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UNIVERSALITY IN DESIGN: USER-CENTRIC METHODOLOGY FOR INFRASTRUCTURE PROJECTS – BRUSSELS EXPERIENCE

Dr. Eng. Arch. Gordana Micic[1]

Abstract: Many urban studies highlight the issue of discontinuities between public spaces, particularly in underground mobility infrastructure. These spaces often suffer from poor connections to the surface, rendering them almost invisible to passers-by and further isolating them from the public realm. This research focuses on a user-centric approach as a key condition for achieving continuity and coherence in metro station design within the broader urban fabric. It aims to establish a comprehensive, 360-degree design methodology, drawing on insights from Brussels' metro station projects.

Through the integration of multimodality principles with sustainability, urban planning, aesthetics, technique and maintenance, the proposed methodology prioritises universal accessibility to create welcoming and inclusive underground public spaces. From a forward-looking perspective, the study examines the intersection of urban temporal and spatial dynamics with aesthetic, functional, and technical elements, translating these into project management mechanisms. It is conducted alongside research on the interface between mobility and urban planning, ensuring that transportation hubs are not just functional nodes but also integrated, accessible, and liveable spaces for all.

Keywords: Design, station, multidisciplinarity, urban planning, public transport

1. INTRODUCTION

City life revolves around public spaces. It is a place for movement, encounter, and civic life, a 'common space' that exists at the intersection of individual and collective spatial experience (Lévy & Lussault, 2013). Public space takes many forms: open or enclosed, freely accessible or regulated, inherited or newly created. Those 'in between' spaces, whether stops, stations or multimodal hubs, are crucial interfaces for facilitating connections between cities and transportation networks.

However, while certain cities, such as Montreal and Toronto (Besner, 2017; Boisvert, 2011), have a well-developed underground pedestrian network, this is not the case in many other cities around the world. The poor connection between subway stations and urban space results in them being invisible or barely perceptible to passers-by. (Bertolini, 2008; Labbé, 2014; Sander, 1996). This physical detachment gives rise to various types of discontinuities and boundaries[2], imposed[3], spontaneous[4], or even imagined[5] (Escallier, 2006; Piermay, 2002). Historically, the design of such infrastructure has been driven by the logic of networks, prioritising speed, efficiency, capacity, and operational functionality (Dupuy, 1987; Kaufmann, 1998). This highlights the need for

[1] Head of Art & Architecture office at STIB-MIVB & Brussels Mobility, Chair of UITP Design & Culture Committee, UCLouvain lecturer
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[2] A border is a barrier or boundary that separates two different territories or systems.
[3] Imposed boundaries are often the result of administrative or legal constraints linked to land rights, which define the limits of an area. They may be the result of strategy, planning, development or operating methods.
[4] Spontaneous boundaries emerge naturally in response to marked social, economic or geographical contrasts. They may be the result of inequalities, urban discontinuities (such as wasteland or infrastructure), or physical obstacles (gradients, slopes, slippery ground), creating a break between the city and the network, particularly stations.
[5] Imaginary boundaries are mental barriers created by negative perceptions of a place (cold, dark, dilapidated) or traumatic experiences (theft, harassment). They influence the way people feel and can limit the use of certain urban spaces or services.

coordinated strategies that ensure continuity between surface and underground spaces while supporting sustainable urban infrastructure.

Numerous studies have highlighted a recurring issue: the failure to incorporate users' needs and expectations into the design of transport infrastructure. Public transport operators are still hesitant to embrace user-centric approaches, which they view as abstract and difficult to apply, especially given the diversity of user profiles. For decades, they have based their designs on the notion of a 'standard user', leading to a high degree of standardisation. This model excludes many users whose needs fall outside the norm.

To understand and evaluate alternatives, this article first outlines the defining features of a user-centric model in urban development projects, along with the elementary principles of commonly practised project management. It helps to contextualise the relevance of the Brussels experience, where a user-oriented methodology has been applied to the design of metro stations. The goal here is not to construct a new science of management, but rather to identify, through a pragmatic lens, some key levers and distinctive features that may enhance project quality compared to traditional models. Ultimately, the aim is to bring stations closer to their users and improve their integration with the urban environment.

By interpreting the project process through specific case studies, this research positions itself as an exploratory inquiry. It is rooted in applied work carried out in a professional framework, forming what might be called an empirical laboratory. The scientific research conducted in parallel has directly fed into the development and implementation of these practical experiments.

2. LOOKING AT THE PROJECT PROCESS

More than ever, the project process is being called upon to integrate the collective dimension (Boutinet, 1990). The traditional expert model, based on a strict hierarchy, is being called upon to give way to co-production, where users become active partners in the design process. In this way, the project becomes a tool for dialogue between users and project managers. This participatory process makes it easier to identify users' needs and expectations and encourages them to take ownership of the spaces (Declève, Forray, & Michialino, 2002). In this context, architectural and engineering skills need to be enhanced by interpersonal skills and an ability to reconcile often complex requirements, while ensuring the coherence of the project.

Refocusing on the user-centric approach calls for examining traditional design methods, including underground infrastructure, in favour of greater openness, transparency, cross-functionality and innovation (Admiraal & Cornaro, 2018; Toussaint & Zimmermann, 2001). By meeting daily needs and saving time for other activities, the concept of the 'urban station' (Micic, 2021) transforms the journey into a stroll through an environment that is safe, welcoming, aesthetically appealing, and restorative. The ecosystemic design conditions underpinning this transformation are illustrated in Figure 1. The quality of its design determines the quality of its use, and vice versa.

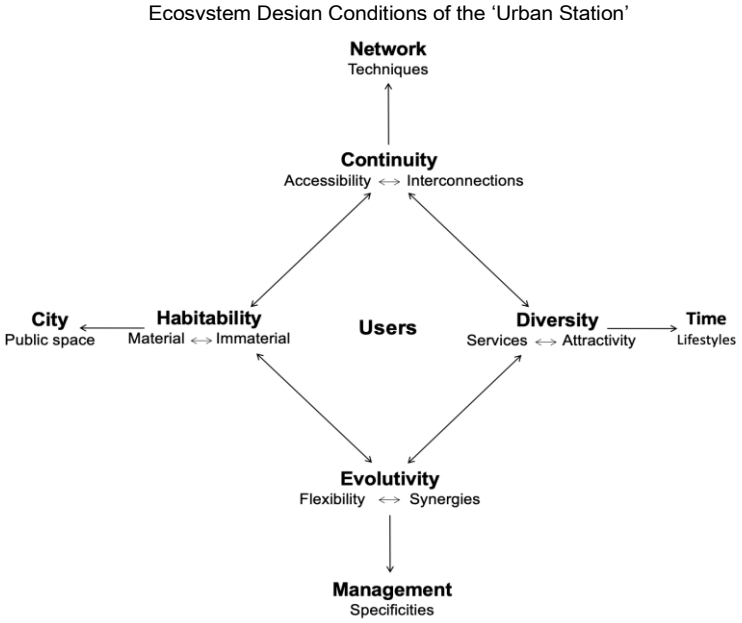

Figure 1. *Schematisation of the Ecosystem Design Conditions of the 'Urban Station'. Source : (Micic, 2021)*

Given the implication of this development on the project process, many project managers are wondering about the 'what' and the 'how to do it'. To grasp the complexity of the project-based approach, it is helpful to revisit three fundamental dimensions: the irreversibility of the process, the dialectical relationship between knowledge and action, and the shifting nature of challenges and management strategies (Arab, 2007; Midler, 1996).

The *knowledge* phase represents the exploratory stage that precedes any concrete action. It involves analysing the context, evaluating the potential of the site, drawing on specialised expertise, and identifying constraints and technical opportunities. This analytical groundwork is essential to developing innovative and context-sensitive responses (Boutinet, 2010). Ultimately, the goal is to transform an initial idea or concept into a tangible, multifaceted reality, rooted in both time and place.

Unlike industrial projects, which typically follow a relatively linear trajectory (Figure 2a), urban design projects are marked by fluctuating and less predictable dynamics (Figure 2b). These projects are primarily engaged during the initial phases: reflection, debate, feasibility studies, preliminary design, and design development. Once this phase is completed, the project tends to solidify and the production phase gradually becomes irreversible (Arab, 2007; Midler, 1996). This inherent instability can be attributed to several factors: the significant heterogeneity and complexity of the elements involved, the often-prolonged duration of such projects, and the persistent tension between the urgency to act and the need for thoughtful reflection. Moreover, it reflects a deeper dialectic between the reversibility and irreversibility of decisions made throughout the process.

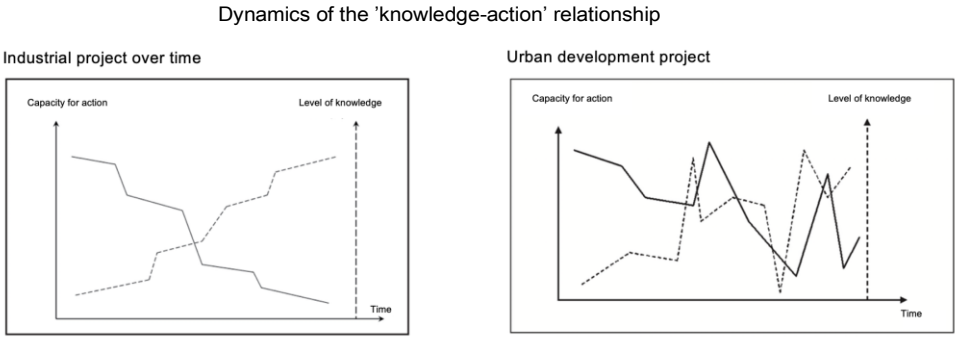

***Figure 2**. Dynamics of the activity of the 'knowledge-action' project: a) Industrial project over time. Source : (Midler, 1996). b) Urban development project. Source : (Arab, 2007).*

From a project management standpoint, the steering process aims to provide structure and guidance for all stakeholders involved, while ensuring coherent and effective governance. Depending on the project's scale and nature, this process mobilises a broad spectrum of actors: public and private authorities, operators, politics, technical experts, institutional partners, various associations, etc. Its role is to coordinate these contributions, anticipate potential risks, whether administrative, political, or technical, evaluate key parameters, and uphold a consistent and unified project vision.

Rooted in the principles of management science, this process is activated from the earliest stages of the project (Gilles, 2011). A central tool in this approach is the 'golden triangle' model, which seeks to balance three interdependent dimensions: quality, cost, and schedule (Figure 2). Maintaining this equilibrium throughout the project lifecycle is a core challenge in ensuring its success (Dobson, 2004; Gilles, 2011).

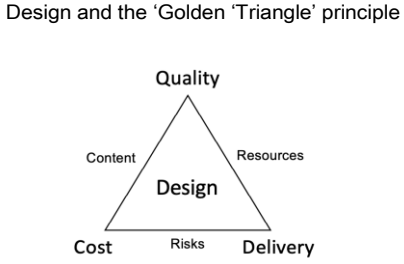

***Figure 3.** Design and the 'Golden Triangle' principle. Source: personal achievement, according to several authors.*

In the realm of public projects, political and media pressures often lead to time and financial constraints becoming the primary focus, with quality taking a back seat. While network operators are generally able to define requirements from a technical and operational standpoint, the diverse and heterogeneous expectations of users are often insufficiently addressed. This oversight underscores the importance of clarifying and reinforcing the concept

of 'quality' in its broadest sense. Only by doing so can a sustainable and equitable balance be re-established in project development and delivery.

3. USER-CENTRIC METHODOLOGY : BRUSSELS EXPERIENCE

The transition toward an accessible city for all gained momentum in the early 21st century, spurred by a growing movement advocating walking as a legitimate and active mode of transport. Committed to enhancing the quality of public space, Brussels Mobility[6], alongside STIB-MIVB[7] and partners including municipalities, institutions, and civil society, launched a series of initiatives to promote a more accessible, inclusive and sustainable urban environment. Institutional support was solidified with the adoption of the Iris II Regional Mobility Plan in 2010 and further strengthened by the launch of the Strategic Pedestrian Plan[8] in 2012, both foundational to fostering a more pedestrian, walkable and people- friendly city. This vision was formalised through key strategic documents such as the Regional Sustainable Development Plan[9] and the Regional Mobility Plan[10], which together framed a coherent approach to integrated urban and mobility planning.

3.1. Universal accessibility as a strategic lever in the design of metro stations

Brussels Mobility and the STIB-MIVB have undertaken a systematic accessibility program aimed at upgrading existing metro infrastructure. A key element of this program is the installation of elevators[11] to ensure step-free access. While elevators represent an essential improvement, they are not, in themselves, sufficient to address the full spectrum of needs encountered by people with reduced mobility[12] or special needs.

Recognising these limitations, in 2018, the Collectif Accessibilité Wallonie Bruxelles (CAWaB) initiated a collaboration with Brussels Mobility and STIB-MIVB to develop a dedicated design reference framework for the underground public spaces of metro and pre-metro stations, an equivalent to the vade-mecums already applied to ground public space. To find synergy between all stakeholders, a multidisciplinary committee was established. This committee comprises representatives from regional authorities, all internal departments of the STIB-MIVB, and the association Atingo. As a specialist on universal accessibility and appointed by CAWaB's members to act as a 'user expert'[13], Atingo is crucial in expressing the intricate, sometimes conflicting[14], realities and requirements of people with reduced mobility.

The decision to incorporate a 'user expert'(Kerroumi & Forgeron, 2021) into the design process was a pragmatic and strategic alternative to a full-scale participatory approach, which was deemed unfeasible due to time constraints and the technical complexity of the project. Acting as a mediator, the user expert voiced user needs while allowing the process to stay focused and technically manageable. This choice was supported by a wealth of pre-existing empirical data from earlier regional surveys, such as the Regional Mobility Plan, the mobility barometer, and STIB-MIVB's customer satisfaction survey. While broader participatory methods remain valuable, particularly in large-scale urban planning, they must not compromise the specific and often rigorous needs of people with reduced mobility (PRM).

The overarching objective is to achieve universal accessibility (Mace, Hardie & Place, 1996) across all metro stations in Brussels. Ensuring access to PRM, regarded as one of the most vulnerable user groups, not only fulfils a fundamental equity imperative, but also enhances usability for all categories of users. In this context, findings from the 2008 Health Survey conducted by the Access and Go association (formerly ANLH) reveal that more than 30% of individuals over the age of 15 experience either permanent or temporary physical or psychological limitations. These figures underscore the broader societal relevance of accessibility, positioning it as a cornerstone of inclusive urban mobility.

[6] Administration of the Bruxelles-Capitale Regional Public Service.
[7] Acronym for Société des Transports Intercommunaux de Bruxelles – trad.: Brussels Intercommunal Transport Company
[8] The following dimensions are determined by the ten quality criteria, GO10, outlined in the *Strategic Pedestrian Plan*: Network, Itinerary, Intermodality, Experience, Space, Physical Comfort, Autonomy, Mobility hubs, Safety, and Health.
[9] https://perspective.brussels/fr/outils-de-planification/plans-strategiques/plan-regional-de-developpement-prd/prdd
[10] https://be.brussels/fr/transport-mobilite/enjeux-de-la-mobilite/plan-regional-de-mobilite
[11] Currently, elevators are installed in 57 of the 69 stations. Source : SSE/DITP – RBC & STIB-MIVB.
[12] Abrev. PRM
[13] https://humancentereddesign.org/user-expert-lab
[14] Findings indicate that interventions effective for one type of disability may not be suitable or appropriate for others.

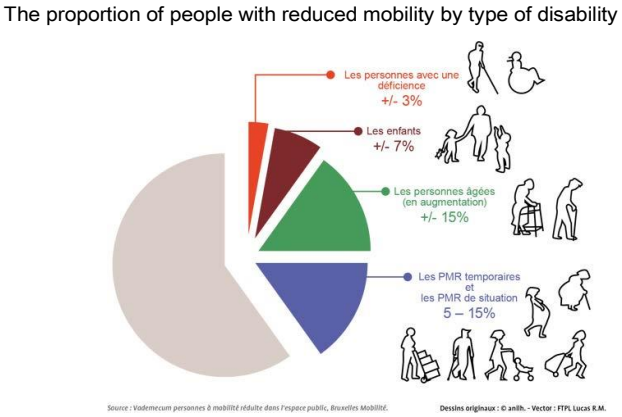

Figure 4. *The proportion of people with reduced mobility by type of disability and permanent or temporary - people aged over 15. Findings from the 2008 Health Survey conducted by the Access and Go association (formerly ANLH). Source: Vademecum for people with reduced mobility in public spaces. Brussels Mobility.*

Drawing on the foundational principles of universal design, the committee quickly acknowledged that the subterranean environment of metro stations constitutes a complex, three-dimensional spatial system with distinct operational and functional characteristics. Within this context, the needs of people with reduced mobility (PRM) cannot be addressed in isolation from the technical and logistical constraints traditionally associated with the operation of transit networks.

Beyond accessibility, other important considerations should be made, such as multimodality, urban planning, safety, the integration of diverse urban services (e.g. retail, food services, public services, cultural venues), all framed within principles of sustainability and environmental responsibility. Given this plural complexity, the multidisciplinary committee determined that the scope of action needed to extend beyond the principles of universal design alone. Instead, a more comprehensive 'global design' approach was adopted, one that is transversal, systemic, and capable of integrating a wide range of perspectives, requirements and constraints.

To achieve this, the Regional Mobility Commission (CRM) and its specialised subsections (such as those pertaining to active modes and PRM), Beliris, SNCB, equal.brussels, gender associations, academic institutions, and others were among the important institutional actors that contributed to this cooperative effort. The inclusive methodology helped ensure that the resulting standard would be robust, context-sensitive, and broadly applicable.

3.2. A Global Design Framework

At the end of 2022, the official reference framework '*Directives relatives à la conception des stations de métro de Bruxelles : Stations nouvelles – Projets de rénovation'*[15] was approved. The name of the '*Directives'* was to set them apart from other standards and emphasise their practical application. By applying an integrated and inclusive vision for public mobility spaces, this document consolidates a set of design requirements and operational constraints anchored in core principles: equality of use, flexibility, intuitive simplicity, comfort, well-being, and safety for all users, including the staff. The overarching aim is to ensure that everyone, regardless of gender, age, or (dis)ability, can navigate the metro and pre-metro environment freely, autonomously, and with ease, across the full range of services provided.

More specifically, the *Directives* aim to:

- Enhance the overall quality of the station as a public space.
- Contribute to urban and ecological development.
- Preserve and valorise the architectural and artistic heritage of existing stations.
- Ensure universal accessibility and inclusivity for all.
- Guarantee the safety and security of users, staff, and infrastructure.
- Improve intermodality and encourage multimodal travel, including micro-mobility solutions.
- Anticipate future developments in public transportation networks.
- Reduce the psychological barriers associated with underground environments.
- Make public transit systems safer, more comfortable, and more welcoming for all.
- Facilitate effective maintenance and long-term infrastructure management.

[15] Translation in English: '*Brussels Metro and Pre-Metro Station Design Directives: New stations – Renovation projects'*

While adhering to current standards and relevant regulatory frameworks, it offers a holistic approach to the spatial organisation of metro stations, the selection of materials and equipment, and the integration of user-centric design principles. Grounded on detailed knowledge of public behaviour and user needs, the document formulates recommendations aimed at intuitively guiding and orienting individuals within the station environment. For instance, signage should be designed to reinforce users' natural orientation, serving as a complementary element to a thoughtfully conceived spatial layout that is inherently legible and user-friendly.

To distinguish itself from purely technical standards, the *Directives* adopts a structured methodology inspired by the pedestrian user's journey (Figure 5a). Its modular layout is organised into thematic sections containing individual sheets, allowing for flexible consultation and targeted updates. Each component can evolve independently without compromising the coherence of the whole. The document has been supplemented by updated metro standard plans, which provide more technical translations of specific recommendations.

One of the central challenges in developing this design framework was ensuring consistency across the multitude of technical and functional disciplines engaged throughout the design process. Considering the wide range of demands, restrictions, and contextual factors, it was frequently essential to engage in negotiations and identify harmonious solutions to disparate expectations. Those could arise from the unique characteristics of different mobility limitations or from other technical, functional, cultural, architectural, heritage-related, environmental, or social considerations.

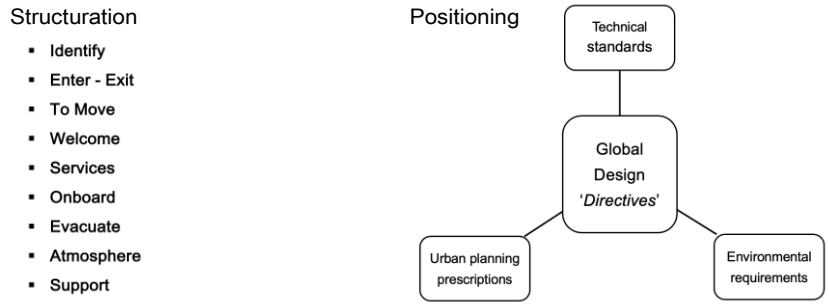

Figure 5. a) Structuring of the 'Directives' for the design of metro and pre-metro stations in Brussels. b) Positioning of the 'Directives' in relation to other reference requirements. Source: Brussels Mobility et la STIB-MIVB.

Crucially, the *Directives* was conceived with the intent to preserve a margin for creativity, an element considered fundamental to sustaining architectural and urban innovation within metro station projects. It does not replace existing documents but rather complements and integrates them, aligning with broader frameworks related to the city, transport networks, and the environment (Figure 5b). Intended for all stakeholders involved in the design, development, or redevelopment of metro stations and their surroundings, whether for comprehensive or targeted interventions, the document provides a clear and structured framework to support project designers throughout the process.

3.3. Implementation of *Directives*

Approved at the end of 2022, the *Directives* have entered a two-year implementation phase, allowing project managers to gradually familiarise themselves with the content and test its application across a range of contexts. This experimental period is intended to facilitate final refinements prior to the release of the definitive version of the document.

In practice, however, the implementation of new reference framework, particularly those not immediately perceived as *technically essential*, can present significant challenges. On the one hand, project managers may find it difficult to alter long-standing professional routines. On the other, designers, whether due to a strong attachment to their own creative vision or a limited understanding of accessibility concerns, may underestimate the needs of people with reduced mobility.

Implementation tends to be more straightforward in the context of new projects, where compliance with the reference can be integrated from the outset into the contractual framework binding design teams. In contrast, applying the guidelines to existing metro stations, or to projects already underway or in execution, proves more complex. Any modification of previously "validated" components must contend with various constraints, especially in terms of budget and schedule.

The issue of scope is essential, as all projects have specific intervention limits, often confined to only part of a station. At present, the design framework applies exclusively to the modified sections, while the rest remains unchanged, pending future opportunities for improvement.

Projects are assessed against the reference standards at various stages of their development. To support this process, training sessions are organised for project managers and other key stakeholders, facilitating consistent and informed implementation.

In this context, the design standards also serve as the foundation for a cross-functional audit, designed to produce a comprehensive inventory of publicly accessible infrastructure. This audit aims to create a form of station 'identity card', offering a systemic overview of renovation or transformation needs. This approach supports the development of a strategic renovation plan and helps schedule targeted interventions.

It is self-evident that aligning all stations within the Brussels network with the new standards will require both time and substantial financial investment, particularly for projects dedicated to comprehensive accessibility upgrades. As such, a strategic, phased approach is being adopted, capitalising on ongoing and future projects to limit additional costs. Some recommendations will be implemented in the short term, while others will follow in the medium or long term.

Moreover, it is important to note that certain parts of metro stations fall within the scope of partner-led developments, such as retail, residential, or office projects, and the design guidelines must also be applied in these contexts. The same principle extends to urban development initiatives in the neighbourhoods surrounding stations, whether directly adjacent or in the broader vicinity. This is based on the understanding that a station's boundary does not end at its entrance: the surrounding public space must also facilitate safe, comfortable, and intuitive access for all users.

4. THE RESULTS OF PRACTICE

The two-year implementation phase that followed the guide's approval in late 2022 provided an opportunity not only to test the standard's requirements and constraints but also to evaluate the practical methods of its application. Interestingly, among the many directives it contains, only a few were found to be especially difficult to implement. Ongoing consultation within the multidisciplinary committee helped to clarify these issues and fine-tune the framework where needed.

Nevertheless, its practical implementation turned out to be even more complex. Directives that were easily measurable, such as the precise dimensions or specifications, were generally more easily comprehended and applied. By contrast, technically unmeasurable aspects, like those related to spatial legibility, sensory perception, or architectural expression, required additional support. Exemptions, too, proved challenging. Due to the variety of contextual conditions, deviations from the standard had to be addressed with customised, empirically grounded solutions that followed the same principles used to develop the framework itself.

One persistent challenge lies in the entrenchment of conventional design practices, which often resist change. While inclusive and user-centric approaches are gaining traction, they are not yet fully established. This makes the early, cross-functional integration of the framework into new projects critical. For projects already underway, however, a transition period is necessary adjustments are constrained by existing contracts, schedules, and budgets.

To support both the transition and future planning, the framework serves as the foundation for a systematic audit process of existing stations. These audits produce a detailed inventory of public spaces and allow for the creation of "identity cards" for each station, outlining strengths, weaknesses, and levels of compliance. This facilitates the strategic planning of renovations in short-, medium-, and long-term phases, which are tailored to the available resources and in accordance with broader urban developments.

Training proved essential throughout this process. Many professionals involved in metro development held personal and sometimes narrow views on accessibility, rather than a shared, well-informed understanding. Raising awareness among project managers and stakeholders helped foster a more unified approach to applying the framework and addressing the needs of people with reduced mobility. Support from upper management staff played a crucial role, particularly during the transitional phase when existing projects were already constrained by budget and time.

As the design reference framework, *Directives* not only consolidate technical, aesthetic, and functional best practices, but also help clarify the quality dimension within the traditional quality-cost-deadline (Q-C-D) triangle.

By reducing the risk of overlooking critical user needs, it improves project outcomes and supports smoother execution by aligning design decisions with scheduling and budgetary realities.

Moreover, the data gathered from audits feeds into 3D digital models of station infrastructure, enabling better coordination among stakeholders across the station's lifecycle. These tools also enhance transparency and public communication, offering clear insights for political and civic discussions. It's also a useful tool for outlining requirements for different partners, especially those involved in projects that are adjacent or within the surroundings of metro stations.

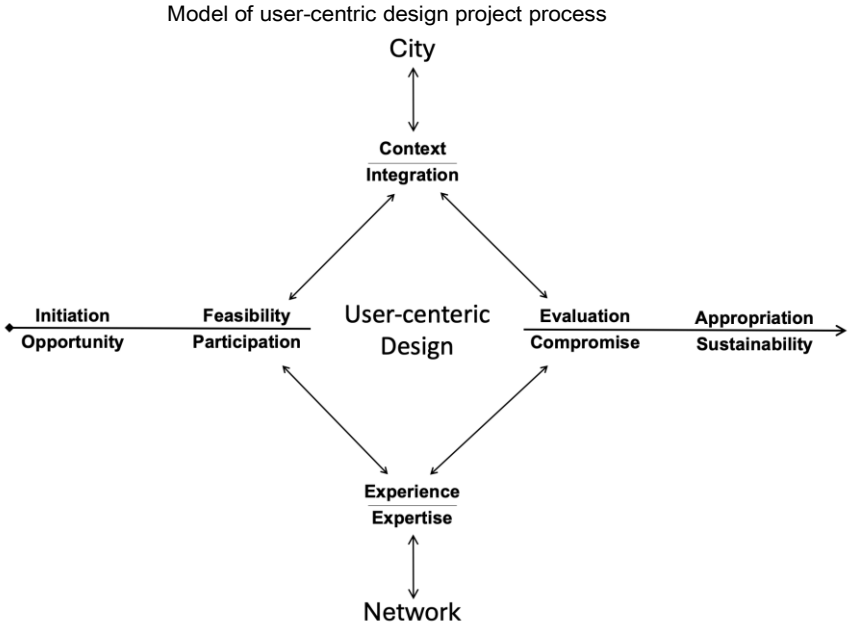

Figure 6. *The project process based on user-centred design. Source : personal achievement from different sources.*

Evermore, this methodology provides the basis for a strategic and comprehensive and overview of the metro network. It facilitates the efficient coordination of maintenance operations, assists in the prioritisation of projects, and coordinates future development, all while reducing the likelihood of misalignment or oversight.

5. CONCLUSION

The design of underground public spaces, often regarded as inherently complex and opaque, continues to pose significant challenges within urban development. These environments demand a holistic, ecosystemic and integrated design approach that fully incorporates the human dimension. In this regard, a universal design perspective serves as a lever in the global conceptualisation of urban metro stations.

The transition away from traditional methodologies marks a progressive shift toward a more collaborative, user-centric model of urban project development. This kind of framework makes it possible to meet different, and sometimes conflicting, requirements and needs, such as technical, functional, aesthetic, and experiential ones, by promoting coherence and mutual understanding. It underscores the necessity of a multidimensional and interdisciplinary approach to planning, ensuring that the complexity of urban infrastructure is addressed through *fitting* design solutions that meet the expectations of all parties.

The strategic governance of infrastructure projects must commit to the principle of universality, not simply as a technical objective, but as a fundamental right and a cornerstone of urban transformation. While contextual variability necessitates tailored responses, the overarching objective remains consistent: to integrate people's interests into a long-term strategic vision that integrates above- and belowground public spaces into a coherent urban fabric. Cultivating synergies among all stakeholders, with a user-centric approach embedded in the earliest stages of project development, fosters the creation of public spaces that are not only sustainable and legible but also equitable and responsive to actual and future demands for mobility, inclusion, and urban quality of life.

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*Rem.: Personal translation from French to English with the assistance of AI tools.