URBAN EUROPE

SmartHubs

Smart Mobility Hubs as Game Changers in Transport

WP5.   Impact assessment of SmartHubs living labs

Deliverable D 5.7
Application of the SmartHubs Appraisal Tool

Version: 1.0

Date: 21/12/2023

Responsible partner: Vrije Universiteit Brussel

Authors:

Lluis Martinez, Mobilise – Vrije Universiteit Brussel
Christoph Kirchberger, Technische Universität Wien
Kelt Garritsen, University of Twente
David Duran, Technical University of Munich
Hilda Tellioglu, ACUR – Technische Universität Wien
Imre Keserü, Mobilise – Vrije Universiteit Brussel

Contributors:

Charlotte van Vessem, Mobilise – Vrije Universiteit Brussel
Jelten Baguet, Mpact

VUB mobilise
analysing sustainability, mobilising people

NWO   FFG Forschung wirkt.   innoviris .brussels we fund your future   Federal Ministry of Education and Research

Document change record

Version	Date	Status	Author	Description
0.1	24/11/2023	Draft	Martinez, L., Kirchberger, C., Garritsen, K., Duran, D., & Keserü, I.	The draft version v0.1
0.2	09/12/2023	Draft	Martinez, L., Kirchberger, C., Garritsen, K., Duran, D., Tellioglu, H. & Keserü, I.	The reviewed draft version v0.2
1.0	21/12/2023	Final version	Martinez, L., Kirchberger, C., Garritsen, K., Duran, D., Tellioglu, H. & Keserü, I.	Version 1.0

Table of Contents

List of Figures

List of Tables

EXECUTIVE SUMMARY

The deliverable presents a comprehensive assessment of the application of the SmartHubs Appraisal Tool across the four living labs of the project: Anderlecht, Munich, The Hague, and Vienna. The SmartHubs Appraisal Tool is a stakeholder assessment methodology which can support the co-creation process of mobility hubs. The tool can be applied following two related methods, the Multi-Actor Multi-Criteria Analysis (MAMCA) and the Stakeholder-based Impact Scoring (SIS).

Through its application in the four living labs of the SmartHubs project, the tool proved being central in reflecting stakeholder preferences, identifying essential criteria for mobility hub design, and supporting the co-creation process. The results emphasize the significance of engaging diverse stakeholders, including residents, governments, and mobility operators, to ensure inclusivity, sustainability, and community responsiveness. Crucial findings reveal criteria universally important for most stakeholders across multiple locations such as safety, service availability, visibility, reliability, accessibility, and alignment with local needs.

In conclusion, this pioneering application of a stakeholder assessment tool in mobility hub development provides valuable insights. This deliverable underscores the need to enhance the tool's usability, understanding, and alignment with stakeholders' criteria. Recommendations include tailored facilitator training and a predefined list of criteria to streamline the identification stage. The study acknowledges limitations arising from diverse contexts and facilitators but emphasizes the validity of results through a common reporting framework. The findings and recommendations offer a foundation for future research, emphasizing the continual refinement of methodologies and effective facilitator training to advance the co-creation process of mobility hubs.

1. Introduction to the SmartHubs Appraisal Tool

As the main objective of the SmartHubs project is to assess if a co-creation process can enable mobility hubs to act as game changers, the development of tools to support the co-creation process is relevant. In this regard, the SmartHubs Appraisal Tool aims to facilitate the co-design process of a smart mobility hub, allowing stakeholders to identify the most preferred option among a range of alternatives. Grimble & Wellard (1997) define a stakeholder as "any group of people, organised or unorganised, who share a common interest or stake in a particular issue or system; they can be at any level or position in society, from global, national and regional concerns down to the level of household or intra-household, and be groups of any size or aggregation."

The SmartHubs Appraisal Tool can be applied by using two different methods The choice of the method to apply depends on the type of project or element being evaluated, as well as on the approach to decision-making. Although the following sub-sections introduce both methods, the instructions on how to apply them can be found in the the SmartHubs Deliverable 3.5 (Martinez et al., 2022).

The following paragraphs of this section introduce both methods. The second section of this deliverable presents the four living labs and the third section explains the application of the tool: the aim of the application, the participants involved, calendar and locations, challenges, results, and assessment. The fourth section presents the conclusions of the study, referring to the limitations and further research.

1.1 MAMCA[1]

Multi-actor Multi-Criteria Analysis (MAMCA) is a methodology to assess stakeholder preferences by taking the stakeholders explicitly into account (Macharis, 2000, 2004). MAMCA is an extension of the Multi-Criteria Analysis (MCA), differing from the latter by explicitly introducing stakeholders before the criteria and weights are defined (Macharis et al., 2012). Furthermore, the MAMCA methodology encourages stakeholders "to reflect on what they want and on the rationale for these wants" (Macharis et al., 2009, p.197), which can facilitate reaching consensus.

The MAMCA approach was conceived to evaluate transport projects, in which the interests of stakeholders are competing and conflicting. MAMCA has been applied on several occasions, to decide about the improvement of mobility in the city centre of Leuven (Keseru et al., 2016); the possible extension of a logistics operator at Zaventem International Airport (Macharis et al., 2009); policy measures that can improve mobility and logistics in Flanders (Macharis et al., 2010); and measures to improve traffic safety in Brussels (Pappers et al., 2021).

The MAMCA methodology consists of seven steps that are shown in Figure 1. First, the possible alternatives that will be evaluated are identified and classified. Second, a stakeholder analysis, in which the groups whose

---

[1] Section copied from SmartHubs Deliverable 3.5 (Martinez et al., 2022).

opinions should be taken into account are identified and contacted, is conducted. In step three, each stakeholder group defines their criteria (c) and gives weights (w) to the criteria, according to the importance they give to each criterion. In step four, the criteria established by stakeholders are 'operationalised' by designating indicators to measure the impact of an alternative concerning each criterion. In step five, the alternatives are analysed by using indicators and are consequently ranked. In step six, results are shown, and consensus-making is encouraged. However, if consensus is not reached, new alternatives can be created and a new MAMCA is conducted. Lastly, the results of the MAMCA inform the implementation of the chosen alternative (Macharis et al., 2009).
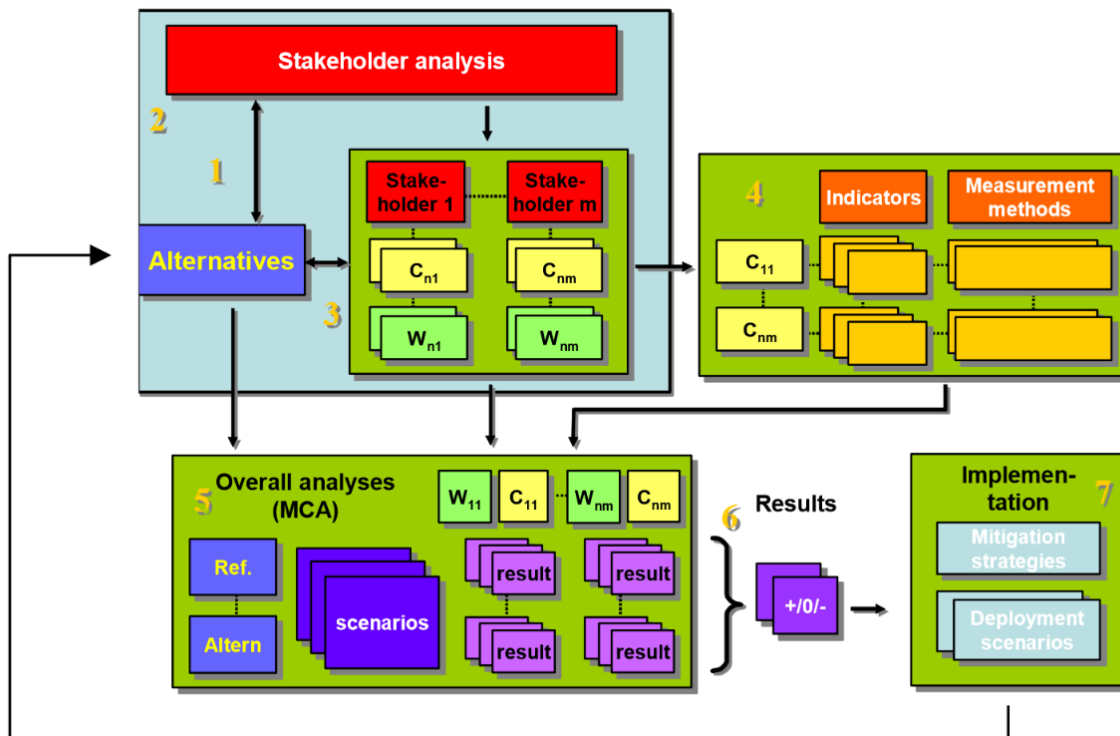
Figure 1. The steps of Multi-Actor Multi-Criteria Analysis (Macharis et al., 2009)

1.2 SIS[2]

Stakeholder-based Impact Scoring (SIS) is a participatory ex-ante appraisal method developed by te Boveldt et al. (2022), based on the concept of weighted impact. SIS is useful to quantify the negative and positive impacts of projects on stakeholders, assuming that impact is the result of objective estimations or observations done by experts, and subjective value judgements done by stakeholders. As such, it can be considered a middle ground between the Cost-Benefit Analysis (CBA) and MAMCA. As in MAMCA, SIS acknowledges the subjective aspect of appraisal by involving stakeholders in coupling objective impact estimations with subjective value judgements. As is the case of CBA, it does not lead to an aggregated

---

preference ranking but enables the identification of positive and negative impacts of alternatives compared to the current situation. Nonetheless, SIS still requires a certain degree of aggregation, by summating scores from different stakeholders to obtain numerical results. The very goal of SIS is to synthesise what is possible while leaving the value-laden trade-offs and decision-making open for political debate. As such, the evaluation conducted in the early strategic phase of projects should not prematurely conclude the discussion, but rather enhance it (te Boveldt et al., 2022).

By enabling the analyst to interpret the negative and positive impact scores separately, SIS is particularly appropriate in complex transport projects, which are often altered and defined throughout their course of planning or implementation. For instance, te Boveldt et al. (2022) applied the SIS to appraise the alternatives to the redevelopment of an overpass in Brussels. The tool was applied in this project because the uncertainty on central aspects such as costs and the development of inter-regional infrastructure impeded high-precision appraisal. Furthermore, as this was a politically sensitive project, most stakeholders had a pre-defined preferred alternative. It was therefore convenient to highlight the impacts, to nurture and support the debate, instead of ranking alternatives and prescribing a decision.

2. Context of the living labs

The application of the SmartHubs Appraisal tool took place in four different Smarthubs living labs and it was applied within these four different local contexts: Anderlecht (Brussels), Munich, Rotterdam-The Hague and Eastern Austria (Vienna). The two latter cases had more than one location in which mobility hubs were located or were expected to be implemented. In the context of the MAMCA or SIS processes, only one location was chosen at each living lab. This section describes the context of the living labs – selected location and overall process – because the application of the SmartHubs Appraisal Tool must be adapted to it. Additional information about each living lab can be found in the Smarthubs Deliverables 4.2 (Kirchberger et al., 2023), 4.3 (Martinez et al., 2023), 4.4 (Garritsen et al., 2023) and 4.5 (Duran-Rodas et al., 2023).

2.1 Anderlecht Living Lab (Brussels)

The Anderlecht Living Lab was set up in the Cureghem neighbourhood, just outside the centre of Brussels and next to the Brussels South Station, the largest railway station in Belgium. From a socio-economic point of view, this can be considered a disadvantaged neighbourhood. It is one of the most densely populated parts of Brussels, the unemployment rate stands at a staggering 27% and the median taxable income in Cureghem is considerably lower than the regional average. This neighbourhood hosts a higher share of people without Belgian nationality (European Union, Türkiye, Northern Africa, Sub-Sahara) than the regional average. The share of people above the age of 25 with a higher education degree is also much lower than the regional average (Statbel, 2021). Although many families in Cureghem cannot afford a car, parking pressure is among the highest in the Capital Region (due to the high population density). Its proximity to some of the major road axes in Brussels has repercussions for the neighbourhood in terms of air pollution and noise (Environnement.Brussels, 2022). Concerning mobility, Cureghem is well deserved and a central area in the

transport network, and there are several stations of shared mobility services and an increasingly developed cycling infrastructure.

2.1.1 The mobility hub: Place du Conseil/Raadsplein

The selected location in the Anderlecht Living Lab was the square Conseil/Raadsplein and it was not a dedicated mobility hub, as this type of infrastructure was not yet deployed in the Brussels Region. Nonetheless, this location hosted public transport and shared mobility services and in the context of this research project, a temporary digital information kiosk was placed in the square. From this kiosk, the tram stop, *Cambio* shared cars, *Villo!* shared bike and car parking facilities were visible. No signposting was added to the bike-sharing station (around the corner) and no other modifications were implemented because it was not possible. The mobility hubs assessed through the MAMCA process were four co-designed options for future mobility hubs in the Place du Conseil.

- Co-designed option 1: The basic hub
- Co-designed option 2: The green hub
- Co-designed option 3: The all-in hub
- Co-designed option 4: The social hub

More information about the four alternatives can be found in Appendix 1.

2.1.2 Process overview

The living lab activities started in January 2022 and finished in February 2023 (see Figure 2).

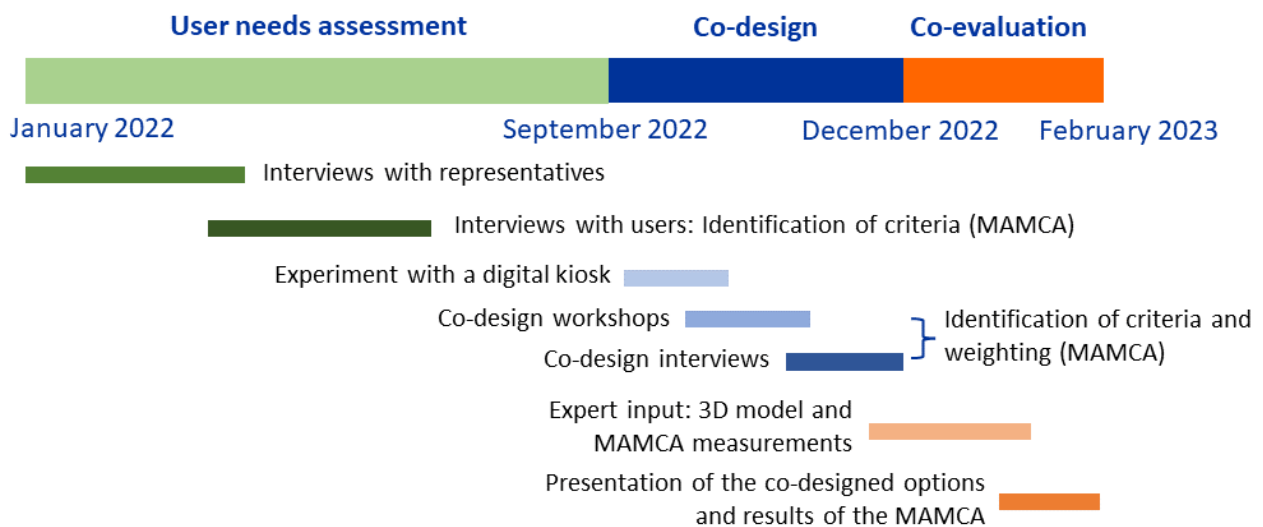Figure 2. Activities conducted in the Anderlecht Living Lab (Brussels)

2.2 Munich Living Lab

Munich's Living Lab focused on the co-design, implementation, and co-evaluation of a new, temporary mobility hub. The hub was developed under the premise of optimizing the use of the current public infrastructure to create a mobility hub that promotes active transport modes and shared mobility services.

Concurrently, the hub aimed to invite people to linger and support local businesses such as cafés, and restaurants in the immediate vicinity. This approach aimed to foster a sense of community and contribute to a better living environment.

The area selected to plan the hub around the Technical University of Munich has significant potential considering three main conditions typically related to mobility hubs' characteristics. Following the guidelines for the integration of mobility hubs into the urban space (Duran-Rodas et al., 2022), high concentration of points of interest (services, activities, etc.), existing public transport coverage, and high traffic/demand potential are favourable conditions for the implementation of mobility hubs. The university surroundings offered a wide variety of services like supermarkets, entertaining venues (museums, galleries, etc.), bike-sharing services, charging stations, restaurants, and cafes. The public transport coverage in the area includes two subway (U-Bahn) stations (1 line), and three bus stops (3 different line services). In addition, tram stops are located approximately 200m from the main campus.

2.2.1 The mobility hub: TUM Steinheilstrasse

The mobility hub was located in the surroundings of the Technical University of Munich (Steinheilstrasse). This area typically experiences high traffic from various modes of transportation, and it offers a diverse range of amenities and services. Based on the hubs' goals, an existing parklet was chosen to be transformed into a mobility hub. The parklet's attributes, including seating opportunities, good lighting conditions, bicycle parking facilities, and an appealing design, made it a suitable location for this purpose. The target users included university students and employees from the university, as well as residents of the area. The pictures from the intervention can be found in the Appendix 2. In this case, the alternatives being assessed by the SmartHubs Appraisal tool are only two: the continuation of the mobility hub next year or not.

2.2.2 Process overview

To transform the space and implement the mobility hub, different participatory approaches were employed, including an on-street panel and a co-design game. The on-street panel served as an initial step to identify the "wish list" of potential users. This was followed by the co-design game, which was played on three occasions. Initially, it involved a class of bachelor's students (n=150), followed by a session with students who are also residents of the neighbourhood (n=40), and a third round during a street festival (n=18). The co-creation game was designed to pinpoint the features and elements that players desired in a hub. It also aimed to promote inclusive design thinking by introducing vulnerable personas as potential hub users.

The design obtained through the game was implemented during the summer of 2022. The hub operated in October 2022. During this period, the hub mainly served as a social gathering place and for leisure purposes, as indicated by the participants of a brief survey (59% of the answers). The second most common reasons for utilizing the hub's amenities were making use of shared mobility services and utilizing the self-service bike repair station. However, some users mentioned that the availability of shared mobility options (e.g., e-scooters) could be enhanced. Overall, users expressed satisfaction with the wayfinding, safety, and lighting conditions.

2.3 Rotterdam-The Hague Living Lab

The Dutch living lab comprises two hub locations in the metropolitan region Rotterdam-The Hague (further: MRDH), located in the western part of the Netherlands and consisting of 21 different municipalities, having a population of 2.4 million (MRDH, 2023) and hosting 1.2 million job locations. The largest municipalities within the MRDH region are Rotterdam (655.000 inhabitants) and The Hague (553.000), and both cities contain one of the SmartHubs living lab locations (CBS, 2022).[3]

2.3.1 The mobility hub: Hobbemaplein

Hobbemaplein is a busy square in The Hague, offering a lot of shops, restaurants and access to the (permanent) market location *Haagse Markt*. The square is located on the border of the *Transvaalkwartier* and *Schildersbuurt* neighbourhoods, two diverse and vibrant neighbourhoods, with relatively large shares of social housing units (DHIC, 2022a, 2022b). The square Hobbemaplein is ongoing renovation which started with an extensive participatory process, including for instance gathering the opinion of residents or co-designing in a later stage. The project team of the municipality is currently working on a preferred design alternative for Hobbemaplein (Municipality of The Hague, 2021a, 2022c). This design does not yet include mobility hub elements, providing an opportunity for co-creation of hub alternatives, and performing the MAMCA.[4]

Three distinctive design options were developed by the researchers from the University of Twente (see Appendix 3), with input from the co-design game sessions, the municipality of The Hague and the SmartHubs integration ladder (Geurs et al., 2023). The hubs are designed so that they can show the preference of the stakeholders towards different implementations of a hub. The three designs are:

  I.   *A basic mobility hub*. This design has a simple offer of shared modes, but access is not conflict-free for most modes. The hub does not offer non-mobility services.
  II. *A transport hub*. This design focuses on providing conflict-free access to most shared modes and mobility services, with a large offer of shared modes on both sides of the bus lane, and the presence of a staffed mobility service point.
  III. *A social hub*. This design focuses on the social aspect, with basic mobility services but a wide offer of non-mobility services such as a parcel locker and a municipal info point in the library.

2.3.2 Process overview

The living lab activities that were executed in The Hague are shown in Figure 3. There is some overlap between some of the stages, due to delays in the project. The SmartHubs design game was played multiple times, also during the co-evaluation stage with the project team of the Hobbemaplein project.

---

[3] This section is based onthe Living Lab report D4.4 – section 1.1 (Garritsen et al., 2023).

[4] This section is based on the Living Lab report D4.4 – section 1.3.3 (Garritsen et al., 2023).
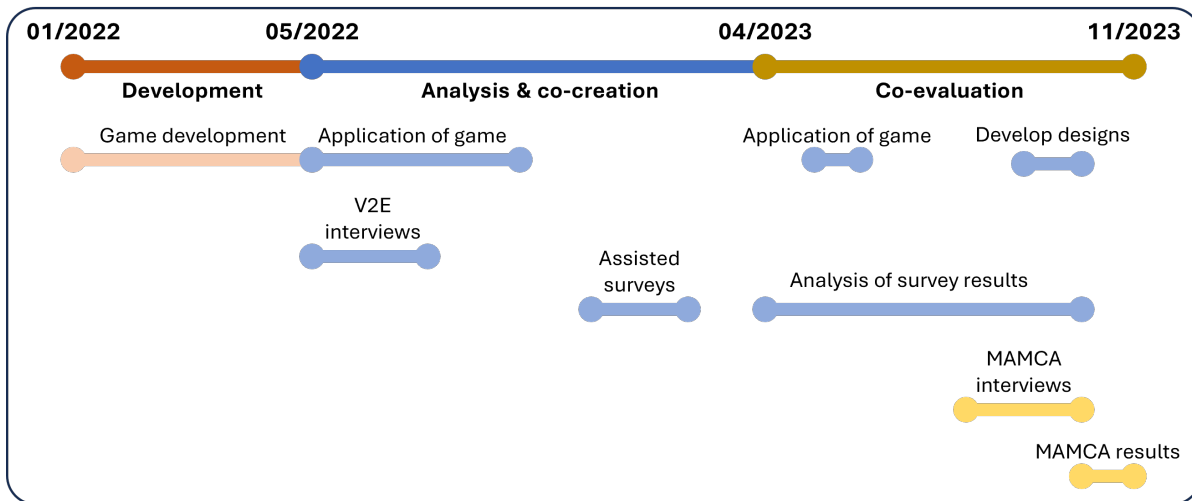
Figure 3. Activities conducted in The Hague Living Lab

At the start of the SmartHubs project, the intention was to integrate the SmartHubs Appraisal Tool into the participatory process of the local project team of the municipality responsible for the redesign of the area. However, the SmartHubs MAMCA which was conducted has not been part of the Hobbemaplein project of the municipality. A participatory process was already planned as part of the project and the MAMCA was expected to significantly increase workload. Therefore, it was decided not to integrate the application of the SmartHubs Appraisal Tool into this process. As a result, the SmartHubs MAMCA was conducted on completely fictional mobility hub alternatives, and are not intended to be implemented. However, the MAMCA outcomes can be used as input for the decision-making process of the Hobbemaplein project design in the future.

2.4 Eastern Austria Living Lab (EALL)

The EALL consists of two Austrian federal states: the Austrian capital and federal state Vienna and the federal state Lower Austria. Lower Austria surrounds Vienna entirely which has led to strong dependencies between these spatial entities, especially when looking into the mobility system and commuter relations. Throughout the living lab, different developments in the field of mobility hubs can be observed with several public and private organisations (ÖBB 360, LISA, Wien Mobil, Easymobil, MO.Point) establishing networks of hubs.

2.4.1 The mobility hubs: a local network

Two mobility hubs in Vienna (Mobility station Maria-Tusch Straße and Mobility station Bruno-Marek-Allee) and one in Lower Austria (Mobility Station Pillichsdorf) were selected for the living lab implementation. Nonetheless, within the EALL the approach to the study of mobility hubs focuses on the network, moving beyond individual hubs. Especially for Aspern Seestadt, as a large urban development area with still many possibilities to include mobility hubs in the overall planning regulations, it is important to establish a network of shared cars, cargo bicycles, and micro-mobility options to increase the attractiveness of sustainable transport solutions. Based on the spatial specifications and existing innovative approaches (like collective and Hybrid-Garages) in Seestadt, three scenarios were developed and configured.

I.   ÖV-Hubs (ÖV = Öffentlicher Verkehr = public transport): hubs connected to existing public transportation hubs
II. Hoch-Hubs (hoch = high): hubs located at existing elevated garages
III. Superblock-Hubs: hubs located in underground garages embedded in the neighbourhoods

Different specifications and modes were assumed for the three scenarios, each of them focusing on offering multimodal options at different points of a trip chain for different users (e.g., the Superblock-Hubs are located close to the housing facilities of many inhabitants). More information is available in the Appendix 4.

3.4.2 Process overview

As shown in the Figure 4, the evaluation phase consisted of the MAMCA application in the case study Maria-Tusch Straße. As discovered in prior phases, the topic of network designs became more relevant, leading to the decision to use the MAMCA tool for this topic and not for the single hub designs at Maria-Tusch Straße.

06/2022 11/2022	12/2022	02/2023	03/2023	07/2023
Phase: Development and setup	**Phase: Analyses and Co-Creation phase**		**Phase: Evaluation**	
		Realization of **Survey** (A)	**Analysis** of survey results	
Design game **development** (A)	Interviews with V2E groups (B, P)	**Non-Digital** Workshop (P)		
	Design Game **prototyping** workshop	Design Game **application** (M,B)		
		Development of designs (M, B)		
		Accessibility analysis (A)		
		Preparation of MAMCA and **scenarios**	Realization of **MAMCA workshops** (M)	
				Summary of **MAMCA** results

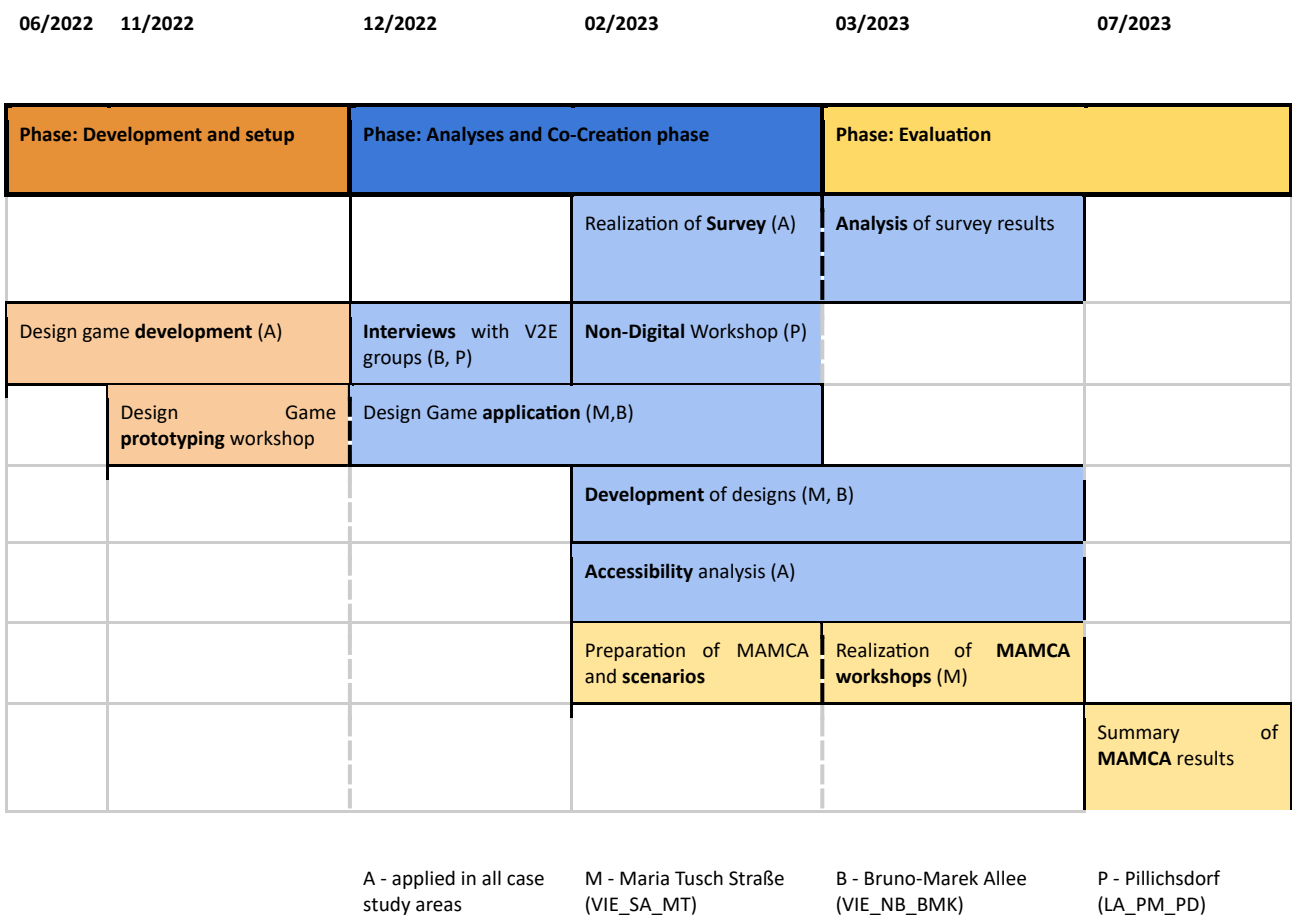| A - applied in all case study areas	M - Maria Tusch Straße (VIE_SA_MT)	B - Bruno-Marek Allee (VIE_NB_BMK)	P - Pillichsdorf (LA_PM_PD)

Figure 4. Activities conducted in the Eastern Austria Living Lab

3. Application of the tool

The Smarthubs Appraisal tool was applied in three locations using the MAMCA methodology, and in Munich through the SIS methodology. The aim of the different processes, the participants, the dates, and events are explained in the following sub-sections. Likewise, the challenges encountered in applying the tool, the results and the assessment tool can be found in this section.

3.1 Anderlecht Living Lab (Brussels)

In the Anderlecht Living Lab, the SmartHubs Appraisal Tool was used as part of the co-creation process for a future mobility hub. Thus, four co-designed options (see Section 2.1.1) of a mobility hub that resulted from such a process were appraised using the tool.

3.1.1 Participants

The stakeholder groups considered to be relevant for the MAMCA are the same groups included in the living lab:

- The citizens, a central stakeholder group considering the focus of the living lab on inclusivity and vulnerable groups.
- The local government: the Municipality of Anderlecht.
- The regional government, and transport administrator: Bruxelles Mobilité.
- The local and regional public transport operator: the STIB-MIVB.
- A station-based shared mobility operator: Cambio, the largest car-sharing operator in Brussels.
- A free-floating shared mobility operator: Felyx, the largest shared moped operator in Brussels.

Although at least one person belonging to each group was involved in the MAMCA process, not everyone participated in the same manner to ensure their involvement, it was necessary to adapt the methodology

3.1.2 Locations and dates of MAMCA workshops

The first stage of the MAMCA process – collecting the criteria and allocating weights to indicate their relevance – was done between 24 October 2022 and 11 January 2023. During this first stage, all stakeholders were involved through the co-creation workshops and/or one-on-one interactions, in person or through a video call. As the co-creation process started in January 2022, with a needs assessment, eight main criteria relevant for (non-)users were already identified. Thus, the participants were given the chance to suggest new criteria and/or select them from this list. The second stage – showcasing the four co-designed options and the results of the MAMCA assessment, discussing with the participants and collecting their feedback – was conducted between the 6 and 20 February 2023.

The workshops were organised in three different locations: at the Place du Conseil, where the second on-street event was taking place, at the building of a local civic society organisation and the building of the mobility department of the municipality. The change of locations was due to the nuisances encountered during the first workshop (e.g., noise, cold, …) as well as wanting to facilitate the participation of the targeted stakeholders. All the in-person one-on-one interactions occurred during the on-street events of 28 November 2022 and 6 February 2023.

3.1.3 Challenges

Mobility hub designs and implementation strategies face significant challenges when appraised through the Multi-Actor Multi-Criteria Analysis (MAMCA). One major obstacle is the time needed to develop the process, requiring the availability and eagerness of all relevant stakeholders to participate and attend the different activities of the process, which should at least take time on two occasions. In this regard, the expertise and facilitation skills of the person coordinating the process are also central. Moreover, the first step – identifying criteria – is not straightforward, and many participants encounter difficulties in formulating relevant criteria. While experts find it more manageable, other stakeholders, especially citizens, struggle with it, requiring the facilitator to propose criteria. However, as shown in the Brussels' application, this may bias the final selection and omit criteria that are relevant for participants but unknown to the facilitator. Additionally, the diversity of criteria requires different indicators, adding complexity to measuring performance across various alternatives.

Understanding the MAMCA tool poses another difficulty, particularly for individuals with limited education or proficiency in the local language. Explaining the activities demands extra time, or else it can increase mistrust and perceived opacity. Bridging this knowledge gap becomes crucial to fostering inclusivity in the assessment process. Lastly, when stakeholders lack the time for workshops and are absent from the meetings, one-on-one interactions can address this issue but they do not allow the collective discussion to happen, limiting the possibilities of reaching a consensus. The challenge lies in finding a balance that ensures the representation of every stakeholder group throughout the process while accommodating the availability of participants.

3.1.4 Results

The criteria chosen by each stakeholder group and the relevance they indicated for each one are shown in Table 1. In the case that several people participated in a single stakeholder group, an average (mean) weighting was calculated. In the table, the criteria that only have weights indicated by one stakeholder, were not identified by the other stakeholders.

Table 1. Criteria and weights identified in Anderlecht (Brussels)

Criteria	Citizens	Local admin.	Regional admin.	Public transport operator	Car-sharing operator	Shared moped operator
Availability and reliability of the vehicles	7.7	9.8	10	10	8	10
Flexible, adapted, and subsidised pricing and subscriptions	8.5	7.4	4	6	5	7
Barrier-free spaces, inclusive design, and usability of vehicles/facilities	7.6	7.2	10	9	8	8
Non-digital accessibility	6.0	6.2	10	8	7	0
Simplified signage, information, and communication	6.4	7.8	6	10	9	8

Promotion and training to use the services	6.2	5.0	3	7	8	6
Assistance from staff/someone present at the hub	7.6	5.0	5	3	1	4
Safety and security	9.5	8.4	8	8	9	8
Integration according to the actual use of the space				10		
Ticket integration: MaaS				8		
Integration of existing services within the geographical zone				10		
Flexibility: possible to easily move stations/elements					10	
Size chosen considering the benefits for the neighbourhood					10	

The criteria and weightings were used to perform the MAMCA using the software and identify to what extent each co-designed option fulfils the priorities of each stakeholder group. As shown in Figure 5, Option two – The green hub (see Appendix 1) fulfilled the best criteria of all stakeholder groups.

Figure 5. Results of the MAMCA in Anderlecht (Brussels)
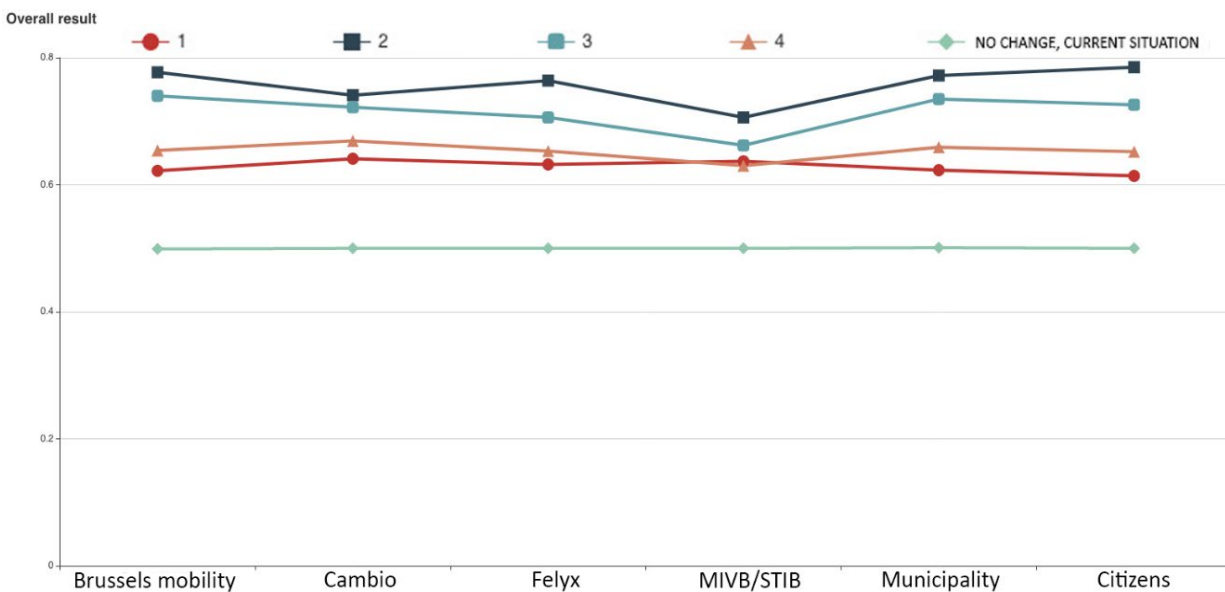
3.1.5 Comparison of decisions with/without MAMCA

The results of the stakeholder assessment tool did not match the direct choice of the participants which were made during the second stage of the MAMCA process. At this stage, one of the stakeholder groups, the shared moped operator, was not involved due to changes in their internal organisation. Table 2 shows the

preferences stated by each stakeholder group based on the visualisations, which are options one (basic hub) and three (all-in hub).

Table 2. Direct choice of participants in Anderlecht (Brussels)

Co-designed options	Citizens	Local admin.	Regional admin.	Public transport operator	Car-sharing operator
1. The basic hub		X	X		X
2. The green hub					
3. The all-in hub	X			X	
4. The social hub					

This mismatch can be explained because participants gave criteria at an early stage of the co-design process when the reflection was at a more abstract level while the choice of the co-design options was made through concrete visualisations of the designs. This might have led participants to reflect on other elements that might have not been considered in the given criteria, such as the attractiveness of the design. In this regard, the cost of implementation and maintenance was not even mentioned by most groups but when debating about the co-designed options it appeared to be very important. Participants could have also decided based on their intuition, subjective preferences and emotional triggers produced by the visualisations of the designs. Nonetheless, the co-design two (green hub) is somehow an in-between option of the co-design one and three, which might explain also why this one scores the best in the MAMCA.

3.1.6 Assessment of the tool

The MAMCA process proved valuable in revealing the preferences of stakeholders concerning the co-design of a mobility hub while fostering a reflection on how to ensure that such preferences are met in the resulting implementation. The 53 people who participated in the second stage of the MAMCA process evaluated the tool, with a majority of them expressing satisfaction with the results of the assessment. However, most participants did not find the tool easy to understand, especially those belonging to the stakeholder group 'citizens'. People with lower education or in vulnerable groups have additional difficulties understanding the tool and how the results were obtained. The latter required additional time to participate in the assessment, although many people did not have it.

The choices of participants did not coincide with the results of the tool, showing the need to improve the criteria selection stage to ensure that all relevant criteria for each stakeholder are considered. For participants having difficulties with understanding the tool and results, a sense of mistrust emerged, making it challenging for them to align their final choice with the MAMCA's outcomes. A majority expressed a preference for retaining personal choices, even if the tool indicated that other options would be beneficial for their stakeholder groups. Aligning stakeholder perceptions with the analytical outcomes becomes a critical aspect of the appraisal process. In this regard, the visualisations should be critically used to avoid emotion-driven choices.

3.2 Munich Living Lab

The Munich Living Lab focused on implementing a Mobility Hub as part of a street experiment. The Stakeholders-based Impact Scoring (SIS) method was conducted to assess this intervention and justify the long-term implementation of the hub. The purpose was to quantify both the negative and positive impacts of selected criteria as perceived by three different stakeholder groups. The evaluated criteria were selected based on the living lab's goals and relevant aspects highlighted by the stakeholders during the workshops. The SIS evaluation considered a scenario without any intervention on the past state (i.e., without mobility hub implementation) and the real scenario, where a street experiment (parklet) was adapted into a mobility hub.

3.2.1 Participants

The stakeholders involved were the same ones considered in the living lab:

- Mobility department of the city of Munich, the local government.
- MVV, the local public transport operator (MVV).
- Citizens.

The citizen group was composed of 10 people with diverse social backgrounds (age, gender, income, education, occupation, and migration background) who were asked to participate in a survey for weighting the factors. All the stakeholders identified in the living lab were included, as they all played a significant role in the planning process and the acceptance of interventions in the public space.

3.2.2 Locations and dates of SIS workshops

The SIS process was developed in two phases. First, workshops with each stakeholder group were conducted to identify their primary interests, which were then used as the criteria for the evaluation. These aspects included the hub's suitability as a place to stay, the provision of multiple mobility options, the use of sustainable and durable materials, the availability of information/wayfinding, visibility, integration with other mobility hubs, digital integration, and user-friendliness. In a subsequent meeting, stakeholders from all three groups were asked to assign a score ranging from 0 to 6 (indicating the importance level, from not important to very important) to each of these criteria.

The workshops with different stakeholders were held after the implementation of the mobility hub on three different dates: 28 October 2022, 5 December 2022, and 14 March 2023. The citizens' workshop took place on-site, while the workshops with the planners of the public transport provider were held on the premises of TUM and with the mobility department of the City of Munich online.

3.2.3 Challenges

The Stakeholders-based Impact Scoring (SIS) method faces a primary challenge related to the subjectivity involved in aggregating assessing factors into categories and assigning their relative importance weights and scores. Initially, the task involved summarizing generic categories for various factors, with stakeholders providing input on what they deemed important. However, for the sake of tool usability, these factors had to

be condensed into categories. Determining the optimal number of categories and their arrangement proved challenging. A second challenge arose when assigning weights to different categories. While input from various stakeholders was targeted to rank the chosen categories, some cases resulted in most categories being considered very important, making it difficult to establish a clear weighting for each category.

The most challenging step in the tool's process was setting scores for each category, ranging from -1 as the most negative, to 0 as neutral, and to 1 as the most positive. Despite relying on comments and opinions, determining these scores remained highly subjective, varying depending on the individual analyzing the comments related to different categories. As a result, scores may differ from person to person based on who sets them. Additionally, the process faced extra challenges in terms of contacting diverse stakeholders and organizing workshops.

3.2.4 Results

SIS is a participatory appraisal method to quantify the negative and positive impacts of projects on stakeholders, based on the assumption that impact is the product of 'objective' observations or estimations (by experts), and 'subjective' value judgements (by stakeholders)" (te Boveldt et al. 2022). For this approach, the results of the evaluations of the citizens were summarised, the representatives from the City of Munich, and the representatives of the public transport operator in Munich. After conducting workshops with these stakeholders, their primary interests were incorporated as criteria (see Table 3). In a subsequent round, representatives of these stakeholders were requested to rank the criteria on a scale from 0 (not important at all) to 6 (very important). As a requirement of the tool, these values were converted on a scale from 0 to 10.

Table 3. Criteria and weights obtained in Munich

Factors	Citizens	City of Munich	Public transport operator
The hub as a place to stay	6.7		3.3
Multiple sustainable mobility options	10.0	10.0	10.0
Sustainable and durable materials		1.7	
Information (e.g. pole, directions, schedules, etc.)		6.7	8.3
Visibility		8.3	8.3
Integration with other mobility hubs		3.3	
Digital integration		5.0	
User friendly (simple to use)		10.0	
Proximity to Public transport stop			6.7
Well maintained			6.7
A design that is both cosy and sustainable,	5.8		
Inclusive design and information	5.0		
Safe, quiet and clean	5.0		

The appraisal tool revealed that the hub has significantly more beneficial impacts than negative ones, as shown in **Error! Reference source not found.**. It can be stated that the hub is more in line with the interests of citizens, followed by the mobility department of the City of Munich, and finally the public transport

operator. Some negative aspects considered by the citizens include the slight increase in noise due to people gathering at the hub, while for the City of Munich, the hub's location outside the network of hubs in the city is a drawback, and for the public transport operator, the fact that the hub is not directly located at a public transport station is a challenge. On the positive side, the most relevant impacts for citizens are the multiple mobility services, the various other activities that can be performed at the hub, and the cosy design. The City of Munich considers the benefits of the multiple services offered at the hub and its ease of use, while the public transport operator appreciates the multiple services, the visibility, and the information provided at the hub. Finally, as shown in Figure 6,the benefits of implementing the mobility hub for the long term will be for citizens.

Figure 6. Relative impacts for each stakeholder group if implementing the mobility hub. Positive impacts are shown as positive per cent, and negative as a negative per cent.

The scenario without a mobility hub was also examined, revealing that the sole category affected by the absence of the hub would be the reduction of noise generated by hub users. The primary beneficiaries of this scenario would be residents residing near the mobility hub (see Figure 7).
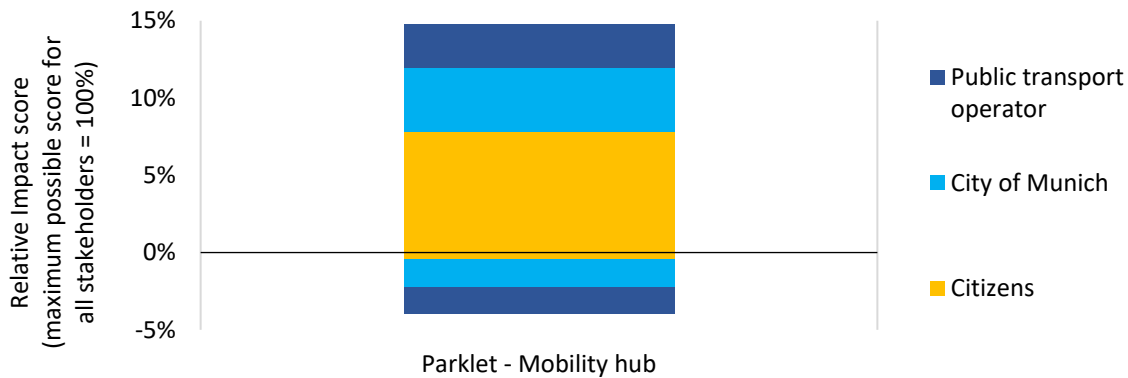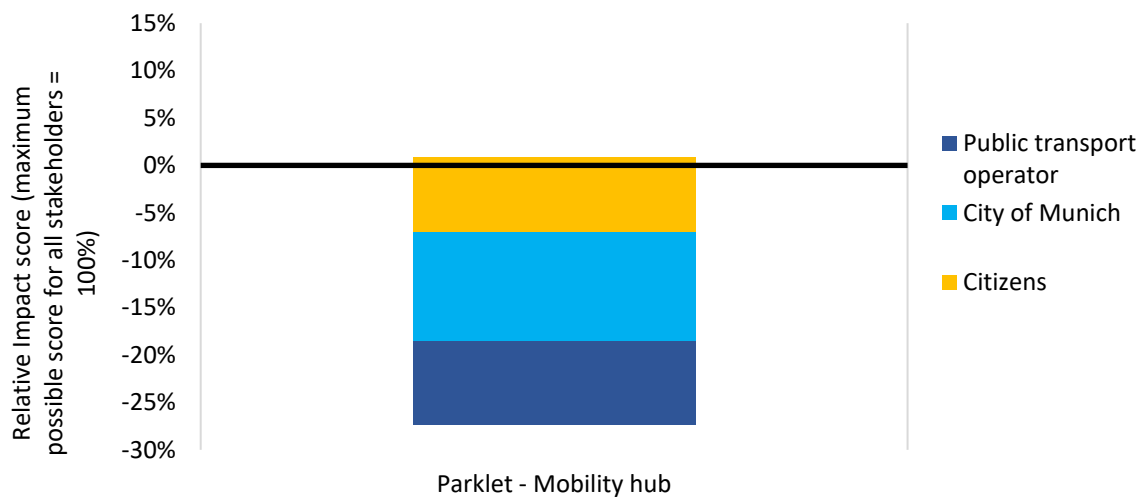
Figure 7. Relative impacts for each stakeholder group in not implementing the mobility hub. Positive impacts are shown as positive per cent, and negative as a negative per cent.

3.2.5 Comparison of decisions with/without SIS

The SIS tool facilitated the visualization of which stakeholders would benefit the most from the mobility hub and identified key aspects crucial for its future development, potentially in other locations. Through concise graphics, the tool summarized the intervention's potential, streamlining the decision-making process. While without the SIS tool, results would have relied on observations and people's reactions, the tool provides specific numerical insights, enabling decision-makers to better justify the intervention's impact.

3.2.6 Assessment of the tool

The tool revealed that the hub generates more positive impacts than negative ones, aligning well with the interests of citizens, the Mobility Department of the City of Munich, and the public transport operator. The primary contribution of the tool lies in visualizing which stakeholders benefit from the intervention and identifying the factors influencing its positive or negative impact. Furthermore, the method has the potential to compare different impacts, thereby facilitating the decision-making process. Despite the inherent subjectivity in assigning categories and scores, it is important to note that the assessment adopts a participatory approach, incorporating the relevant factors for each stakeholder. The use of Excel sheet templates enhances the method's user-friendliness, transparency, adaptability to various contexts, and replicability. Due to its subjective nature, implementing this tool in official assessment procedures may pose challenges. Nevertheless, it effectively serves as a guiding framework for discerning "winners and losers" when testing various scenarios.

3.3 Rotterdam-The Hague Living Lab

In The Hague, the MAMCA was used to provide an impact assessment of three co-designed alternatives of a mobility hub in Hobbemaplein to see if there was a (strong) preference of the stakeholders for one of the alternatives based on their criteria.

3.3.1 Participants

The MAMCA process included the seven main stakeholders identified in the Hobbemaplein:

- *Municipality of The Hague* – the municipality is leading the Hobbemaplein project.
- *HTM* – the public transportation provider of The Hague.
- *MRDH* – the metropolitan region of Rotterdam – The Hague, and officially acting as PT authority.
- *Resident's organization* – to involve the local citizens, the residential organization for the *Schilderswijk* neighbourhood will be involved. The questions for the interview will be discussed in a resident's consultation session.
- *Fietsersbond* – an organization representing the interests of cyclists in the Netherlands.
- *Shared mobility providers* – provide shared bikes and e-scooters within the municipality.
- *Local businesses – Haagse Markt* is a permanent market near Hobbemaplein and one of the largest markets in Europe. There are a lot of different entrepreneurs, and the market attracts a lot of tourists, making it an important local stakeholder.

Although most stakeholder groups were represented by one or two people, the involvement of local residents included several participants during a consultation session.

3.3.2 Locations and dates of MAMCA activities

The identification of alternatives and relevant stakeholders was discussed and determined with the municipality. The other steps involve the stakeholders mentioned in the previous section, and by means of interviews and questionnaires, the criteria and their weighting can be determined. A final expert session with some stakeholders and the municipality will not be scheduled due to the issues mentioned earlier but the final assessment will be done by the team of the UT based on the interviews.

Between the 16th of August and the 13th of September 2023, 9 online interviews (1-hour maximum, via Microsoft Teams) were conducted with 6 different stakeholders. For the local residents, the interviews were conducted via email, and criteria were discussed during a consultation session for residents of the neighbourhoods near the Hobbemaplein. The interviews were split into three parts: (I) *Personal / organisational questions*, regarding the work and role of the interviewee on hubs, (II) *Goal of a mobility hub,* and (III) *Criteria for a mobility hub*. No pre-defined list of criteria was introduced to the interviewee during the interview, so all criteria are based on the thinking and point of view of the specific stakeholder. Due to unforeseen events, the co-evaluation workshop could not be organised and thus, participants did not state their preferred option or discuss the results of the MAMCA after giving them through mainly interviews.

3.3.3 Challenges

The integration between the participation process of the project Hobbemaplein and the research of the SmartHubs team was a challenge, especially due to ongoing delays in the process and designs, and the sensitivity of the topic in the local context. This required adapting the forms of involvement to the different stakeholders to ensure their participation. Thus, no final workshop or co-evaluation event could take place due to the requirements of the municipality related to the ongoing participatory process in the square. Furthermore, comparing designs of mobility hubs was not possible, since the development of a mobility hub was not part of the municipality's scope. All of this made it difficult to intertwine the two processes and to incorporate the appraisal tool in a real-life case.

When the criteria and especially their indicators differ slightly per stakeholder group, the comparison of the alternatives becomes more difficult, especially when the alternatives are not fully developed and not all details are clear. Likewise, giving an exact score in the MAMCA tool (using pairwise comparison) can be difficult and a bit arbitrary (e.g., does design A score a 5, 6 or 7 compared to design B?), while the impact on the result can be high. Moreover, a closing session would be helpful to evaluate the MAMCA method from a research perspective. For example, it would be interesting to discuss with the different stakeholders how MAMCA can be integrated into the planning process, and if the method increases the workload compared to regular participatory planning processes.

The appraisal tool requires a lot of effort from the stakeholders. For instance, the stakeholders sometimes struggled with defining criteria for the potential hub when no pre-defined list of criteria was given. The stakeholders also mentioned that mobility hubs can be complex, especially when there is no strong understanding of the topic. This could have been improved when multiple representatives of one stakeholder group could work together on a list of criteria during a workshop, instead of interviewing them separately. Moreover, with different criteria per stakeholder group, there arises a need for more explanation and discussion on the criteria per stakeholder group when the results are presented. Lastly, with different criteria per stakeholder group and divergent results, there is a need for a validation session to confirm the preferences shown by the results and discuss the differences between the groups.

3.3.4 Results

Through the input given by participants, the researchers developed a list of general criteria and indicators based on the criteria mentioned during the interview. This list was sent to the stakeholders, who were asked to rank the criteria and to make comments or revisions. In the end, this process resulted in a distinct list of criteria and weights for each stakeholder group.

Table 4 shows the criteria per stakeholder group, ranked from highest (1) to lowest (7) weighting. The criteria and their indicators differ from stakeholder to stakeholder, since these were determined by each group separately. Commonly cited criteria are *safety and security* (regarding social and traffic safety at the hub), *accessibility and proximity* (on the closeness of modes and services and reachability of the hub), *inclusive design* (regarding access for all (vulnerable-)groups), and *wayfinding and information* (regarding signage and information provision).

Table 4. Criteria and weights obtained in The Hague

Criteria	Local residents	Municipality	PT authority	PT provider	Shared mobility provider	Cycling representatives	Local businesses
Accessibility, inclusive design	0.333		0.400				
Accessibility and proximity				0.146	0.246	0.267	
Accessibility and visibility		0.174					0.222
Affordability		0.174					
Assistance from staff		0.174				0.200	

Criterion							
Availability of shared vehicles		0.174			0.188	0.233	0.133
Bicycle parking availability	0.333						
Complementary shared mobility				0.188			
Future-proof				0.094			
Inclusive design		0.116			0.188		0.156
Maintainability				0.135			
Safety and security	0.333	0.186	0.280	0.208	0.203	0.300	0.111
Spatial integration				0.104			0.178
Wayfinding and information			0.320	0.125	0.174		0.200

The preliminary results of the MAMCA and ranking of alternatives can be seen in Figure 8. The transport hub scores the highest overall, which is mostly due to its high scores on accessibility, social safety (due to the presence of staff at the hub) and good wayfinding and information. Interestingly, the social hub scores lower for residents and municipality, due to the concerns with social safety: too many places to sit could cause a nuisance. Conversely, the basic hub scores highest for the PT provider as the presence of too many shared mobility options in the transport hubs, competes with the PT offer.
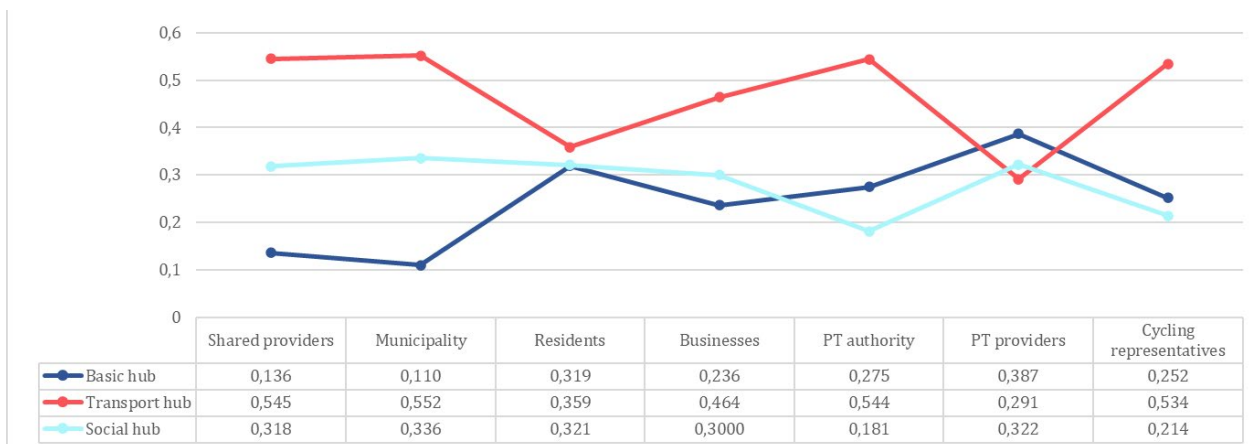

	Shared providers	Municipality	Residents	Businesses	PT authority	PT providers	Cycling representatives
Basic hub	0,136	0,110	0,319	0,236	0,275	0,387	0,252
Transport hub	0,545	0,552	0,359	0,464	0,544	0,291	0,534
Social hub	0,318	0,336	0,321	0,3000	0,181	0,322	0,214

Figure 8. Results of the MAMCA in The Hague

The overall results are interesting, especially when compared to the goal of many stakeholders: improving the liveability at the square and promoting active and public transport. The social hub design was expected to score better on liveability goals. However, the social hub design scores lower score on social safety, accessibility and availability of shared vehicles.

3.3.5 Comparison of decisions with/without MAMCA

As the process was interrupted to avoid conflicts with the participatory process organised by the municipality in the same square, it was not possible to organise a co-evaluation workshop. Thus, the different stakeholders

could not select their preferred co-design option, and the comparison with the results of the MAMCA could not be completed.

3.3.6 Assessment of the tool

As the process was interrupted to avoid conflicts with the participatory process organised by the municipality, it was not possible to organise a co-evaluation workshop. Although the different stakeholders could not assess the tool, the appraisal progress so far could still provide meaningful input for the municipality of The Hague. It offered insight into the diverse viewpoints of the stakeholders towards the future development of a mobility hub at Hobbemaplein, despite the subjectivity of the MAMCA results and the subtle differences between the stakeholder criteria (caused by the open-ended questions). The tool provided assistance in the decision-making process by identifying the positive or negative impact of certain hub elements. Furthermore, the interviews with stakeholders also uncovered an overarching goal of the stakeholders for promoting the liveability and active and public transport. This shared goal could serve as starting point to find common ground for future hub development. All in all, despite challenges in implementing the tool in an ongoing participatory process, the MAMCA tool provided interesting insights into the potential of a co-evaluation process.

3.4 Eastern Austria Living Lab (EALL)

As the housing development in Aspern Seestadt was halfway completed (~50% of housing for more than 10.000 inhabitants is finished, see Deliverable 4.2 (Kirchberger et al., 2023) for more information on the area) and changes in the city-wide mobility hub strategy could be observed, the question of which kind of network is suitable for this dense and car-reduced area, which offers many factors which can support mobility behaviour using sustainable modes (e.g., city of short distances, attractive public spaces), is more relevant.

The objectives for the application of the MAMCA tool in this context were:
- Gathering feedback on developed scenarios for future design processes on mobility hub networks (iterative, non-linear approach)
- Identifying the most controversial scenarios and scenarios with a high level of consensus
- Activating stakeholders for the topic of a mobility hub network in Aspern Seestadt

3.4.1 Participants

The stakeholders involved in the MAMCA process differ from the main stakeholder groups identified in the first place, which included the Academia, Industry, Government and Civil society. For the application of the MAMCA tool, some additional stakeholders were invited through the network of the aspern.mobil LAB:
- City Developer: this "development agency" coordinates all urban planning activities and the building of the infrastructure, in close collaboration with the City of Vienna.
- Public Mobility Hub Provider: connected to a public transport provider, this stakeholder sets up a framework to gather different shared mobility.
- Private Mobility Hub Provider.
- Self-employed entrepreneur.
- Intermediary institution.
- Residents of Seestadt. This group was divided into two sub-groups: Adults (Resident 1) and Teenagers (Resident 2).

From each group, at least one representative took part in the two-day workshop. Due to limited resources, it was not possible to facilitate workshops for or between sub-groups within these stakeholder groups, which for residents, leads to a more simplified output.

3.4.2 Locations and dates of MAMCA workshops

Two workshops were organized by MOVE (TU Wien) in cooperation with the aspern.mobil LAB. The first workshop took place in Aspern Seestadt on July 31st, 2023 (3.30 pm- 6 pm). The second workshop was held online via ZOOM on August 3rd, 2023 to reduce the time expenditure of the stakeholders. The short time span between workshops should guarantee that the complex contents of the MAMCA tool could still be remembered by participants.

3.4.3 Challenges

The main challenge for the researchers was to get acquainted with the tool because it was the first application of the researchers involved in Vienna. Moreover, it was also difficult to break down complex issues and communicate them in an understandable way to participants. For participants who have different professional backgrounds, the topic was very new and therefore a common language had to be found for all knowledge backgrounds. However, the team was able to overcome the initial difficulties of differing term definitions (e.g., goals, criteria, indicators).

The stakeholders struggled slightly with the tasks and steps they had to complete within the process. This was especially true in the beginning when they had to define goals and criteria for a fictional hub network in the Seestadt. In the evaluation, the stakeholder pointed out the challenges and gave some advice for improvement:

- Clarity of scenarios: The effectiveness of the method is dependent on a strong understanding of the subject matter, as illustrated by the example of the three different types of hubs, where the differences were not entirely clear. There is a need for a more thorough explanation of the advantages and disadvantages of each hub type to make well-informed decisions, especially regarding nuanced differences like high and collective garages. Mobility hub networks are complex issues where it is challenging to be able to explain all differences in a short time frame.
- Influence of Criteria Explanation: Clarity about the criteria used influenced decision-making, transforming impulsive choices into more informed ones.
- Confirmation and Differences: The method mostly aligned with initial preferences and confirmed them. However, some differences emerged as MAMCA's evaluations differed from personal decisions, leading to a re-evaluation of the issue for possible overlooked factors.
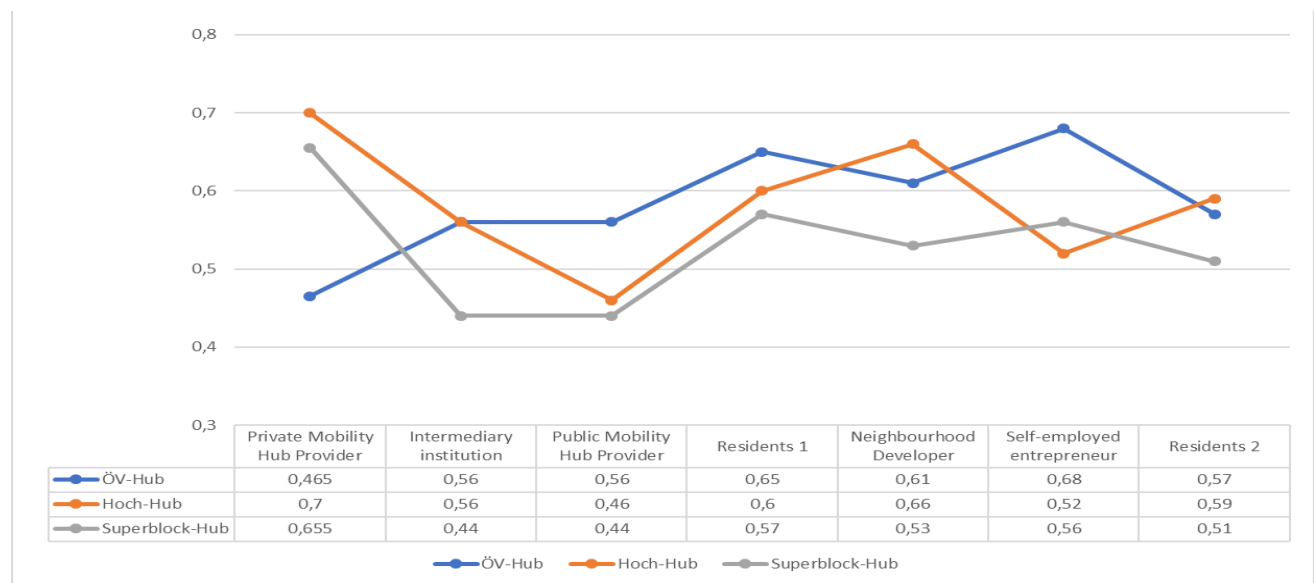
3.4.4 Results

In total, 25 criteria were indicated by participants and only two criteria were indicated by more than one stakeholder group (see Table 5). All criteria were provided by the participants in the 1st workshop.

Table 5. Criteria and weights obtained in Vienna

Criteria	Resident 1	Resident 2	Public mobility hub provider	Private mobility hub provider	Intermediary institution	City developer	Self-employed entrepreneur
Access for all residents		0.1					
Accessibility	0.2						
Availability	0.15						
Create flexible space			0.2	0.55			
Create places for social gathering						0.2	
Ease of transfer between modes						0.1	
Favorable legal conditions for operators				0.25			
Ensure protection against vandalism				0.1			
Ensure punctuality and convenience for workers							0.4
Flexibility of uses							0.4
Reduction of MIV		0.3					
Lower barriers to entry					0.1		
Low-threshold of use	0.25	0.3			0.4	0.2	
Long-term sustainable business model						0.3	
Promotion of sustainable mobility		0.15					
Reduction of dependence on own car	0.25						
Reduction of commuter's emissions							0.2
Reduction of MIV in public transport					0.1		
Reduction of MIV trips in everyday life						0.2	
Suitable infrastructure for each mobility offer			0.6				
Time-saving		0.15					

Users are not excluded	0.2	
Users' diversity		0.4
Visibility	0.15	
Protection of vehicles	0.1	

The results of the MAMCA process (Figure 9. Results of the MAMCA in Vienna show that the two options meet the criteria of stakeholders to a similar extent. The options ÖV-Hub and Hoch-Hub meet the requirements of four groups and are also the second best performing for two other groups. However, when looking at it closely, the option ÖV-Hubs would perform slightly better. The option Superblock-Hub is less

	Private Mobility Hub Provider	Intermediary institution	Public Mobility Hub Provider	Residents 1	Neighbourhood Developer	Self-employed entrepreneur	Residents 2
ÖV-Hub	0,465	0,56	0,56	0,65	0,61	0,68	0,57
Hoch-Hub	0,7	0,56	0,46	0,6	0,66	0,52	0,59
Superblock-Hub	0,655	0,44	0,44	0,57	0,53	0,56	0,51

relevant concerning the criteria stated by the participants.

Figure 9. Results of the MAMCA in Vienna

3.4.5 Comparison of decisions with/without MAMCA

The participants could indicate their preferred option, as shown in the Table 6:

Table 6. Direct choice of participants in Vienna

Option	Resident 1	Resident 2	Public mobility hub provider	Private mobility hub provider	Intermediary institution	City developer	Self-employed entrepreneur
ÖV-Hub	X	X	X			X	
Hoch-Hub							
Superblock-Hub				X	X		X

The method confirms most of the original assessment. In the first vote as well as in MAMCA, the ÖV Hub was the first choice. Although the appraisal matched the direct choice of a participant, this person ultimately preferred another option. Another participant stated that the two criteria were evaluated differently by the MAMCA method than by his/her reasoning. This encouraged this participant to look at the issue again and to see whether it may have overlooked something in the original decision.

3.4.6 Assessment of the tool

The application of the tool in Vienna should be contextualized within the constraints of limited resources and a compressed procedure, with the absence of a co-creative design phase and two full days for the definition of indicators and evaluation. Noteworthy advantages of the tool encompass a coherent structure delineating the overarching process, a user-friendly workflow facilitated by the online platform, and a transparent interrelation between criteria, evaluation processes, and resulting outcomes. Participants engage in a reflective exercise related to their objectives on the subject. Nevertheless, some disadvantages of the tool were identified. Firstly, its application necessitates improved integration into more open, less structured formats of participation, accounting for "soft" decision factors and opposition to scenarios. The task structure for participants depends heavily on the facilitator's guidance, participants' knowledge of the topic, and their experience with similar methodologies. The simplification of scenarios was necessary to enable their evaluation, fostering a predisposition toward their alignment. In summary, the tool needs to be well integrated into a planning process and balanced out with other less complex participatory methods to be able to reach out to more stakeholder groups. Lastly, the tool requires a longer learning period for facilitators to be able to realize it in a well-structured way.

3.5. Comparison across living labs

The comparison of the four applications of the SmartHubs Appraisal tool focus in six elements: the objectives and timing of the application, the participants and relevant methodologies, the challenges, the most relevant criteria, the results, and the assessment given by participants and facilitators.

3.5.1 Objectives and timing of the assessment

The four living labs applied the SmartHubs Appraisal Tool with a different aim. In Munich, the assessment was conducted to justify the long-term implementation of an existing mobility hub in a parklet. This approach, in which only two options are evaluated, requires the use of the SIS methodology. In The Hague and Anderlecht, the assessment was part of a co-creation process to conceive a future mobility hub. In Vienna, where mobility hubs are largely present, the application of the tool is aimed at identifying a preferred typology of hub network. The three cases that were considering several options applied the MAMCA methodology. Furthermore, the tool was also used at two different stages of the hub implementation process. In the case of Munich, the SIS methodology was conducted after testing a mobility hub to choose its continuity. In the other three living labs, the MAMCA methodology was applied to assess future scenarios that have been not implemented before.

3.5.2 Participants and relevant methodologies

In the SmartHubs Appraisal Tool process across the four living labs, very diverse stakeholders are engaged. This might be due to the specificities of each context as well as the availability of stakeholders to participate. In the four cases citizens and local residents are involved, as well as the local governments. Public transport operators, like STIB-MIVB, MVV, and HTM, as well as shared mobility operators are included in the assessment processes. The only case that includes very different stakeholders is Vienna, where city developers and other private organisations are invited to the process. The latter can be explained by the specificity of this assessment in which the aim was to evaluate a mobility hub network in a newly developed area of the city.

The methodologies used to involve participants in the stakeholder assessment process across the four cases included one-on-one interactions (interviews or assisted questionnaires) and workshops, which were online or in-person. The choice of the methodology was related to the availability of the participants, as several participants could not join the workshops. Depending on the living lab, the methodologies were used to identify and weight criteria and/or to present and discuss the results.

3.5.3 Challenges

The main challenges are related to the time required to apply the SmartHubs Appraisal Tool as well as the possibilities and skills of the facilitator. The latter is relevant because it can be difficult for the participants to identify what criteria are relevant for them, as well as to what extent they are relevant. In this regard, communication between the facilitator and the participants can be also challenging as it is central to ensure that everyone understands the different steps and requirements regardless of their level of expertise and familiarity with the topic. This is also central to lowering the threshold of participation and includes participants with a lower education level or limited literacy of the official local language. Furthermore, the indicators and measurements needed to assess the alternatives based on the criteria given by participants can be difficult to identify, or the necessary data may not be available. Lastly, the local political and social context may be decisive in allowing the process to be implemented, as the relevant stakeholders may not be eager to participate or the local authorities may prefer it to not happen.

3.5.4 Relevant criteria

The main stakeholder groups that can be found across the four living labs indicated the following criteria as most relevant:

o Citizens

For this group, safety and security are the most important criteria followed by the pricing and ticketing of the services. The physical access and inclusive design of the hubs are central, as well as the low threshold of use and the possibility of finding assistance from staff at the hub. Lastly, the presence of sustainable mobility options is also important, including the related infrastructure (e.g., bicycle parking). The latter is related to another criterion given by citizens which is the reduction of the dependence on their own cars and the use of induction motor vehicles.

o Local government

The most relevant criteria relate to the availability, visibility and reliability of the services and infrastructure, including the presence of sustainable mobility options, and the proximity to a public transport stop. The safety and security of the users are also crucial, as it is the effectiveness and simplicity of the signage and communication, and the pricing and ticketing of the services.

o   Regional Government

The availability and reliability of the services and infrastructure are very important for this group, as it is the physical access and inclusive design of the hubs. For this, effective and simple signage and communication are also considered important, as it is the possibility of using the services without requiring a smartphone or a high level of digital skills. Lastly, the safety and security of users is also highlighted.

o   Public transport operator

This group indicates as more important criteria the availability, visibility and reliability of the services, and infrastructure, including the presence of sustainable mobility options that are complementary. The accessibility provided and proximity of the hubs, as well as the presence of effective and simple signage and communication are also identified. The physical access and inclusive design of the hubs are highlighted, as well as the suitable spatial integration of the hub and its services with the existing infrastructure. The latter also concerns digital integration and ticketing integration with other transport services. Lastly, the safety and security of users is also relevant.

o   Shared transport operator

The most relevant criteria relate to the availability and reliability of the services and infrastructure, as well as the flexibility of the space and the infrastructure which should facilitate adaptations. The accessibility provided and the proximity of the hub are also highlighted. Likewise, the effectiveness and simplicity of the signage and communication, and the safety and security of the users are also considered to be important. It is also indicated as a relevant criterion to align the size and services available at the hub with the context and the local needs. Lastly, the legal conditions for the sustainable operation of the hub or network are also highlighted.

o   Local businesses

The availability (e.g., number of modes available), visibility and reliability (e.g., punctuality, convenience) of the services and the hub are highlighted. Likewise, the effectiveness and simplicity of the signage and communication, the integration of the hub within the space and the inclusivity of the design of the hub are relevant criteria. Furthermore, the mobility hub must facilitate long-term sustainable business models and the reduction of transport-related emissions of companies.

3.5.5 Correlation among relevant criteria and the SmartHubs KPIs

The criteria most often indicated as relevant by the different groups have been compared with the 57 KPIs identified in the SmartHubs Deliverable 2.2 (Pappers et al.., 2022):

o   Accessibility and proximity offered by the hub.

      Although there are two KPIs related to this criterion – hub network density and length, and number of hubs in the network – there are no KPIs specifically measuring accessibility and proximity. This criterion is partially considered in the KPI 'Integration with local/regional/national transport policy'.

o   Availability of services and (sustainable) modes.

      Ten KPIs relate to this criteria, although measuring more concrete elements, such as the number of vehicles available at the hub, the number of transport modes available at the hub, and the availability of toilets.

o   Signage, information provided, and communication

      Eight KPIs relate to this criterion: the presence of printed timetables, quality of the wayfinding within the hub, availability of real-time departure and arrival information for public transport as well as for shared mobility options, presence of overview of location and explanation of

mobility options, availability of drop-off/pick-up points for taxi, carpooling, ridesharing, and ride-sourcing.

o Physical accessibility and inclusive design

Five KPIs relate to this criterion: Accessibility of digital services for people with disabilities, accessibility of hubs for people with disabilities, accessibility of transport modes for people with disabilities, availability of kiss&ride places, and amenities adapted for delivery vehicles.

o Pricing and ticketing

Seven KPIs relate to this criterion: The possibility of buying a ticket that combines several modes, the possibility for users to unlock transport modes and facilities using a smartphone, the number of applications/subscriptions necessary for full use of the hub and its services, quality of the ticketing service, availability of ticket machines, availability of digital ticketing and the availability of QR codes for fast registration and use of mobility options.

o Reliability of the services and vehicles

Three KPIs relate to this criterion: average and maximum waiting time, public transport frequency, and crowding at the mobility hub.

o Safety and security of users

Five KPIs relate to this criterion: Perceived risk of crime in urban transport, coverage of CCTV cameras, number of accidents at the hub, proportion of secure bicycle parking, and quality of public lighting.

o Visibility of the infrastructure

Although there are no KPIs that directly address this criterion, the ones that refer to wayfinding are partially related to it.

Several KPIs are not considered in the criteria indicated by participants, especially the KPIs that relate to democratic integration. Moreover, the KPIs about digital integration, are contained in criteria that do not only focus on the digital elements of mobility hubs.

3.5.6 Results

The SmartHubs Appraisal Tool indicated the most relevant alternatives in the four living labs, offering more clear results in three cases. In Munich, the only location where the SIS method was applied, the option of maintaining the parklet mobility hub was considered as better meeting the criteria of the participants. In Anderlecht, the co-designed option 'Green hub' best met the criteria of all stakeholders, while in The Hague, the option 'Transport hub' did so according to the criteria of six stakeholders out of seven. Although in Vienna two options obtained similar results, the alternative ÖV-Hub performed slightly better, and it was also the option chosen by direct vote of four out of the seven stakeholders involved. The common elements of the options that better performed in the assessment are that they offer more transport modes at a closer distance, with easier exchanges between modes. Moreover, these mobility hubs are found at the street level and in the case of Anderlecht and The Hague, they provide more thorough information for travelers, including a digital information kiosk, and feature non-mobility services (e.g., coffee kiosk, sitting area). Interestingly, the direct choice of participants, which was only asked in two living labs, did not match the results of the MAMCA in both locations. In Anderlecht, none of the participants chose the option assigned by the MAMCA. The mismatch between the MAMCA results and the direct choice can be explained because the process of identifying and weighting criteria is based on an abstract reflection, while the selection of a preferred option is done based on more concrete information and/or visuals. The latter might have led participants to reflect

on other elements that might have not been considered when identifying criteria and choose on the basis of new criteria (e.g., aesthetics, perceived cost of maintenance).

3.5.7 Assessment of the tool

The applications of the SmartHubs Appraisal Tool (MAMCA and SIS) have shown their relevance to enable the reflection on stakeholders' preferences as well as in identifying relevant criteria concerning the design and implementation of mobility hubs. The structure offered by the tool facilitates the engagement of participants, in online or in-person formats, as well as guidance from the facilitator. The latter being crucial for the application of the tool, specific training for facilitators is recommended. Although participants in Anderlecht and Vienna have expressed their satisfaction with the tool, several difficulties were expressed. Firstly, the extent to which participants understood the tool and the process was very unequal, especially among citizens with lower education. Secondly, there was a mismatch between the results of the assessment and the direct choices of participants, as the latter was sometimes made on the basis of criteria that were not previously stated. The latter shows the need to improve the criteria identification and weighting stage, in which participants can find difficulties, requiring additional time and support from the facilitator. A possible solution, as indicated by one of the facilitators could be to provide an exhaustive predefined list of criteria from which participants can choose and rate the most relevant ones. This list can be produced through the results presented in this deliverable. Lastly, from the methods used in the different living labs, collaborative workshops are the most effective to apply the tool because they can ensure shared meaning and fruitful discussions take place.

4. Conclusions

This deliverable answers the research question "To what extent can a stakeholder assessment tool support the co-creation process of a mobility hub?". For this, several elements of the four applications conducted in the living labs of the SmartHubs project are investigated: the aim and benefits of applying the tool, the stage in which it should be applied, relevant stakeholders to be involved in the process and their preferred criteria, the alignment of the criteria with the SmartHubs KPIs (Deliverable 2.2), and the possible improvements of the tool and its application process.

The application of the SmartHubs Appraisal Tool has shown its pivotal role in supporting the co-creation process of mobility hubs. The different applications demonstrate their relevance in reflecting stakeholders' preferences and identifying crucial criteria for mobility hub design and implementation. The SmartHubs Appraisal Tool, employed both before and after implementation, serves as a decisive factor in determining the nature and viability of mobility hubs. Although the methodologies employed varied based on participant availability and were instrumental in identifying and weighting criteria, collaborative workshops are considered to be the most adequate method.

Engaging a diverse spectrum of stakeholders, ranging from local residents to local or regional governments, public transport operators, and shared mobility operators, is central to ensuring inclusivity, sustainability, and community responsiveness. In the context of mobility hubs, the criteria that stakeholders universally consider more important are the safety and security of users, availability of services and (sustainable) modes, visibility of the infrastructure, reliability of the services and vehicles, accessibility and proximity offered by the hub,

signage and communication, inclusive design, pricing and ticketing, and alignment with local needs. When comparing these findings with the KPIs identified in the SmartHubs Deliverable 2.2 (Pappers et al., 2022) we can see that although most criteria are related to several KPIs, the accessibility and proximity provided by the hub and the visibility of the infrastructure are not considered in the KPIs. Likewise, the KPIs for democratic integration cannot be found in the criteria given by the stakeholders, showing that this form of integration is less relevant for the stakeholders.

The findings underscore the importance of enhancing the tool's usability, understanding, and alignment with stakeholders' (hidden) criteria. The need for flexible and inclusive approaches tailored to unique contextual challenges and that allow to decrease the time required to apply the tool are highlighted. For this, the provision of tailored facilitator training is recommended, as well as an exhaustive predefined list of criteria to simplify the criteria identification stage.

The main limitations of this study are related to the differences among the contexts in which the tool was applied, and the fact that it was applied by different facilitators. The latter required the establishment of a common framework for reporting about the tool, although a certain type of data was not collected in the four living labs, limiting the scope of the analysis. For this, the analysis of the four cases is based on the information that is available and comparable, as a means to ensure the validity of the results. As this is, to our knowledge, the first experience in which a stakeholder assessment tool is applied in the context of mobility hubs, further research could apply the findings and recommendations contained in this deliverable to refine the methodology. Moreover, the development of effective training for the facilitators of the process could also be a subject of further research.

References

CBS. (2022). Kerncijfers wijken en buurten 2022. CBS Statline. Retrieved 16-02-2023 from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/85318NED/table?ts=1671702238020

DHIC. (2022a). Wijkprofielen - 29 Schildersbuurt. Municipality of The Hague.

DHIC. (2022b). Wijkprofielen - 30 Transvaalkwartier. M. o. T. Hague.

Duran-Rodas, D., Navarro Avalos, F., Hall, J., Nichols, A., Büttner, B., Baguet, J., & Susilo, Y. (2022) SmartHubs Deliverable 3.1, Guidelines for the integration of mobility hubs into the urban space

Duran-Rodas, D., Navarro Avalos, F., Nichols, A., Büttner, B. (2023) SmartHubs Deliverable 4.5, Living Lab report – Munich

Environnement.Brussels, 2022, 'Qualité de l'air à Bruxelles : Les zones trop pollués sont une réalité. Retrieved on April 2023 from https://environnement.brussels/citoyen/news/qualite-de-lair-bruxelles-les-zones-trop-polluees-sont-une-realite.

Garritsen, K., Grigolon, A., & Geurs, K. (2023) SmartHubs Deliverable 4.4, Living Lab report – Rotterdam-The Hague.

Geurs, K., Grigolon, A., Münzel, K., Gkiotsalitis, K., Duran-Rodas, D., Büttner, B., Kirchberger, C., Pappers, J., Martinez, L., Graf, A., Hansel, J., Gkrava, R., & Klementschitz, R. (2023). The Smarthubs integration ladder: a conceptual model for the categorisation of shared mobility hubs. Transport Reviews. https://doi.org/10.1080/01441647.2023.2239499

Grimble, R., & Wellard, K. (1997). Stakeholder methodologies in natural resource management: A review of principles, contexts, experiences and opportunities. Agricultural Systems, 55(2), 173–193. https://doi.org/10.1016/S0308-521X(97)00006-1

Keseru, I., Bulckaen, J., & Macharis, C. (2016). The multi-actor multi-criteria analysis in action for sustainable urban mobility decisions: The case of Leuven. International Journal of Multicriteria Decision Making, 6(3), 211–236. https://doi.org/10.1504/IJMCDM.2016.079713

Kirchberger, D., Dörrzapf, L., Berger, M., Gkavra, R., Klementschitz, R., Roider, O., Susilo, Y., & Eckerl, Y. (2023) Deliverable 4.2, Living Lab report – Eastern Austria

Macharis, C. (2000). Strategische modellering voor intermodale terminals. Socio-economische evaluatie van de locatie van binnenvaart/weg terminals in Vlaanderen. [PhD Dissertation]. Vrije Universiteit Brussel.

Macharis, C. (2004). The optimal location of an intermodal barge terminal. In M. Beuthe, D. V. Himanen, P. A. Reggiani, & D. L. Zamparini (Eds.), Transport Developments and Innovations in an Evolving World (pp. 211–234). Springer.

Macharis, C., de Witte, A., & Ampe, J. (2009). The multi-actor, multi-criteria analysis methodology (MAMCA) for the evaluation of transport projects: Theory and practice. Journal of Advanced Transportation, 43(2), 183–202. https://doi.org/10.1002/atr.5670430206

Macharis, C., De Witte, A., & Turcksin, L. (2010). The Multi-Actor Multi-Criteria Analysis (MAMCA) application in the Flemish long-term decision-making process on mobility and logistics. Transport Policy, 17(5), 303–311. https://doi.org/10.1016/j.tranpol.2010.02.004

Macharis, C., Turcksin, L., & Lebeau, K. (2012). Multi actor multi criteria analysis (MAMCA) as a tool to support sustainable decisions: State of use. Decision Support Systems, 54(1), 610–620. https://doi.org/10.1016/j.dss.2012.08.008

Martinez, L., Baguet, J., & Keserü, I. (2023) SmartHubs Deliverable 4.3, Living Lab report – Brussels

MRDH. (2023). Gemeenten Metropoolregio Rotterdam Den Haag. Retrieved 16-02-2023 from https://www.mrdh.nl/wie-zijn/gemeenten

Municipality of The Hague. (2021a). Stand van zaken proces aanpassingen tramlijn 6 en 12. Dienst Stedelijke Ontwikkeling Gemeente Den Haag,

Municipality of The Hague. (2021b). Voorstel van het college inzake Strategie mobiliteitstransitie Den Haag 2022 - 2040. Gemeente Den Haag,

Municipality of The Hague. (2022a). Staat van de Stad - Den Haag 2022.

Municipality of The Hague. (2022c). Werk aan de Wijk - Hobbemaplein & Hobbemastraat. Municipality of The Hague,. Retrieved 21-2-2023 from https://werkaandewijk.denhaag.nl/projecten/hobbemaplein

Pappers, J., Keserü, I., & Macharis, C. (2021). Participatory evaluation in transport planning: The application of Multi-Actor Multi-Criteria Analysis in co-creation to solve mobility problems in Brussels. Transport in Human Scale Cities. https://doi.org/10.4337/9781800370517.00028

Pappers, J., Martinez, L., & Keserü, I. (2022) SmartHubs Deliverable 2.2, Synthesis of KPIs to evaluate mobility hubs

Regional average calculated from the separate data for each of the 19 municipalities, 2021. Retrieved on November 2023 from STATBEL, Datalab – Census: https://statbel.fgov.be/nl/themas/datalab/datalab-census-onderwijs#figures

te Boveldt, G., Keseru, I., & Macharis, C. (2022). When monetarisation and ranking are not appropriate. A novel stakeholder-based appraisal method. Transportation Research Part A: Policy and Practice, 156, 192–205. https://doi.org/10.1016/j.tra.2021.12.004

Acknowledgements

Appendix 1. Alternatives at the Anderlecht Living Lab

Co-designed option 1: The basic hub

- Transportation modes: Bus, tramway, shared bikes, shared cars.
- Amenities: Shelter, designated parking space for shared e-scooters, bike parking, secure bike parking, and an EV-charging station for cars.
- Other elements: Improved bicycle access, the information provided in English and Arabic, adapted to people with visual and hearing impairments, CCTV cameras, and increased vegetation.

Source: Flames & Mobilise, 2023

Co-designed option 2: The green hub

- Transportation modes: Bus, tramway, shared bikes, shared cars, shared cargo bikes.
- Facilities: Shelter and waiting area, designated parking space for shared e-scooters, bike parking, an EV-charging station for cars, restrooms, monitored info point, and maintenance room.
- Other elements: Improved bicycle access, signage, accessibility for people with reduced mobility, adapted to people with visual and hearing impairments, additional lighting, new tables and benches, increased vegetation, and use of sustainable materials.

Source: Flames & Mobilise, 2023

Co-designed option 3: The all-in hub

- Transportation modes: Bus, tramway, shared bikes, shared cars, shared cargo bikes.
- Facilities: Shelter and waiting area, designated parking space for shared e-scooters, bike parking, secure bike parking, bike repair shop, parcel lockers, restrooms, coffee kiosk, and maintenance room.
- Other elements: car parking, text-free signage, accessibility for people with reduced mobility, additional lighting, new tables and benches, and increased vegetation.

Source: Flames & Mobilise, 2023

Co-designed option 4: The social hub

- Transportation modes: Bus, tramway, shared bikes, shared cars.
- Facilities: Shelter and waiting area, secure bike parking, bike repair station, restrooms, maintenance room.
- Other elements: parking, signage, accessibility for people with reduced mobility, additional lighting, CCTV cameras, new benches, increased vegetation, and use of sustainable materials.

Source: Flames & Mobilise, 2023

Appendix 2. Alternatives at the Munich Living Lab

Picture of the location before the implementation of the mobility hub (Duran-Rodas et al.,, 2022).

Picture of the TUM-Steinheilstrassev mobility hubs (Duran-Rodas et al., 2022).
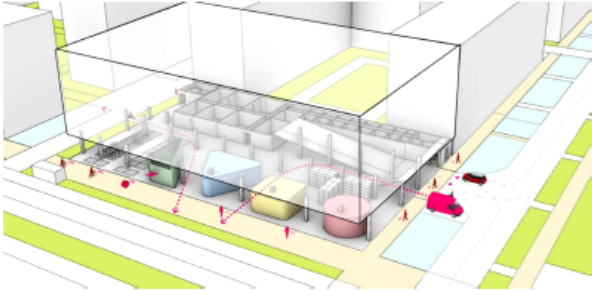

Picture of the mobility hub (Duran-Rodas et al., 2022)

Appendix 3. Alternatives at The Hague Living Lab

Name	Alternative 1 - **Basic hub**	Alternative 2 - **Transport hub**	Alternative 3 - **Social hub**
Design			
Description	A basic mobility hub with a simple offer of shared modes and some mobility services but no other additional non-mobility services.	A mobility hub focused on transport and mobility related services, with a large offer of shared modes at both sides of the bus lane, and presence of a service point with an employee.	A mobility hub focused on the social aspect, with basic mobility services but a wider offer of non-mobility services such as a parcel locker & municipal info point in the library.
PT modes	Bus & tram	Bus & tram	Bus & tram
Bike sharing	min. 10 e-bikes Available at one side of the bus lane, not conflict free Designated parking area	min. 15 e-bikes & min. 2 cargo bikes Available at both side of the bus lane, mostly conflict free Designated parking areas Repair point at the employed service point	min. 5 e-bikes Available at one side of the bus lane, not conflict free Designated parking area
Car sharing	No designated shared car parking	1 shared car parking, not conflict free	No designated shared car parking
Moped sharing	min. 3 mopeds Available at one side of the bus lane, not conflict free Designated parking area	min. 8 mopeds Available at one side of the bus lane, not conflict free Designated parking area	No shared mopeds parking at the hub
Change modes	max. ~100m Conflict free between 1 bus stop and 1 tram stop, others require crossing of a bus lane and tram rails.	max. ~50m Conflict free for most modes, only the shared car requires crossing the bus lane in most cases.	max. ~100m Conflict free between 1 bus stop and 1 tram stop, others require crossing of a bus lane and tram rails.
Travel info	Realtime travel information screens Digital kiosk	Realtime travel information screens Digital kiosk Employed service point for PT and shared modes	Realtime travel information screens
Non-mobility	Benches for seating	Coffee point at the service point Benches for seating, covered waiting area	Municipal information point, integrated with the library Parcel locker Play elements and benches for seating Free, local wi-fi Security camera's
Investment	€	€€€	€€

MobilityHub Network-Alternatives aspern Seestadt (Vienna)

Characteristics	Alternative 1			Alternative 2		Alternative 3	
Title	Public transport - Hubs			High - Hubs		Superblock - Hubs	
Symbolic image							
Hub - type	XL	M	S	L	XS	M	XS
Quantity - modes	3 (public transport = high-ranking)	3	2	2	1	2	1
Quantity - car sharing per hub	at least 3	1	-	at least 10	-	2	-
Diversity - car sharing	transporter, family van, compact car	compact car	-	transporter, family van, compact car	-	family van, compact car	-
Quantity - bike sharing	at least 20	10	10	at least 15	5	10	5
Diversity - bike sharing	cargo bike, e-bike, bicycles	cargo bike, e-bike, bicycles	bicycles	cargo bike, e-bike, bicycles	cargo bike, bicycles	cargo bike, e-bike	bicycles
Visibility in the public space	very good	very good	very good	mediocre	very good	poor	good
Changeover public transport	max. 50 m	max. 50 m	max. 200 m	100-500 m	~250 m	~250 m	~250 m
Accessibility	very easy	very easy	very easy	medium	very easy	rather difficult	very easy
Grid density	1000 m	600 m	500 m	800 m	350 m	600 m	350 m
Expandability	limited	rather limited	medium	almost not limited	medium	rather not limited	medium
Necessary co-operation partners	• City of Vienna for use of public space			• City of Vienna for use of public space • Car park operator(s) • 3420 for use of ground floor car parks		• City of Vienna for use of public space • Property developers for the use of open space on properties • operator(s) car parks	
Target groups by mobilty type and typical travel chains	• Public transport users			• Visitors by car, coming from outside • Companies with low transport requirements		• Residents with short distances in Seestadt and transport routes within /outside Seestadt	
Digital integration	level 3 (integration of booking and payment for all offers)			level 3 (integration of booking and payment for all offers)		level 3 (integration of booking and payment for all offers)	
Return option at other locations	only for bike sharing			for all offers		only for bike sharing	