspects

3. Results and discussions

The presented distribution of key roles and responsibilities allows to assign sectoral responsibilities for inclusive realisation of the elaborated list of mobility and accessibility requirements. By discussing this thorough intersection with stakeholders, eight key inclusive components (*i components*) for the development of an inclusive mobility system would be derived (figure 2).

Figure 2. *i components*

i Car | Inclusive Vehicle Equipment: The category *i Car* describes the requirements for an inclusive exterior and interior equipment and design of transport vehicles.
i Environment | Inclusive Environment: The category *i Environment* presents the requirements for an inclusive barrier-free and user-friendly design of transport stations and transport nodes. *i Environment* also includes guidance systems and passenger information and navigation systems that are part of the built environment. A distinction is made between visual, tactile and acoustic components. In addition, required forms of interaction between the built environment, technologies and humans are described.
i Ride | Inclusive Trip Management: The category *i Ride* addresses the inclusive design of digital trip management elements. This category includes digital passenger information, guidance and navigation systems that can be accessed by electronic devices (e.g. smartphone, tablet, smartwatch, info-terminals etc.). Inclusive trip management includes barrier-free and user-friendly ticketing, reservation, payment, routing and navigation processes for each stage of the travel experience (pre-trip, on-trip, post-trip).
i Assist | Inclusive Assistance: Within the category *i Assist*, opportunities for provision of individual and personal assistance are described. The main potential of personal assistance is to serve as a backup level for electronic systems and services (that are mainly described in the category *i Ride*).
i Organize | Inclusive Operational Organisation: The category *i Organize* describes solutions for the operational organization and operational framework (inclusive company strategies). This category also includes communication levels between the government, the private sector, academia, civil society and advocacy groups.
i Code | Inclusive Regulations and Standards: The category *i Code* points out the necessity of standardized processes, traffic rules, standards and norms.
i Image | Inclusive Awareness Raising: The category *i Image* highlights the development of inclusive image campaigns and describes general requirements for public awareness raising in the context of automated mobility and inclusion.
i Funding | Inclusive Funding: The category *i Funding* describes the necessity of financial support for applied and basic research in the context of mobility and inclusion. Besides research funding, it depicts the financial needs for provision, upkeep and adaptation of (not barrier-free) infrastructure and for adoption of transport innovations (that result out of applied and basic research from the private sector and academia). *i Funding* also contains public subsidisations of private mobility and enterprise support.

Table 5 illustrates the *i components*, the respective component-subcategories and the main responsibilities for successful realization and implementation of the subcategory (government G, private sector P, academia A, civil society and advocacy groups S). It should be noted that for each subcategory, a full-featured list of accessibility and mobility requirements (including references to standards already met/unmet) has been elaborated. The following table only provides a structural overview.

Table 5. *i components*, component-subcategories and main sectoral responsibilities for realization and implementation (G: government, P: private sector, A: academia, S: civil society and advocacy groups).

i Car		i Environment		i Ride		i Assist	
G **P** A S	External and internal appearance of vehicles	G **P** A S	Access routes to, in and from traffic stations	G **P** **A** **S**	Corporate design for passenger information and navigation systems (indoor and outdoor)	G **P** **A** **S**	Individual support during each stage of the trip (pre-trip, on-trip, post-trip)
G **P** A S	Door and door operation	G **P** A S	Doors and door operation	G **P** **A** **S**	Optical guidance systems and passenger information	G **P** A S	Enabling permanent passenger feedback
G **P** A **S**	Boarding Assistance	G **P** A S	Stairs, escalators, ramps and lifts in traffic stations	G **P** **A** **S**	Tactile guidance systems and passenger information	**G** **P** **A** **S**	Enabling permanent access to information on the current status of the transport system
G **P** A S	Equipment of passenger compartments	G **P** A S	Waiting areas & parking spaces	G **P** **A** **S**	Acoustic guidance systems and passenger information	G **P** A S	Emergency and safety management
G **P** A **S**	Emergency and safety management	G **P** **A** **S**	Interactions between technologies, the built environment and humans	G **P** A **S**	Emergency and safety management	G P A S	…
G P A S	…	G **P** A **S**	Emergency and safety management	G P A S	…	G P A S	…
G P A S	…	G P A S	…	G P A S	…	G P A S	…

Table 5 (continue). *i components*, component-subcategories and main sectoral responsibilities for realization and implementation (G: government, P: private sector, A: academia, S: civil society and advocacy groups).

i Organize		i Code		i Image		i Funding	
G **P** A S	Inclusive Guidelines for Operational Organisation	**G** **P** A **S**	Standardization of emergency and safety management	**G** **P** **A** **S**	Public Awareness Raising	**G** **P** A S	Financial support of applied and basic research
G **P** A **S**	Inclusion of people with disabilities in all construction and reconstruction processes	**G** P A **S**	Standardization of traffic rules and rules of conduct	**G** **P** A S	Public advertisement of implemented and realized measures on inclusion	**G** **P** A S	Financial support for provision, upkeep and adaptation of infrastructure
G **P** A S	Professional employee training to raise awareness on inclusion and equality	**G** **P** **A** **S**	Standardization of information, guidance and navigation systems	G P A S	…	**G** **P** A S	Financial support for adoption of transport innovations
G **P** A **S**	Recruitment of individuals with disabilities in key positions	**G** **P** **A** **S**	Standardization of vehicle appearance & components	G P A S	…	G P A S	…
G P A S	…	**G** **P** **A** **S**	Standardization of elements within the built environment	G P A S	…	G P A S	…
G P A S	…	G P A S	…	G P A S	…	G P A S	…

4. Conclusions

The conceptual framework presented in this paper involves organisational, societal, economical, governmental, technological and non-technological aspects for a successful realisation of an inclusive mobility system. Developments in the field of digitization and automation are expected to transform the future of mobility as digital technologies are increasingly being incorporated into vehicles, traffic systems, infrastructure and passenger information systems. There exist several areas within transport division where technological improvements are needed (e.g. ensuring that transport operators provide disabled people with the information they need to use mobility services). Thus, innovations in the field of automation and digitization have the potential to improve accessibility, equality and inclusion for marginalised groups. Besides the thematic analysis of Universal Design Principles, accessibility and

mobility requirements and roles and responsibilities of involved actors, the presented framework on inclusive mobility still must be supplemented by a fourth level of analysis: automation and digitization. By including this additional analysis, the delta to what extent automation and digitization will contribute to inclusion and equality can be captured qualitatively.

Acknowledgment
This research was partially conducted within the project "AM inclusive!" that is funded by the Austrian Ministry for Climate Protection, Environment, Energy, Mobility, Innovation and Technology within the research programme "Mobility of the Future".

References

[1] UN General Assembly, "Universal Declaration of Human Rights", 217 A (III), 1948.
[2] UN General Assembly, "UN Goals on Sustainable Development", *available at https://sustainabledevelopment.un.org/?menu=1300* [accessed on 25 March, 2020].
[3] United Nations, "Convention on the Rights of Persons with Disabilities", *Convention on the Rights of Persons with disabilities (CPRD) | Persons with disabilities, A/RES/61/106,* 2007.
[4] M. Peris-Ortiz, L. Farinha, J. J. Ferreira, N. O. Fernandes, „Multiple Helix Ecosystems for Sustainable Competitiveness", *Innovation, Technology, and Knowledge Management, Springer International Publishing Switzerland,* 2016.
[5] H. Persson, H. Ahman, A. V. Yngling, J. Gulliksen, "Universal design, inclusive design, accessible design, design for all: different concepts-one goal? On the concept of accessibility-historical, methodological and philosophical aspects," *Univ Access Inf Soc 14*, pp. 505-526, 2015.
[6] BMVIT, "Leitfaden für barrierefreien öffentlichen Verkehr", 2009.
[7] IbGM Institut für barrierefreie Gestaltung und Mobilität, „Survey on information for people with reduced mobility in the field of public transport*", Study for EMTA (European Metropolitan Transport Authorities*, 2003.
[8] I. Docherty, G. Marsden, J. Anable, "The governance of smart mobility", *Transportation Research Part A 115*, pp. 114-125, 2018.
[9] M. Alonso Raposo, M. Grosso, J. Despres, E. Fernandez Macias, C. Galassi, A. Krasenbrink, J. Krause, L. Levati, A. Mourtzouchou, B. Saveyn, C. Thiel, B. Ciuffo, " AN analysis of possible socio-economic effects of a Cooperative, Connected and Automated Mobility (CCAM) in Europe. Effects of automated driving on the economy, employment and skills", *JRC Science For Policy Report,* 2018.
[10] A. l'Hostis, B. Muller, G. Meyer, A. Bruckner, E. Foldesi," MOBIL-ITY4EU - D2.1 - Societal needs and requirements for future transportation and mobility as well asopportunities and challenges of current solutions", *Research Report IFSTTAR - Institut Françaisdes Sciences et Technologies des Transports, de l'Aménagement et des Réseaux*, 2016.
[11] M. M. Mustaquim, "A Study of Universal Design in Everyday Life od Elderly Adults", *Procedia Computer Science 67,* pp. 57-66, 2015.