Discussing the accessibility of urban environments: standards, efforts, perceptions

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Abstract

In recent years, there has been a renewed interest in the transport literature regarding the observed discrepancies between measured and perceived accessibility. This particularly concerns people on whom unequal access weight the most. Confronting this ambivalence is essential as it shapes the nuanced understandings of decision-makers, technicians and the broader population, ultimately affecting the relevance of policy responses. Few studies have yet explored how this distinction should be introduced into public reasoning. First, we draw on insights from social geography and disability studies to describe the three underlying states of accessibility: 1) institutional norms, 2) efforts made when moving within the city, and 3) individuals' dispositions and perceptions. Connecting these aspects to Fraser's theory of social justice, we propose a participatory methodology for dealing with disabling environments. It is then used to inform transport policies aimed at alleviating access inequalities affecting Persons with Reduced Mobility in Strasbourg, France. Our contribution lies in the development of mixed-methods measures and collaborative planning to support associations in their advocacy efforts. We conclude with a discussion on the positioning of researchers in a participative process with respect to public officials and operators.

Keywords: Participatory research, Transport policy, Disability, Recognition, Advocacy

Highlights

- Accessibility tackles concerns related to redistribution as well as representation and recognition.
- These concerns are respectively linked to physical access, internalized motility and the development of standards.
- We contribute to a better appreciation of diverse experiences and perceptions by focusing on public participation.
- Constraint-based measures can address heterogeneity and intersectionality issues within vulnerable populations.
- Mitigating information asymmetries between (public transport) stakeholders is the main challenge and a *sine qua non* of (our) action research.

Introduction

One of the widely shared views among researchers is that concerns about the redistribution operated by transport systems in relation to equity and social exclusion should primarily focus on accessibility as a human capability (e.g. Beyazit, 2011; Pereira, 2017; Vecchio and Martens, 2021). Most studies thus align with Sen's and Nussbaum's perspective: capability—rather than utility—should be the basis for justice, emphasizing the range of abilities and opportunities individuals have at their disposal to generate valuable outcomes (Sen, 1985, 1993, 2009; Nussbaum, 2011). Various cumulative-opportunity and gravity-type accessibility metrics have been developed, building on the pioneering work of Hansen (1959). These place-based measures consider accessibility as a combined capability and count the opportunities typically associated with the benefits of density (such as jobs, services, leisure activities, etc.) from a given location, within an isochrone. However, since these measures are generic and vary depending on the type of opportunity—if it is excludable or not, rivalrous or not (cf. the typology of Ostrom and Ostrom, 1977), a large range of methods are available, whether accounting for competition or congestion (e.g. Shen, 1998; Páez et al., 2019; Soukhov, 2023). More recently, the greenhouse gas reduction goals (IPCC, 2023) provided incentives for the development of carbon-constrained measures (Kinigadner et al., 2020). In parallel, there have been many advocates for developing individual-based approaches (e.g. Geurs and Van Wee, 2004; Martens, 2016) and evaluating transport systems not on the base of macro- and technical performances, but rather on the service that differently located people receive according to their needs. This type of measure is more sensitive to inequalities between individuals and considers how individual characteristics (such as income, age, impairments, gender, etc.), as well as personal commitments, can affect abilities. It includes activity-based (e.g. Dong et al., 2006; Nahmias-Biran, 2021) and space-time measures (e.g. Kwan, 1998), which often require large amounts of microdata or household mobility surveys.

In any case, characterizing accessibility poverty (understood as a capability deprivation) or drawing value judgements from these indicators is arduous. The first challenge to consider is the mismatches between measured accessibility and the way it is perceived by people of different background and age, among others (Lättman et al., 2018, Pot et al., 2021, Ryan and Pereira, 2021). Added to this is the disaggregation of accessibility needs over particular areas and for specific transport users. Besides, the use of the theory of *sufficientarianism*, which is quite common (e.g. Lucas et al., 2016; van der Veen et al., 2020), has been widely criticized for many reasons (Timmer, 2022). By setting thresholds—more or less arbitrarily—representing minimum accessibility standards, it establishes a priority that can clearly guide policymakers. Yet, after reaching the threshold, this absolute priority shifts to no priority at all. Policies become indifferent to inequalities or preferences, and therefore qualified.

These difficulties echo Sen's reluctance with regard to operationalization, as he defended 'primarily a critical perspective to encourage public reasoning and respect agency on the definition of what should count for the evaluation of social states' (Baujard and Gilardone, 2017). We reaffirm that such a critical reading of the procedural aspect of justice is crucial. Whereas most quantitative publications focus on defining what's equitable or not, we should bear in mind that these measures, which are both positive (i.e. descriptive or constative) and normative (Páez et al., 2012), tackle concerns related to (re)distribution as well as representation and recognition. We develop these dimensions of social justice using Fraser's theoretical framework (2008):

- *Redistribution* refers to the equitable sharing of opportunities, costs and efforts. Contemporary debates are all rooted in or influenced by Rawls' conception of egalitarian justice (2001). In line with the veil of ignorance concept, which starts from a situation in which no one knows who will have to bear what burden, the solution is to maximize the position of the least well-off and ensure

the acceptance of the distribution, assuming it is not compromised by sentiments of downgrading, marginalization, or the monopolization of opportunities by a dominant group, whether real or perceived. This is mainly what equity planning is about (Krumholz and Hexter, 2018).

— *Representation* is about politics. It is probably the concept that is closest in semantics to the *Right to the city* as theorized by Lefebvre (1967). This right, 'far more than an individual liberty to access urban resources, [is] a common, on which depends upon the exercise of a collective power to reshape the processes of urbanization' (Harvey, 2003). In this sense, citizens must be empowered and able to challenge a mobility norm to which they are subjected, exposed, or worse still, excluded. It is therefore crucial that all stakeholders are represented in the decision-making process. This implies broad participation and the consideration of their feelings, whether linked to autonomy, comfort, or safety. Such perspectives resonate with the advocacy planning theory (Davidoff, 1965).

— *Recognition,* which should theoretically result from the latest, focuses on ensuring the respect of all social practices, particularly those of minorities. It is expressed through legal and institutional norms. For public authorities, the main challenge regarding accessibility is the design of universal infrastructures, and, in cases where immediate action is not materially feasible, determining what constitutes a reasonable accommodation, for instance segregated and tailored services.

In Figure 1, we propose to link these three dimensions to the three 'states' of the social world[1], in accordance with Ripoll (2024). On the outside, the three states of accessibility are shown as constantly in tension. They do not exist independently of one another, so it is crucial to 'dialectize' them, as represented by the arrow. Around the circle, we detail the social contexts in which these realities clash.

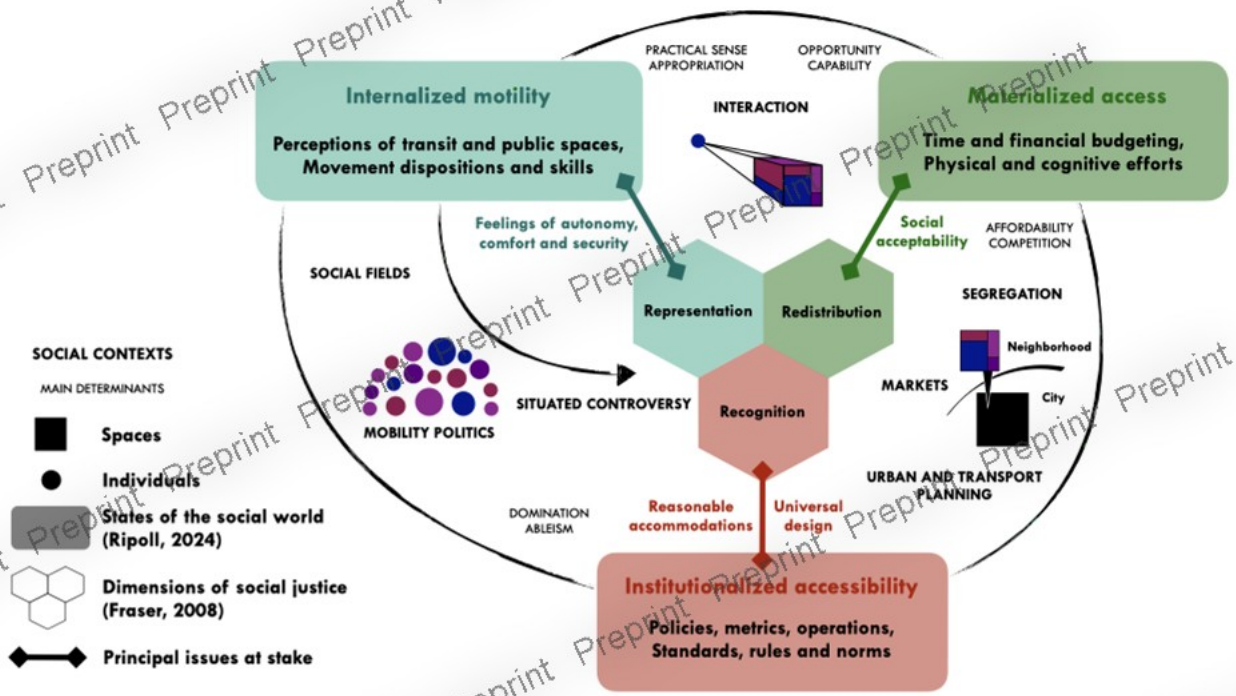

Figure 1. The dialectics of accessibility, physical access and motility.
N.B. All the sketches are purely illustrative.

[1] This conception stems from Lefebvre's spatial triad (1974) coupled with Bourdieu and Passeron's theory on the three states of cultural capital: internalized, objectified and institutionalized (Bourdieu, 2018).

The measurement standards described above and all other planning norms are part of the institutionalized state of accessibility. They are mainly employed by urban planners, academics and transport operators, who aim to mitigate the segregation trends inherent in urban growth (gentrification, sprawl, etc.) and decay (aging, economic recession, etc.). These issues are currently worsened by the intense competition for accessibility and proximity improvements in urban environments (Pozoukidou and Chatziyiannaki, 2021). The impact of public transportation (PT) and active mobility investments on the displacement of incumbent residents (Anguelovski et al., 2016; Padeiro et al., 2019) suggests that access should be considered in conjunction with social disadvantage (Lucas, 2012). The latter includes obviously car dependence (Illich, 1974), modal mismatches (Grengs, 2010), or other constraints arising from housing affordability and subsequent relocation in suburban contexts (e.g. Allan and Farber, 2020; Pons et al., 2024)—whose fairness is at least questionable. The variety of efforts in accessing opportunities through physical, cognitive, and financial efforts are a structural component of this mobility divide. By definition, these experiences are subjective and depend on individuals' practical sense (Bourdieu, 2020)—hence the sketch of a space distorted by perspective (Figure 1). This succession of interactions with the social environment shapes continuously motility, i.e. the potential and actual capacity of people to be mobile. Kauffmann et al. (2004) identified three major features of motility (access, competence and appropriation), adding an internalized dimension to the conventional mobility research. It encompasses the set of schemes structuring individuals' mobility, including perceptions of public spaces, particularly transit areas, dispositions, and skills. These schemes, incorporated by stakeholders, contribute in turn to the institutional construction of norms. Their formalization is relational, meaning it arises from interacting *social fields* ('a network, or a configuration, of objective relations between positions objectively defined', Bourdieu and Wacquant, 1992: 72–3), primarily across a multiscalar administration (European, national, local), NGOs, operating companies and experts, some of which act under the hierarchical authority of political decision-makers. Like any other technical conception, the ensuing standards can (un)intentionally marginalize minority populations or reproduce modes of domination by embedding them in 'machines, instruments, and structures of common use' (Winner, 1980). For instance, ableism (i.e. the imposition of a norm grounded on prejudice and expressed through the discrimination of 'the impaired') may be seen as the expression of a *symbolic violence*[2], resulting in forms of 'disablist oppression and disabled resistance' (Kitchin, 1998). The latter have predictably lessened with the gradual incorporation of disabled peoples' organizations into impairment-management (Blackmore and Hodgkins, 2012), though inclusion is far from fully realized on the ground.

When discussed, this set of considerations manifest as a context-specific controversy, typically dealing with transport poverty (redistribution), public participation (representation) and disability (recognition). Each aspect cannot be radically disconnected from the others since—we insist—social states are interdependent and do not exist in isolation. For example, in our case on PT users, an initiative to evaluate mobility efforts and their spatial (re)distribution also contributed to recognize users' diversity, as long as the research process does not under-represent their viewpoints. For that last matter, recent progress in interactive mapping has further enhanced the appreciation of diverse experiences or perceptions, thus advancing participatory approaches (e.g. Stewart, 2017; Pajares et al., 2021). Such developments are tied to ongoing questions about the nature of knowledge—more specifically, how knowledge can be used to support the interests of the most vulnerable people, helping them strengthen their position in society (Habermas, 2015). In this vein, we develop hereafter a methodology close to participatory action research (Kitchin, 2001; Baum et al., 2006), aimed at reducing accessibility inequities through the involvement of diverse people and associations—who, in turn, take public actions. Our first objective was to improve recognition using specific measures, in order to make inequalities more visible. We thus used qualitative insights to

[2] *Symbolic violence* is a concept used in analyses of social reproduction and relations of domination, which helps to structure the social order through the internalization of hierarchies and norms (Weininger, 2005).

calibrate accessibility measures that promote universalism. Our research drew inspiration from the gradual emergence of mobility studies mixing quantitative and qualitative methods, which mainly use convergent parallel, exploratory or explanatory sequential designs (e.g. respectively Routhier et al., 2019; Shay et al., 2016; Tiznado-Aitken et al., 2020). More broadly, we built on *disability studies* approaches (e.g. Imrie, 2012; Hall and Wilton, 2017; Goodley and al., 2019) by focusing on individual experiences. We acknowledged subjectivities as a reality in themselves, whether access constraints were observed, perceived or both.

This article examines the benefits, challenges, and complexities of developing a participatory research within a mixed-methods approach in a case study for *Greater Strasbourg* (Section 1). Our work is therefore based on two convergent investigations: a quantitative exploration, which aims to measure and map urban accessibility according to mobility constraints; and a qualitative study, which seeks to gather and interpret the experiences of Persons with Reduced Mobility[3] (PRM), translating them into policy issues. This provides a foundation for collective reflection with stakeholders (associations, transport operators and authorities) on possible solutions (Section 2).

1. Methodology

1.1. French context

The concept of accessibility for disabled people was first introduced into French law in 1975, which laid the groundwork for making public buildings, housing, and transportation accessible. Article 49 of this law required that architectural modifications enable access for disabled individuals, while Article 52 proposed two approaches for transportation: making public transportation accessible and developing specialized services, the latter sometimes viewed as segregative. Between 1975 and 2005, public policies primarily focused on developing specialized transport services, with the adaptation of regular PT remaining a secondary concern. Associations, particularly the *French Association of the Paralyzed* (known today as *APF France handicap*) and the *Group of Intellectuals with Physical Disabilities*, played major roles in advocating for inclusion. The 2005 law marked a turning point by imposing more precise objectives and sanctions for non-compliance. It extended the accessibility mandate to encompass the entire mobility chain, including buildings, roads, public spaces, and transportation. It also established the creation of municipal accessibility commissions in municipalities with more than 5,000 inhabitants, tasked with monitoring the state of accessibility and proposing improvements. Over the years, the issue of social and spatial inequalities in mobility has become increasingly prominent in public discourse. This was further highlighted by the rise of urban policies (*Politique de la ville*) in the 1990s and 2000s, which addressed public action within deprived urban districts—many of them suburban—listed as *Priority Neighborhoods* by the French administration. These policies consider inequalities in access to essential resources such as employment, healthcare, and education, thus recognizing accessibility as a key condition for social participation. Since then, significant national investments have been made to deploy high-frequency PT in these neighborhoods, particularly tramways. Despite these advances, accessibility and 'inclusive mobility'—as it is most often framed in contemporary public debate—remains salient issues in France. Although the concept of a 'right to mobility' was introduced in the 2019 Mobility Orientation Law, this provision does not compel the State or local authorities to guarantee effective access for everyone. In 2023, the French government was condemned by the European Committee of Social Rights for violating several articles of the European Social Charter directly affecting people with disabilities. The National Consultative Commission on Human Rights concluded that, in France, people with disabilities are still suffering from discrimination and forms

[3] Whether 'caused by disability, age or any other factor' (cf. the eponymous European Union legislation).

of social exclusion, facing ongoing barriers to their autonomy and full participation in society due to a lack of coordinated and sufficient responses.

Our study is set in Greater Strasbourg, an administrative area located on the border between France and Germany (Rhine River) with a population of about half a million inhabitants. After the old tramway disappeared in the early 1960s, a redevelopment has been underway since the 1990s after the rejection of a costly underground light metro project. Besides its relatively young age and the modest size of the local urban area, relatively good accessibility of Strasbourg's transport infrastructure can be attributed to the former mayor's preference for street-level facilities, fostering pedestrianization and traffic evaporation. In this city, accessibility objectives for PRM intersect with the broader challenge of sustainability, which is often the primary lens through which mobility projects are conceptualized. Within the Greater Strasbourg Authority (*Eurométropole de Strasbourg*, notably in charge of transportation), this is reflected in the placement of the 'Mobility' department under the General Directorate for 'Ecological and Economic Transformation'. The issue of accessibility challenges the local authority, its competencies, and its human resources. At the crossroads of social and territorial action, coordinating efforts to address the diverse levers of accessibility—such as information, communication, strategy development—appears complex. *Strasbourg Transport Company* (usually abbreviated CTS) and associations representing people with disabilities are also key stakeholders. The local authority interacts with associations and collaborates with the (public) operating company. However, the lack of a designated PRM representative within this company complicates communication on these issues between the two organizations.

1.2. Epistemological stance

We chose to define our target group as *vulnerable*. These individuals are in vulnerable situations because their physical or visual impairments can potentially—not necessarily—affect their ability to move or access services compared to a non-disabled individual. In other words, the use of this term emphasizes the potential nature of (dis)ability and accessibility, highlighting the possibility that required access efforts become dissuasive or impracticable, therefore exclusive. This distinction separates impairments from the experience of disability and frames the research project within a situational approach. Disability is then seen as a socio-environmental construct, shaped by the social, cultural, and physical environment in which one finds oneself. The study, therefore, focuses on the environment as a determinant of disability situations. To understand accessibility, it is necessary to analyze the interaction between the individuals and their environment (social, institutional, and urban).

Three populations were pre-identified: physically and visually impaired people, along with the elderly (who often experience multiple physical impairments). It is through these characteristics that it has been possible to identify targeted individuals—with the valued help of people working in the fields of disability and social welfare for various organizations. Although these populations may appear to be defined—or even self-defined—by their impairments, their realities can differ widely. The ability to move or the lack thereof among individuals cannot be explained solely by impairments, or used tools (electric or manual chair, walking stick), or devoted guides (e.g. dogs). Even within social groups sharing the same physical impairment, each person develops their own competences and routine. These individual abilities and dispositions can either compensate for or reinforce disability situations. These initial factors therefore impact the intensity of potential disability situations. Using a cane requires specific skills for instance, and a person who has learned these skills will generally have fewer difficulties moving around, as they can avoid many obstacles. Consequently, a homogeneous group of individuals with impairments will not share the same experiences of mobility. More specifically, for the same trip, each person will need to exert different levels of physical, cognitive, and material effort. Additionally, within these three populations, there are individuals with varying degrees of impairment. Physical impairments themselves can differ in form

and severity. The individual trajectories of disability situations also influence the development of compensatory skills. For example, a person with a congenital physical or socio-cognitive impairment will likely have fewer difficulties than someone who acquired the impairment later in life. Moreover, these populations, which share common impairments and form minorities that are both self-determined (organized into associations) and socially constructed, have plural identities (social classes, gender, age, etc.) that interact with their forms of impairment and can either mitigate or exacerbate individual vulnerabilities.

1.3. Observing routes and routines: a research process

We targeted individuals considering themselves to be impaired by reaching out to representative associations of these three populations: *Abrapa* (a personal service association representing the elderly), *C'cité* (representing blind or visually impaired people), and *APF France Handicap* (representing physically impaired people) to conduct interviews with individuals fitting this profile. It is worth mentioning that the last two associations have collaborated or are currently collaborating with the local authorities on urban development projects. Thus, the qualitative research process began by collecting perceptions, then observing and characterizing accessibility efforts in the urban environment.

The first phase focused on gathering mobility experiences and identifying and prioritizing accessibility issues in partnership with the affected individuals. The aim was to capture a broader set of barriers encountered by the participants, whether perceived, quantifiable or both. The go-along interview method was used to identify a variety of accessibility barriers. This method has the advantage of putting vulnerable individuals in a real-life situation along a route chosen as representative of their daily lives. To ensure the most realistic conditions, the researchers accompanied the individuals from their homes to their destinations, including the access trip (from their homes to the first stop or station), the use of transportation (including transfers), and the egress trip (to the destination). The researcher was able to collect empirical data both through observation (during the movement) and through interviews conducted with the participants during the walk and ride. In action, facing various experienced problems, the participants could mention the habitual or unique aspects of certain situations they encountered. This also allowed them to refer to similar difficulties encountered during other journeys. Mobilizing the researcher's observation and the semi-structured nature of the interview conducted along the routes, the team was able to gather the participants' perceptions of accessibility issues in their environment. Focus groups were then organized to further clarify and prioritize these accessibility issues. A participatory approach was developed throughout the analysis of the mobility practices of vulnerable individuals to remain faithful to what the concerned individuals conveyed and, more importantly, to highlight the issues that they considered important. Based on problems already identified during the previous analysis, we facilitated interactions among the concerned individuals to further clarify and characterize the issues. It is through interaction that participants could more easily engage in explaining and arguing their points. The fact that these individuals were gathered together also allowed the research team to work collaboratively with them to prioritize the identified issues. Therefore, this process of retracing, clarifying, and prioritizing the accessibility issues identified in the first phase in a collective and concerted manner will inform the third and final phase of this study: the reflective work on potential solutions.

In the second phase, we conducted discussions and facilitated working sessions to identify desirable and feasible solutions with three sets of expert stakeholders: transport operators, local authorities, and representatives of associations (C'cité and APF). To do this, three complementary tasks were undertaken before organizing the reflection meetings:

1/ Building relationships with the stakeholders and identifying individuals who are available, willing, and knowledgeable about accessibility and disability issues. For a lot of officials, accessibility concerns are not necessarily a priority. One must navigate the commitment and the possibility or impossibility of investing time in these discussions we initiated. In Strasbourg, this work seems significantly dependent on individual commitment beyond the question of their areas of expertise or missions. For example, the *Greater Strasbourg Authority* has an accessibility referent who has been collaborating with associations on these issues for years, even though these missions do not fall within his official position. He was, of course, a reference person in our research.

2/ Gaining a thorough understanding of the national politico-administrative context regarding accessibility for vulnerable people and the political and organizational environment of the local authority on this issue. This effort was essential for targeting the right stakeholders to include in the meetings and understanding the arguments that the local authority might present during discussions.

3/ Determining the research team's role in this reflection process. Faced with these three types of experts, the research team chose to position itself as a decision-making support. In other words, a catalyst for communication. The idea was not to present results, demands or even propose various solutions as recommendations. The pragmatic approach guiding this phase was based on the premise that constructing appropriate and feasible solutions required considering numerous parameters that only the professionals or the concerned individuals could fully assess and recognize. The research team set the following objectives for these meetings: a) To communicate the mobility experiences of vulnerable people to the professionals of the local authority, ensuring that these experiences were conveyed accurately; b) To propose a new conceptualization of the accessibility problem, aiming to contribute to and restart a reflection on potential solutions; c) To collaboratively objectify accessibility and enable its measurement and mapping, addressing aspects like the continuum of effort intensity or establishing limits on factors like time and comfort; d) To develop and facilitate a collaborative process for sketching out possible solutions based on identified problems; e) To gather, understand, and interpret the arguments of experts regarding the feasibility of certain potential actions; f) To support a process of prioritizing public policy problems in light of our findings; g) To ensure that the co-constructed solutions were not only feasible but also reached a consensus among stakeholders.

2. Results

2.1. Addressing (dis)ability with constraint-based measures

It should be stressed that the evaluation of inequalities contribute to building the institutionalized state of accessibility, and thus the recognition of disabilities. For obvious accuracy and representation purposes, one must consider the most comprehensive sample of behaviors and perceptions available. This raises the issue of desegregation within targeted populations. We present here a constraint-based approach to accessibility, claiming that such measures can address heterogeneity and intersectionality issues within vulnerable populations. In our case, we computed travel times by walk and PT with twelve restrictive conditions from origins evenly distributed across the built environment (N≈2500). Go-along interviews have enriched our measures in two main ways:

1/ We focused on physical constraints (walking distance, transfers, steps, gaps, lack of information, etc.) and modeled the experiences of people who face the most difficulties in their movements. For instance, the lived experience of individuals who move very slowly or choose seemingly irrational routes (such as adding one or two extra transfers or significantly increasing total travel time to avoid

walking) allowed the team to assign values to calculation parameters[4] (a walking speed of 2 km/h and a 1.2 times greater aversion to walking compared to an average user). This approach does not follow the classic assumption that these values represent a sample of a targeted population, but instead acknowledges that these values exist and have been genuinely experienced. They correspond to an extreme negative scenario, representing a highly vulnerable potential user, aligning with the study's objective.

2/ We integrated technical knowledge from empirical observations of mobility practices into a reflection steeped in quantitative geography. For instance, Figure 2 illustrates the avoidance of routes not complying with wheelchair standards. The discussion following the go-along interviews revealed also avoided stations mainly due to orientation difficulties and stress. By cross-referencing information on these avoided stops, the researchers enriched the constraints with the notion of *complex station,* characterized by multiple tram lines on different platforms, high traffic in terms of vehicle entry/exit, and more broadly in the urban space, along with additional disruptive elements like ongoing construction or heavy traffic. Five stops were identified as *complex*, in addition to the central station (Landsberg, République, Baggersee, Etoile-Bourse, Homme de Fer).

Figure 2. Mapping travel times for routes complying strictly with wheelchair standards.
Sources: Greater Strasbourg Authority's *Anomalies* dataset, CTS, OSM, CORINE Land Cover. Authors' calculations.

All the refined results are available on a digital atlas[5]. It displays comparative travel times, thus informing the evaluation (i.e. both description and prescription) of extra efforts induced by each constraint. In Figure 3, we combined these constraints to develop a typology of efforts, namely those related to walking, orientation, and crossings. Travel times to fifteen major points of interest—defined through a consultation process—were discretized to better capture the constrained access to the city. It is important to note that these elements represent only a small portion of the ma-

[4] The parameters were set in OpenTripPlanner 1.4.

[5] https://justice-project.eu/atlas/. For arrival and departure times, we used several time windows during working days and weekends.

terial revealed by the qualitative approach, and that some challenges highlighted by the mixed-methods persist. For instance, we couldn't parameterize that a longer road network distance was perceived as shorter by some users due to the straightness of the routes or the quality of urban environment. A classical solution involves calibrating a parameter based on a massive though necessarily partial survey according to an assumption of substitutability of distance units—usually time rather than distance. However, it imperfectly represents the diversity of behaviors. These questions echo various works related to the value of time (Crozet, 2005), spatial syntax (Sevtsuk et al., 2021), or more broadly to walkability (Dovey and Pafka, 2020), but remain unresolved.

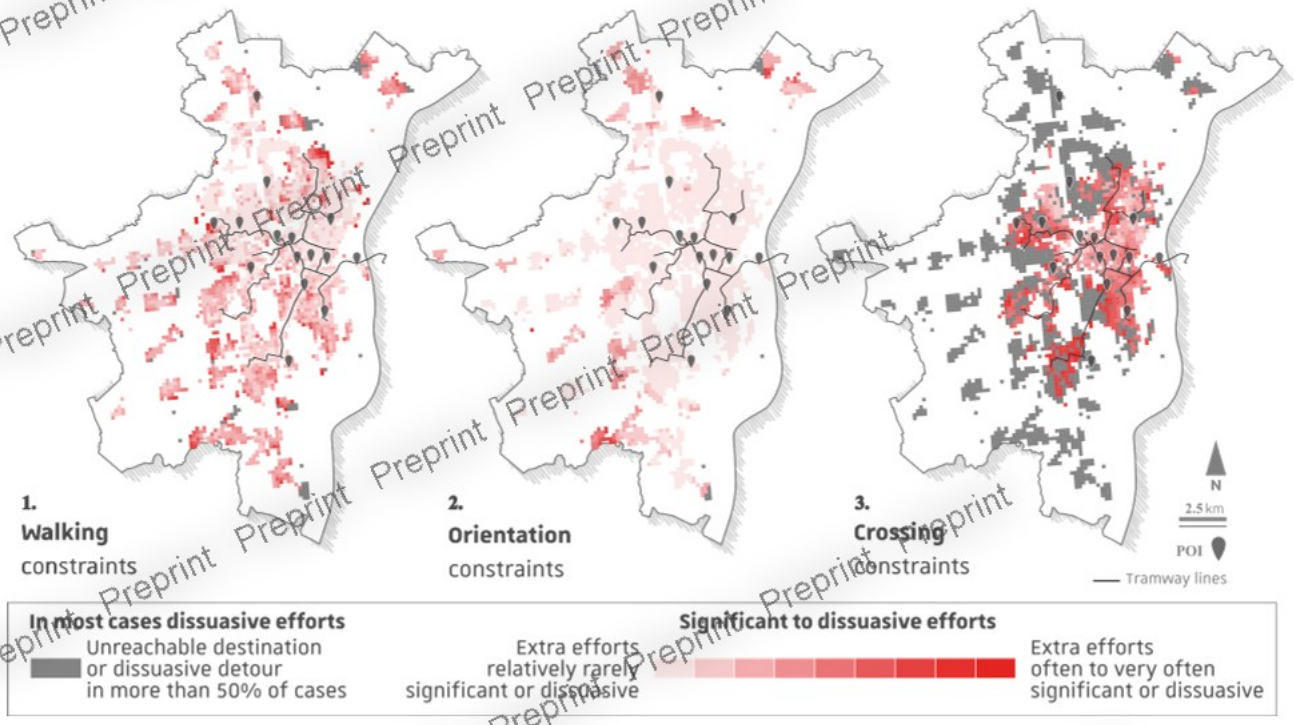

Figure 3. Typology of constraints encountered by users when accessing POIs.
We combined restrictive conditions, respectively: 1/ *walk reluctance* and *reduced speed*; 2/ avoidance of *complex stations* and those lacking *tactile paving*, *maps* or *voice announcements*; 3/ avoidance of *anomalies* within the *street* or *transport networks*, including *non-standard vehicles*. With regard to discretization, detours longer than 20 minutes have been qualified as *significant*, and we retained the definition of *dissuasive* detours (journey time >90 min, >3km walk or >3 transfers). Sources: *Anomalies* dataset, CTS, OSM, CORINE Land Cover. Authors' calculations.

2.2. Advancing accessibility with stakeholders

The aforementioned second phase of the research process (see section 1.3) consisted in working groups discussing potential solutions with stakeholders, based on the issues identified by users. Thirteen issues led to forty-two solutions discussed among participants. Several key points can be underlined. First, due to the quality and modernity of Strasbourg's rolling stock, only seven solutions (17%) involve physical improvements to infrastructure or vehicles. Solutions focus more on the urban environment and roadways (twelve solutions), followed by transport services (ten) and passenger information (ten). Operational factors definitely play a role: renewing a vehicle fleet is a long, costly process, happening progressively as vehicles enter in service and based on their condition. For economic and ecological reasons, there was a shift from transportation to a broader reflection, allowing for a discussion on various dimensions of accessibility and alternative action levers. However, the discussions were still more focused on public transport accessibility rather than accessibility through public transport. Solutions related to the urban environment mostly involve physical elements (eight out of twelve), such as tactile paving, station design, and material identification of

pathways, which are easier and less costly to implement. The remaining four solutions involve regulatory elements related to police powers (e.g. for badly parked bikes) or engaging with vulnerable populations before defining station design. Regarding PT services, traditional solutions like increasing service frequency and extended operating hours were not considered. Instead, less obvious solutions were proposed, such as addressing transport demand, agreements with driving schools, merging demand-responsive transport platforms, and allowing boarding through all doors. These choices reflect the economic and technical challenges of PT services. An original proposal involves increasing taxes for public works companies not complying with construction and environmental requirements, aiming to ensure the continuity of signage and pathways during disruptions. In terms of information-related solutions, discussions did not lead to concrete implementation means or conditions. The strategies mentioned remain vague and seem to serve as a way for stakeholders to offload responsibility. This lever appears easy to implement, possibly because it doesn't require urban interventions and because no information and communication experts were present to address potential limitations. Moreover, although operators are aware of the digital divide, many recommended solutions involving mobile applications. These digital solutions seem to be a fallback option after expressing difficulties with alternative solutions. Nevertheless, some digital proposals are useful and highlight the importance of information in improving accessibility, such as optimizing internal communication by cross-referencing user databases for reduced pricing.

Further, short-term and long-term solutions were distinguished based on feasibility. Short-term actions represent only one-third of the total. However, short timeframes must account for human resources, workload, and administrative time for project initiation. Short-term solutions therefore involve easier experiments, ongoing work, data acquisition, and low-cost accessibility assistance. Long-term actions make up 71% of proposed solutions for rolling stock, with cost and frequency of equipment renewal being the main limitations. Regulatory solutions, which involve actors not represented in discussions, are logically relegated to the long term. Actions involving *support*, *reflection*, *identification*, and *consultation* terms suggest a broader territorial planning strategy for long-term accessibility. One action advocates procedural justice by proposing systematic consultation before deciding about PT station design.

Challenges	Reviewed solutions
Informing users, staff and the general public	Conducting awareness campaigns for cyclists, motorists and PT users; Organizing simulations with drivers to complement existing training courses
Regulating demand	Redirecting to carpooling solutions; Staggering rush hour (in agreement with the university)
Improving PT services	Automatic door opening; Targeted tolerance when checking tickets
Low-cost maintenance and equipment	Monitoring display and announcement equipment; Redesigning complex stations; Fit grip strips from the doorframe to the opening button

Table 1. Short and medium-term solutions discussed in the working groups.

The distinction between long-term and short-term solutions was based on both political and technical factors, as well as stakeholders' perceptions of what is feasible or challenging. The outcomes of the working meetings reflected the realities of the context and participants' perspectives, shaped by their skills, positions, and knowledge. We also navigated theoretical questions and the desires of associations, engaging with technical and economic arguments, as well as an institutional narrative by professionals. This disciplined discourse aimed to deal with the claims, while avoiding to raise expectations among association representatives.

Lastly, feasibility (financial, temporal, material, organizational, and even political) was mentioned fifteen times (37%) as a limitation. Politically, the authorities' strategy may conflict with well-defined objectives (e.g., cycling policies concerning bike impounding and energy savings for automatic tram doors opening). The effectiveness of certain actions was also questioned, primarily by associations representing vulnerable populations. Seven solutions were critiqued, mostly by the academic team, for promoting accommodations over universalism or relying on digital applications. For eleven of the fourteen short-term solutions, no limitations were expressed, likely due to their vague and consensual nature. For example, showing tolerance to a vulnerable person without a ticket was universally agreed upon. Information-related proposals, while widely appreciated, were harder to critique, as it is difficult to anticipate the ineffectiveness of a public awareness campaign.

3. Discussion

The findings presented in this study are largely similar to those reported in the existing literature. But they carry significant policy implications at the local level, providing valuable guidance for the development of transportation policies. We wanted to address what was considered desirable and effective by PT operators, alongside the discussion of levers and obstacles identified by users. These dual objectives were integral to a participatory and collaborative process, aimed at considering both structural and individual interests. Ultimately, this raised questions about our positioning as researchers, particularly in relation to issues of justice and efficiency. This tension also highlights a fundamental dilemma in public policy: the balance between universality and reasonable accommodation. Less inclusive solutions, favored for their practicality and cost-effectiveness, continue to be preferred by decision-makers. The results, while marked by measured ambition—few large-scale actions, reliance on digital applications, referrals to existing services—seem to hold the seeds of a coherent strategy for improving urban accessibility. However, these approaches still raise numerous questions about how to integrate experience-based data into accessibility measures, especially concerning the aggregation and generalization of diverse behaviors.

Organizing collaborative work with experts and professionals from public institutions was not an easy task. On the one hand, this was due to the obvious challenge of coordinating a complex project. More importantly, however, the perspectives and expertise of participants varied significantly based on their educational background, institutional affiliation, service area, and professional role. As a result, discussions on accessibility necessarily involved a wide range of stakeholders. The population with whom and for whom the research was conducted occupies a multifaceted role as informants, subjects, and collaborators. These overlapping roles complicate the research stance, as the tripartite relationship between researchers, stakeholders, and the public influenced our posture throughout the process. For example, regular interviewees often shared their personal experiences while representing their associations, which can consist of hundreds of members. This required constant effort to refocus on their role as representatives. At the same time, these individuals regularly interacted with road services and participated in national accessibility commissions. There is an inevitable information asymmetry between stakeholders and the research team. How can one effectively contribute to public action when they are not fully aware of its structures, organization, constraints, and ongoing projects? Understanding these complex dynamics is crucial before reflecting on public action. Beyond our initial methodology, we have since committed to more informal efforts aimed at maintaining and perpetuating an ongoing dialogue with stakeholders.

4. Conclusion

Overall, these experiences have prompted a re-evaluation of accessibility, thinking beyond its material aspects to a deeper understanding of its institutional and internalized states. Researchers play a dual role: they can both participate in the institutionalization of accessibility by recognizing the needs of the most vulnerable, and seek to understand the norms that shape it. This duality presents epistemological and methodological challenges, particularly when attempting to link individual experiences with the spatial aspects of (dis)ability. Our qualitative approaches have, at the very least, enriched accessibility metrics. This was achieved through knowledge transfer and by translating internalized choices into selection criteria for minimal path algorithms. Throughout the research, we grappled with questions about how our work could contribute to the local controversy—both in terms of measurements and formulated recommendations. For instance, the study considered the feasibility of various solutions, with particular attention to the timing of actions. This question of temporalities emerged as crucial, especially in relation to the expectations of those most affected. However, it is the focus on what is and isn't feasible for the community that drove the discussions. Local authorities operate with finite resources and must prioritize social issues and actions. This is particularly true in Strasbourg, where PT accessibility is relatively less lacking than in many other (greater) cities.

Author Contributions

Pons: Conceptualization, Investigation, Methodology, Formal analysis, Visualization, Writing – original draft, Writing – review & editing.

Bréjat: Investigation, Methodology, Formal analysis, Writing – original draft.

Conesa: Investigation, Methodology, Formal analysis, Writing – original draft, Writing – Review & Editing, Supervision, Funding acquisition.

Acknowledgements

We wish to thank Olivier Finance, Maxime Vermeil and Adrien Blanc for their contributions, as well as the anonymous referees for their constructive critique.

Funding

This research received support from the Joint Project Infrastructure *Urban Europe* (875022) and funding from the French National Research Agency (ANR-20-ENUA-0003).

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Data Availability Statement

The processed data can be found on the interactive atlas.

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