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Mobility Hubs, a lever for more sustainable mobility?

Wassim Hached, Alain L'Hostis

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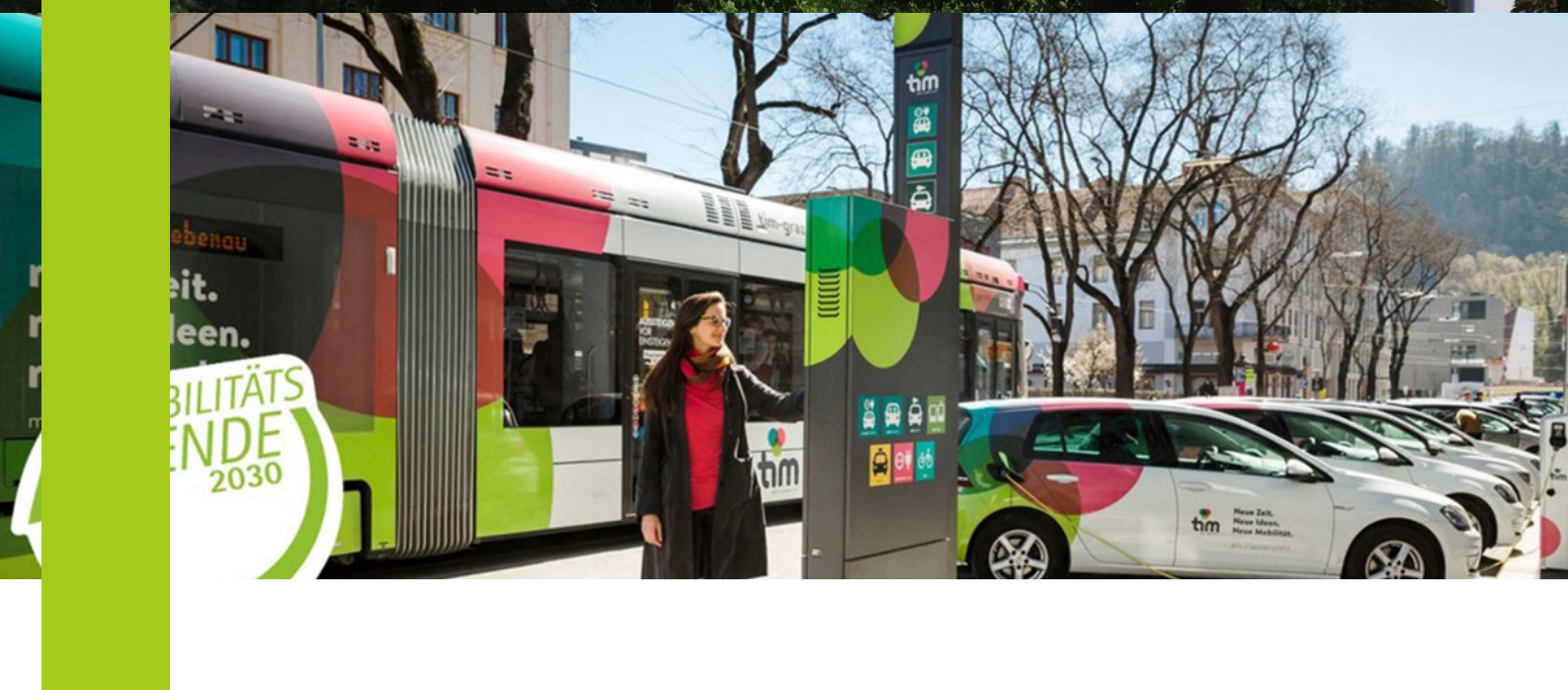
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MOBI-MIX insight report

Mobility hubs, a lever for
more sustainable
mobility?





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Written by Wassim Hached and Alain L'Hostis

Reviewers and contributors: POLIS; CoMoUK; Bax & Company, Valenciennes Métropole and the City of Rotterdam

Designed by Katie Basham (Bax & Company)

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About MOBI-MIX

MOBI-MIX brings together partners from four different countries: the Netherlands (City of Rotterdam), Belgium (Antwerp city, Ghent University, City of Mechelen and POLIS), France (Valenciennes Métropole, Transalley technology park and Gustave Eiffel University), and United Kingdom (Norfolk County Council, Cambridge Cleantech and CoMoUK).

The project aims to encourage behaviour change and to achieve positive environmental gains in the urban environments of five cities/regions in the 2 Seas area. The five MOBI-MIX cities are interested in facilitating the implementation of innovative mobility solutions. The uptake of low carbon transport modes is of interest here, since the overall objective of the project is to decarbonise road transport. Effective implementation of shared mobility and MaaS solutions are the two main ways to achieve these goals. Cities are working closely with mobility providers and other local stakeholders to ensure the shared mobility ecosystem develops to the benefit of the entire city.

A series of four insight reports focuses on the different transport concepts that these cities want to implement, and the aspects which can support the effective deployment (data, policies, etc.). The first report explored MaaS (Mobility as a Service) and can be read [here](#). The second report looked at the State of the Art in carsharing and is available [here](#). While this third one focuses on mobility hubs, the forth and last report will be looking at mobility data for effective policy making.

Introduction

In the last decades, mobility policies and transportation services have been evolving rapidly, mainly in large and medium size cities. By now, most public authorities have placed sustainable mobility objectives at the core of their policies. In this context, we can notice many changes in the urban environment, infrastructure, amenities, and services. In addition to the reinforcement and continuous improvement of public transport, cities also encourage, among other practices, the use of active modes. Along the same way, mobility that moves away from (private) vehicle trips and ownership to shared vehicles is covering more and more cities. Public-Private Partnerships are also being set up to better engage the transition to more sustainable mobility. Within this framework, mobility hubs bring together different means of shared and public transport, offering alternatives to private vehicles. Thus, “mobility hubs present an opportunity to integrate different sustainable transportation options to enhance connectivity across the region. [...] Mobility hubs have the potential to become a catalyst to prioritize low emission transportation options that support existing regional goals and embrace future changes in the urban form.” (Aono, 2019).

Mobility hubs are perceived to be one of the several solutions or mix of solutions, that cities and regions could consider for more sustainable mobility, in order to overcome the “car is king model”. These urban facilities are likely to offer significant advantages over already existing solutions, such as

encouraging the use of public transport, multimodality, walking, cycling, and shared mobility. Indeed, locating several modes of mobility in the same place would increase the visibility of the modes provided. In addition to this, other advantages can be mentioned such as: helping to make transit easier, allowing the possibility of multimodality, giving a wider and more flexible choice, improving accessibility, and compensating for the lack of public transport in many areas... (CoMoUK et al., 2019). The mobility modes which are physically integrated by mobility hubs can be digitally integrated into MaaS (Mobility as a Service) applications, to provide a more efficient transport system and facilitate the users' transit, access to information, reservation or payment, for example.

Mobility hubs implementation, is one of the results and also a representation of the mobility policies of the city/region. This mobility policy itself is the consequence of wider ideological, social, economical and environmental orientations... Mobility hubs could offer cities new concepts of urban planning and can be seen as a form of implementation of TOD (Transit Oriented Development).

Therefore, what are the mobility hubs? What are their main objectives? What are the different types of mobility hubs? What are the most relevant projects of mobility hubs and what should we learn from?



Mobility hubs definition

The term “mobility hub” is estimated to have emerged in the early 2000s, but has become increasingly well known in the last 2 decades. According to Google Trends, which analyses the popularity of top search queries in Google Search across various regions and languages. The first searches for the term “mobility hub” appeared in August 2007 (figure 1).

The frequency of searches for this term has been fluctuating with less and less frequent breaks until October 2010. Since then, interest in the concept has not stopped (Google, 2021). We can then deduce that the term “mobility hub” was introduced at that time or shortly before.

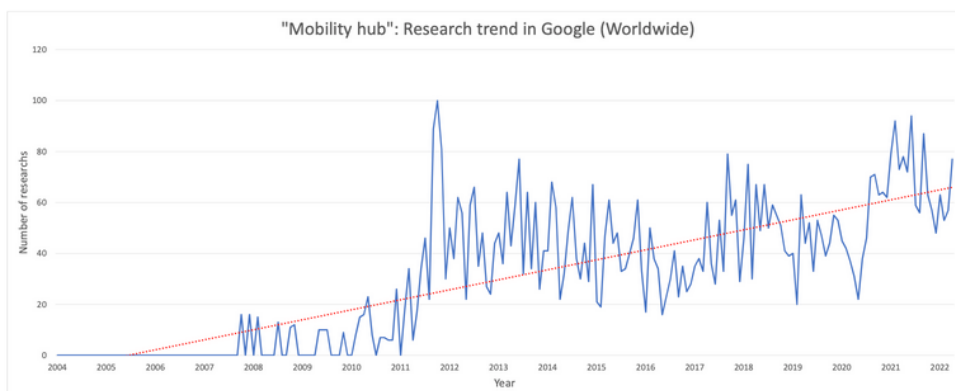


Figure 1: “Mobility hub” research trend (Google, 2021).

We were also made aware that the term mobility hub in its beginnings was not based on a theoretical concept and that no specific author claimed to be the founder. Our research did not allow us to trace the inventor of this term. Till now, there is still a lack of scientific literature on this subject. Several definitions of the term “mobility hub” are used.

However, in the corpus of operational literature, we identified approximately a dozen definitions of the mobility hub. Therefore, various definitions have been and continue to emerge. Each proposed definition depends on the status of the author and his experience, plans, and goals.

Mobility hubs objectives

When designing mobility hubs, cities usually define clear objectives. Authors agree that “The primary objective of mobility hubs is aimed at the reduction of car ownership, car use and car use-related emissions” (Aono, 2019; Claasen, 2020; Interreg NWE, 2019; SANDAG, 2019). Mobility hubs provide alternative shared modes to private cars so “inhabitants can be mobile without owning a private car” (Claasen, 2020; Miramontes et al., 2017). Shared transport then has several advantages, such as “less required parking supply on-street and more efficient use of the required space” (Claasen, 2020; ShareNL, 2018) or increase equity and inclusivity among elderly, disabled people, and low-income groups (SANDAG, 2019). “In addition, it may lead to more connection among people living in the same neighbourhood due to sharing” (Claasen, 2020; ShareNL, 2018).

Aono highlighted 7 main common objectives of mobility hubs:

1. Integration of sustainable transportation options.
2. Improving user experience,
3. Ensures safety and security,
4. “Creates a sense of place through effective and meaningful placemaking strategies”,
5. Flexibility to embrace technological innovations and foster resiliency,
6. Equity by considering accessibility to and availability of transportation options in different neighbourhoods.
7. Opportunities to form effective partnerships.” (Aono, 2019)

The South East Scotland Transport Partnership, (SEStran) presented 4 main groups of objectives, each made up of several sub-objectives. These groups are economy, accessibility, environment, and safety & health. The detailed objectives of each group are summarized in table 1. The economic dimension aims not only to “Improve connectivity through the integration of transportation options and other services” but also to “integrate shared mobility to complement the existing transport network.” (GO SEStran et al., 2020). In regard to the accessibility aspect, the aim is to promote inclusivity, especially for disabled people or those with mobility impairments. The objective is also to improve accessibility for those with limited transport choices or no access to a car and to “support people to make informed travel choices through integration and provision of information”.





With regards to the environmental objective, the aim is to primarily support low carbon choices and reduce emissions.

The objective is also to improve accessibility for those with limited transport choices or no access to a car and to “support people to make informed travel choices through integration and provision of information”. With regards to the environmental objective, the aim is to primarily support low carbon choices and reduce emissions. Besides, mobility hubs should “increase the use of shared mobility as an alternative to the private car and facilitate a shift to more

sustainable and active modes to reduce car ownership” as well as encouraging behavioral change. In this context, one of the objectives of mobility hubs is to ensure an easier and more fluid modal shift towards more sustainable modes of transport. Finally, the health and safety criteria remain important in two aspects: The first one is “ensuring safety and security for people using the hub”. The second is “creating a sense of place and community and reallocating space in the public realm through placemaking and effective land use.” (GO SEStran et al., 2020).

Economy	Accessibility	Environment	Safety & health
Improve connectivity	Promote inclusivity	Low carbon and reduction of emissions	Ensure safety and security
Integration of transportation options and other services	For disabled people or those with mobility impairments	Shared mobility as an alternative to the private car	Create a sense of place and community
Complement the existing transport network	Improve accessibility for those with limited transport choice or no access to a car	Shift to more sustainable and active modes	Reallocate space in the public realm
	Support people to make informed travel choices	Reduce car ownership	
		Encourage behavioural change	
		Facilitate a modal shift	

Table 1 : Mobility hubs objectives according to GO SEStran; (W.HACHED., 2021)

We can therefore deduce that mobility hubs can be considered as urban and political tools at the disposal of cities. The aim is not only to consolidate their environmental policies in terms of mobility but also to achieve broader

social, security, and economic objectives. This was confirmed by the expressed intentions stated by the partner cities of the Mobi-Mix project. We can therefore consider the mobility hub as a multifunctional tool for mobility policy.

Mobility hub types

The broad definition of “mobility hubs” extends their acceptance limits. It offers mobility hubs many possibilities and combinations of roles, sizes, quality... In this case, it seems to be legitimate to classify mobility hubs in different categories. Many cities and authors already classify them according to many parameters such as size, energy used, target users... “Some of the existing literature distinguishes between different types of mobility hubs. These distinctions are essential in understanding mobility hubs as a multifaceted concept, where the local context shapes the hub typology. Additionally, these existing typologies can help inform how to classify hubs [...] in a way that suits the local transportation network.” (Metrolinx 2008).

In this regard, based on their urban location and function, we can then distinguish between “Regional mobility hubs”, “Community mobility hubs” and “Neighborhood mobility hubs” (RTP, n.d.).

Another method to categorize mobility hubs is possible. The Regional Transportation Plan (RTP) for the Greater Toronto and Hamilton Area created by Metrolinx prefers to distinguish mobility hubs by their role in the transportation network. Metrolinx, related that two types of mobility hubs were identified. Anchor hubs and Gateway hubs (Metrolinx, 2011).

It is also possible to classify mobility hubs according to urban context and the transportation function the area serves. This method is used by Metrolinx. The goal is to make it easy to identify “specific needs and characteristics of the area.”

(Aono, 2019; Metrolinx, 2011). Regarding the urban context, the mobility hubs are classified as follows: City Centre, Urban Transit Nodes, Emerging Urban Growth Centres, Historic Town Centres, Suburban Transit Nodes and Unique Destinations (Aono, 2019).

Taking more into consideration the transportation functions, the following sorting is used. Entry, Transfer, and Destination (Aono, 2019).

LA Urban Design Studio (2016) employs these three typologies to categorize mobility hubs, which are: neighbourhood, central and regional hubs. Such typologies represent the requirements for both the surrounding urban environment and the components of the hub (GO SEStran et al., 2020).

The Future Mobility Network, is a knowledge and consultancy agency in the Netherlands, which is made up of a team of independent advisors and partners on actual and future mobility. They have been developing a number of different mobility hubs with a particular interest in electric mobility, in Amsterdam, Nijmegen, Leuven, and Manchester. These mobility hubs are called “ehubs”. They provide electric mobility and hosting infrastructure for local residents, commuters and leisure travelers. Based on their model, there are four main ehubs that vary in size, location, and services provided. Their idea underlying these four categories is that the services of a hub should match the existing transport demand within that location. So, the four e-hubs are defined as minimalist, light, medium, and large (Aono, 2019).

Another hybrid topology combining size, location (urban environment) and services provided can also be used. This typology distinguishes: Large interchanges / City hubs, Transport corridor / Linking hubs, Key destinations (business parks, hospitals, etc), Mini hubs (or a network of mini hubs), Market towns / village hubs (CoMoUK et al., 2019; GO SEStran et al., 2020). Through these different classification approaches, “table 2” shows that it seems that the most recurrent and influential.

element on which the choice of the type of mobility hub is based on size and the urban environment (location). Particular attention is rightly paid to the existing transport infrastructure and offer. In addition to these parameters, it is necessary to point out that the population density and activities (work, leisure, education, health...) have a significant impact on the classification of mobility hubs and defining their size and the services they provide.

Author	Classification	Criteria
RTP, n.d.	Regional, community, neighbourhood mobility hubs	Size, location, density, level of travel generated, existing public transport...
METROLINX, 2011	Anchor, Gateway mobility hubs	Role in urban structure, existing transit lines...
METROLINX, 2011 Aono, 2019	City Centre, Urban Transit Nodes, Emerging Urban Growth Centres, Historic Town Centres, Suburban Transit Nodes and Unique Destinations	Location, density, urban context, land availability, volume of activity and travel...
Aono, 2019	Entry, transfer, and destination	Trip direction (outgoing, transit, entering), facilities and features, public transport...
Aono, 2019 e-hubs	Minimalistic, light, medium, large	Size, features (number of modes), ease to implement, physical impact...
LA Urban Design Studio, 2016 GO SEStran et al., 2020	Neighbourhood, central, regional	Size, location, density, urban context, features...
GO SEStran et al., 2020	Large interchanges / City hubs, Transport corridor / Linking hubs, Key destinations (business parks, hospitals, etc), Mini hubs (or a network of mini hubs), Market towns / village hubs	Size, location, density, level of travel, urban context

Table 2: Different classifications of “mobility hub”?; (W.HACHED., 2021)

In order to achieve more sustainable and fairer mobility, and above all in line with the various social, economic and environmental policies of the city or region, it would perhaps be more judicious to proceed by the development of a global but evolving action plan (like the pedestrian plan, bicycle plans or public transport network plan). This plan will serve as a thoughtful guide with a long-term vision for setting up a network of mobility hubs. It will consider the different characteristics of the urban environment, the population, the current or planned transport infrastructure and other parameters if necessary. A single mobility hub, whatever its size, will certainly only have a one-off impact, and it is unlikely that a tangible change in travel habits and modal shares will result at the city or region scale. "In the UK Nexus had implemented the local hub idea in a single

free-standing location at Ryton, west Gateshead, in 2002, but this proved to have a number of problems with it in practice and was closed in the late 2000s. We believe that this was another factor in the UK failing to embrace the mobility hub concept in the 2000s / 2010s" (mobihub.com, n.d.).

However, a network of mobility hubs will cover more territory, inhabitants, and passengers. Each of the mobility hubs that make up the network must obviously be adapted to the local context and to the role it plays in the global network. This adaptation could be visible through the size of the mobility hub, the modes, links, and the services it offers. The establishment of such a network could begin with the installation of test mobility hubs, which will be used to better adjust future mobility hubs.



Common framework to analyse implementation of mobility hubs

The choice of mobility modes to be provided in a mobility hub is often a delicate step, as it partly influences the success of the hub in achieving its objectives. It is important to be attentive to the needs and expectations of users and local residents. In some cases, it is necessary to take into consideration the goals of organisations covering large areas and with their proper Mobility plans (universities, factories...). However, this should not exclude the possibility of innovation. The involvement of associations and private partners is also important. It would be better to first focus on working with existing providers in the region. If there are none, it would be necessary to consider the need to launch services as a network (like in Bremen and Bergen). Isolated services may have more difficulties and work optimally only in very few cases. The partners, providers of shared modes, based on their experience, can use their own methods to evaluate the potential success (particularly in terms of use and profitability) of one or other mode in any given location. In all cases, several parameters must be considered. We can cite as examples, without being exhaustive:

- *“Land use density,*
- *Multimodal transportation network density, including transit density and service level,*
- *Density of destinations,*
- *Community demographics and individuals’ ability to access transportation options,*

- *Cost, efficiency, reliability, safety, an enjoyability of the options available,*
- *A range of policy and programmatic structure already in place [...] (such as parking districts, cost of parking, shared mobility service areas, and similar)” (Crowther et al., 2020).*

In the previous section, we mentioned that we are sceptical about the miraculous and tangible impacts of a single, isolated mobility hub. However, we are convinced that it is possible to achieve the various mobility objectives (environmental, social, economic, etc.) that cities (or the state) are aiming for through, among other things, mobility hubs. And this is subject to various conditions. One of the main conditions is the development of a network of mobility hubs that is interlinked in such a way as to provide an effective response to the diversity of mobility purposes/needs of all people. The other is to rethink the current way of life and the city as a whole, especially its infrastructure and urban environment. The aim here is to reduce the need for mobility (especially over long distances), to favour the least polluting modes and to restrict the most polluting ones. In this sense, we are referring to improving the distribution of resources/facilities in the city, the deployment of traffic-calmed areas, a cycle network, pedestrian areas, meeting zones, etc.

Of course, given the complexity of the city and its various uses, other conditions not mentioned here are also important.

The strength of the “mobility hub” concept as defined in this insight report is its flexibility. It allows imagining a network of mobility hubs. In this network, each mobility hub is designed to meet two main requirements: addressing local needs and particularities on the one hand, and its more global contribution to larger scale mobility and its role in the mobility hub network on the other hand.

To facilitate the choice of the type of mobility hub to be implemented in the network, we propose as an indicative measure to consider the:

- size of the mobility hub (especially in terms of area and/or number of vehicles), number of transportation modes to be offered,
- choice of these modes of transport,
- status of the mobility hub (permanent or temporary).

In order to meet these questions, several parameters may come into consideration, namely density, travel needs/demands, frequency of these travel needs/demands and length of trips. Figures 2, 3, 4 and 5,

below, can help to establish the type of mobility hub and to identify different parameters of a given mobility hub.

choices and reduce emissions. Besides, mobility hubs should “increase the use of shared mobility as an alternative to the private car and facilitate a shift to more sustainable and active modes to reduce car ownership” as well as encouraging behavioral change. In this context, one of the objectives of mobility hubs is to ensure an easier and more fluid modal shift towards more sustainable modes of transport. Finally, the health and safety criteria remain important in two aspects: The first one is “ensuring safety and security for people using the hub”. The second is “creating a sense of place and community and reallocating space in the public realm through placemaking and effective land use.” (GO SEStran et al., 2020).

Therefore, starting from a specific location, it will first be necessary, as shown in “figure 2”, to study the local density and the importance of the local mobility demand. Based on these parameters, we can place a point on the graph representing the planned mobility hub. Depending on the position of this point in the graph, it is possible to get a first idea of the size of the mobility hub and the number of shared modes to be proposed.

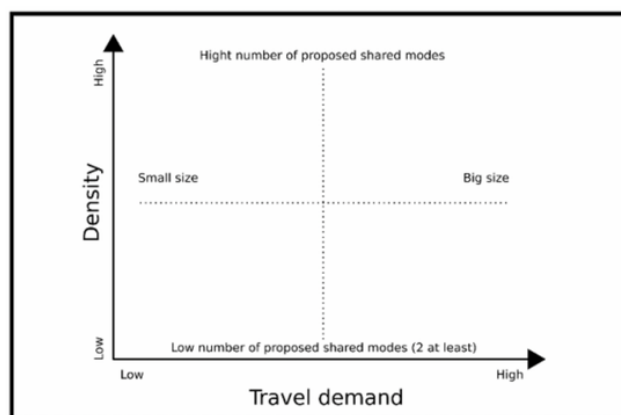


Figure 2: Size and proposed modes in a mobility hub; (W.HACHED., 2021)

The second step, as shown in “figure 3”, which is complementary to “figure 2”, is to assess the frequency of mobility demand/needs. The mobility hub can be permanent if the mobility demand is constant. Temporary mobility hubs can be considered for less frequent mobility demands. We are thinking here particularly of fluctuating mobility demands generated by particular infrastructures/events such as stadiums, exhibition halls, concert halls, etc. These temporary mobility hubs can even be

virtual by clustering free-floating shared modes in the same location.

Considering a temporary mobility hub can be problematic in some cases, especially for public transport and station based vehicles. In these cases, the infrastructure for the modes is created but only used when needed. Public transport would only serve the station within the temporary mobility hub once the hub is functioning. The stations based vehicles are also made available, only when the mobility hub is operating.

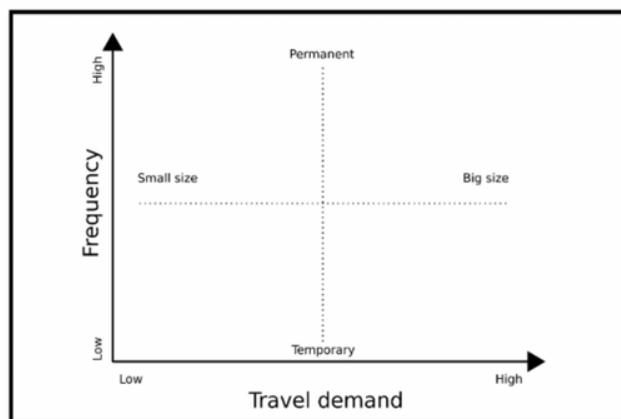


Figure 3: Size and status of mobility hub; (W.HACHED., 2021)

“Figure 4”, is a combination of figure 2 and 3 into a 3-dimensional view. Let's take for example a location where the density is high, the need/demand for mobility is high and permanent. We can then deduce from figure 3 that the planned mobility hub should be permanent, offer several different modes and many vehicles. Therefore, it will have a large size. On the other hand, if we take the example of a location near an exhibition, the

density will be low, the demand for travel is high but rare (low frequency of demand). In this case, it is possible to consider a mobility hub that offers a low diversity of shared modes, but many vehicles are proposed. This particular mobility hub can be temporary and/or virtual and can only be operational depending on the activities of the exhibition hall.

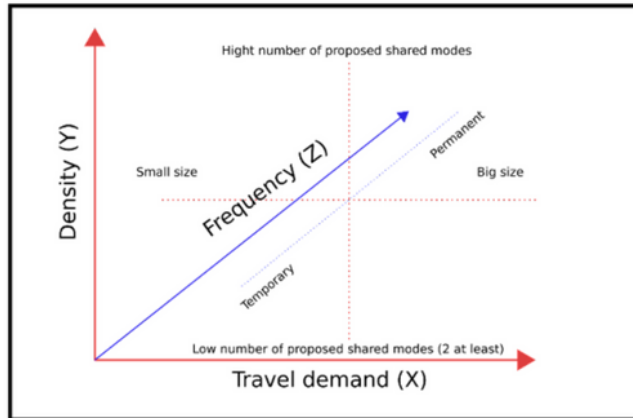


Figure 4: Size, status and proposed modes in a mobility hub; 3D representation; (W.HACHED., 2021)

The last step (“figure 5”), is to choose the travel modes that should be proposed by the mobility hub. For this reason, two parameters seem important to us, namely density and trip length. Density is often correlated with a high travel demand. In this case, the higher the density, the more it will be necessary to opt for grouped shared modes (public transport) in order to accommodate a large number of passengers. The lower the density, the greater the need for individual shared modes such as bicycles or shared scooters.

Trip length is also important in determining which modes to propose. Efficiency is often measured in terms of travel time. Although this is open to criticism, generally the shorter the travel time with a mode, the more efficient it is considered to be. So, the higher the average travel time in the study area, the faster the proposed modes should be. Let's take the example of an area where the density is low, but the travel distances are long, such as rural areas. In this case, it would probably make sense to offer fast individual modes such as car-sharing.

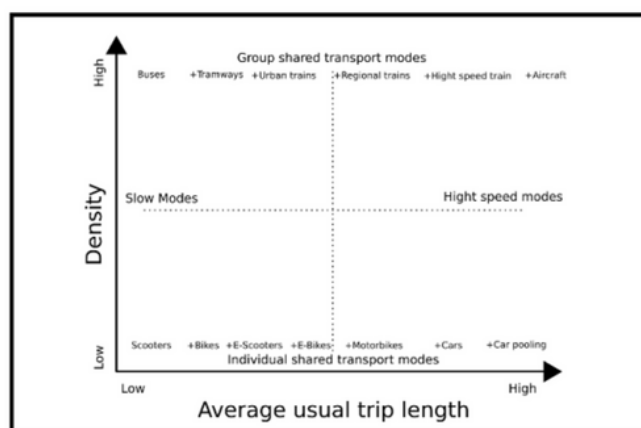



Figure 5: Mobility modes to provide; (W.HACHED., 2021)



After all, the choice of the exact location of a mobility hub is a crucial and delicate step. It plays a key role in the success of the mobility hub in achieving the objectives for which it was designed. For this reason, the planner must first define the objectives of the mobility hub. Then, the choice of the location will necessarily result from a consensus that seeks to find a particular balance (between social, economic, environmental and cultural objectives, etc.). Among the criteria for the choice of location we can mention, for example: the legal possibility in accordance with urban planning documents, the availability of land, the already existing mobility networks (in particular public transport and cycling facilities), the density, the flows generating places, the mobility flows, the demand for mobility, the targeted users ... J. Crowther et al. declare that a mobility hub development can be influenced by:

- “Space within the public right-of-way,
- Land use zoning (permitted uses),
- Availability and cost of parcels outside of the right-of-way,
- Partnerships with land-owning entities, as well as with funders and developers,
- Site constraints,
- Scale of hub site design/intended programming,
- Existing/prior investments in infrastructure,
- Demand for specific modes and services.” (Crowther et al., 2020)

In this way, A. Queirós & G-H. González stipulated that the most suitable location of mobility hubs in the urban space is mainly set in relation to the expected transport users, as well as in regard to the socio-economic impact.

Mobility hubs are often used by urban planners to reorganize disadvantaged areas, in order to create more activity and higher investment in such zones, while simultaneously raising the value of the land (Urban Design Studio, 2016). Another important factor in the location is the demographic structure, accessibility and population density of the area (Queirós and González, 2019; Ratti, 2017).

CoMoUK states that The location of hubs will have a key influence on viability. For this reason, they consider the following criteria (CoMoUK, 2021a):

- “Areas with a high density of people living or passing through
- Public transport nodes
- Gaps in provision of transport and facilities which need addressing
- Trip generators – large employers / university sites / tourism activity / shops
- Areas with restricted car parking
- Cycling paths and / or cycle friendly roads
- Sites marked for redevelopment
- Areas with air quality issues
- Areas which have good visibility and accessibility
- Areas identified as priority through community consultation
- Areas which have suitable utilities
- It is also important to consider areas of social deprivation which may not meet these traditional criteria for viability”

These guidelines reflect the fact that there is no one-size-fits-all approach to the planning and implementation of mobility hubs. Every location has its unique set of both challenges and opportunities depending on its urban context (e.g., urban vs. suburban), its transportation function, and its degree of commitment to the mobility hub concept.

Hence, while many of the identified location areas offer little more than wide car parks, others are conveniently accessible by multiple modes and are indeed dynamic places of activity and destinations themselves (Metrolinx, 2011). However, "In remaking the transportation system, existing areas and those with the potential to be transformed into urban centers present the best

opportunity for the placement of mobility hubs" (RTP, n.d.).

In conclusion, there is no magic formula for choosing the best location for a mobility hub. The ideal location is the one that offers the best balance between the various characteristics (local, regional, regulatory, etc.) and that ensures the best compromise to reconcile the targeted objectives.



Insights to be gained

Each territory is unique. The space and the environment in the broad sense (natural, urban, political, legal, social, economic...) that it offers for each mobility hub is just as specific. Therefore, it seems necessary to recall that in order to achieve these objectives, each of these facilities must be adapted to its own specific context. An adapted solution should be provided. Each mobility hub will then be unique (size, vehicles offered, number of vehicles, services...). "There is not a perfect solution for mobility hubs, and the approach to planning and implementation of each hub will need to be tailored." (GO SEStran et al., 2020).

A network of identical mobility hubs may not be ideal. This solution, which is typically designed to fit the majority of uses and users, could prove to be effective on a city-wide scale. However, it does not consider the disparities and specificities of each area, which nevertheless are very numerous in the city. It could therefore create or reinforce inequalities.

In an increasing concern for equity and in order to overcome disparities, it would be more appropriate to provide a multiscale solution.

This means the development of a network with hierarchical mobility hubs (in terms of importance in the network, size, services offered), each of them adapted and specifically designed to answer the most local specificities.

This does not exclude the possibility of learning from other experiences. In this sense, some authors recommend some keys to a successful mobility hub. For example, RTP highlighted 6 components they find necessary for a successful mobility hub:

1. "Multimodal transportation facilities and services,
2. Economic activity,
3. Intensified/concentrated land uses and urban densities,
4. Pedestrian facilities and accommodations,
5. Embedded technology, and;
6. A strong sense of place." (RTP, n.d.)

Therefore, in order to fulfill the above conditions and to go further, the implementation of a mobility hub will necessarily be preceded by a substantial preparation period. This phase of the project follows several phases, in particular the integration within the urban mobility policies of the city.

Mobility hubs, in urban mobility policy

There are a variety of tools that can be adopted to support the implementation of mobility hubs. They include zoning regulations, a global parking strategy, and the identification of potential development in the catchment area. This involves the creation of a master plan for the station area. The goal is to help ensure that new transport installations are adapted to the various modes of transport, that they also encourage and support changes in modal split, and that they facilitate living and working possibilities (RTP, n.d.). There are several individual aspects that define and characterise mobility hubs and are well documented and studied in available literature: optimal location; key characteristics and components; leadership on their development. Within this framework, S. Aono, from Translink, followed three steps. She, first, reviewed common phases used for planning mobility hubs implementation. Secondly, she outlined several “partnerships and responsibilities involved in mobility hub creation, both internally and externally”. And this under “four main different topics of planning, services and elements, land development, and funding.”. Then she explored existing strategies “to understand


common approaches used by existing mobility hub studies”. Finally, she identified “other key considerations and common challenges found in mobility hub implementation” (Aono, 2019).

In the same vein, Go SEStran states that “establishing new mobility hubs can take time and requires careful planning — working with multiple partners on a complex development may not happen fast or easily.” (GO SEStran et al., 2020). Like any other urban infrastructure, the implementation of one or more mobility hubs requires a series of steps such as planning, implementation, management, and maintenance or adjustment. It is worth pointing out here that it would be wise to involve at least the future target users and local residents in these various steps. It would allow us to achieve a more consensus-based mobility hub that would better correspond to everyone's expectations. This kind of collective and inclusive planning will also strengthen local democracy and offer more transparency to citizens and users. We will develop here three major phases for the establishment of one or more mobility hubs: before, during and after the implementation.

Milestones preceding the establishment of mobility hubs

The idea of creating mobility hubs can be driven by a regional or national ambition in favor of more sustainable mobility. It may also express a more local desire. This desire arises from the awareness of elected representatives and/or citizens of the challenges of sustainable development

and/or from the recognition of local problems. The latter are mainly related to the quality of urban space and mobility, i.e., congestion, noise or air pollution, accidents, etc. It is important to point out here that convincing politicians is important during all steps of the project, especially where



environmental policies are not yet considered as a priority. It is also essential to stress that there are usually important negotiations with politicians, different departments of the territory and other institutions concerned by mobility policy. This requires an important and crucial coordination work.

Where mobility hubs appear to be an appropriate solution, they could take different shapes to help address issues that go beyond mobility (strengthening local life, inclusivity, equity, etc.), since transport is

always a means to an end, and not an end in itself.

Once the decision to develop a mobility hub is taken, the planning stage can begin. For this reason, early communication between the city, stakeholders, residents, and users is already highly recommended, for a more effective acceptance of potential future mobility hubs.

This first step can be considered like a Pre-planning Phase. Its goal is to develop “a Vision and Framework for mobility hubs” (GO SEStran et al., 2020).

Mobility hub planning phases



While there may be political and public will, the implementation of mobility hubs or a network of mobility hubs requires a significant amount of time (1 to 2 years). The process includes several steps. We have highlighted seven of them, in the following order:

1. Regulatory checking, feasibility, and integration,
 2. Urban analysis,
 3. Planning the (network of) mobility hubs,
 4. Building the first mobility hubs,
 5. Impact measures and adjustment,
 6. Generalisation and wider implementation,
 7. Adaptation and permanent improvement.
- Each of these steps is explained. However, it should be noted that we will not be exploring them in detail.

Step 1: Regulatory checking, feasibility, and integration

Once the idea of creating mobility hubs is validated and well established, it would then be necessary to consider a process for their feasibility and effective implementation in the urban space. Among the most important steps, we can underline the **analysis of the regulatory context**, especially existing documents on regulations, transport, and urban planning. And this is at different scales, the local scale, city-scale, and a larger regional scale.

At this stage, Aono proposes to review the “essential city plans such as Official Community Plans and Master Transportation Plans [...] to find any relevant policies and objectives that the mobility hub

should follow or target. This stage also involves referring to planning initiatives on both the regional and municipal levels to ensure the mobility hub complies with the vision outlined in these long-range planning documents. Lastly, local planning documents such as neighbourhood concept plans are essential to review in order for the mobility hub responds to the local community's values." (Aono, 2019). At this stage, the financial dimension may also arise, so it is also important to consider what funding is already available or can be made available for the implementation of mobility hubs.


Step 2: Urban analysis

After studying and/or revising the regulatory context, it is also advisable to **analyse the needs and demands**. "A Suitability Analysis maps the factors that influence transportation choice, including an Equity Analysis, to determine areas of the City most suited for clustering transportation choices." (Crowther et al., 2020). This analysis can also be carried out at different levels, local as well as regional. It is also interesting to **consider the urban environment in detail**, particularly the various networks (road, cycle, pedestrian, public transport, electricity, etc.). "A Feasibility Analysis evaluates the feasibility of implementing mobility hubs within prioritised areas based on the available right-of-way, potential land acquisition or potential land-owner partnerships, and permitted uses and applicable development and design standards (per zoning code)" (Crowther et al., 2020).

According to Aono :

"The following step involves researching the existing and baseline conditions of the planned hub site and its surrounding area. As such, the existing transportation network including street connectivity, cycling and pedestrian infrastructure, and public transit services are reviewed and analysed. This review should also extend to factors such as land use, urban form, and neighbourhood character to fully encompass the site context. Additionally, redevelopment opportunities within and around the site are crucial to analyse in this phase to understand the potential of the mobility hub to promote transit oriented development. Lastly, constraints and opportunities of the site area should be discussed to guide which mobility hub elements will help respond to the site's existing challenges and enhance its strengths. In some mobility hub studies, this also takes the form of a SWOT analysis."(Aono, 2019).





The aim is to satisfy the needs of citizens and users while **ensuring an adequate contribution to the various objectives of the city** (social, economic, environmental, etc.). This “Prioritization Analysis establishes criteria to further narrow areas of suitability based on alignment with City goals” (Crowther et al., 2020). These different steps make it possible to **define clearer and more precise objectives** for future mobility hubs, in order to integrate them more harmoniously into the city and to plan possible modifications to the surrounding space/network. Aono states that, after establishing the planning context, the guidelines for the mobility hub should usually be set out in the form of an overall strategy and the subsequent targets and aspirations that are designed to contribute to the fulfillment of the strategy. Such objectives may also be useful in assessing the mobility hub post-implementation to check that it is reaching its intended goals and to highlight where improvements are most important. The earlier step of defining opportunities and challenges and this step represent an ideal occasion to actively involve the community and relevant stakeholders to facilitate the achievement of a vision that addresses the concerns, values and vision of the neighbourhood as identified by the community and the stakeholders (Aono, 2019).


Step 3: Planning the (network of) mobility hubs

Considering the previous steps, it is now possible to imagine the ideal location zones of future mobility hubs to better meet the determined objectives. In order to meet the objectives and to ensure fair urban planning, it would be better to **adopt a global vision** (of the city or the region).

This would initially allow us to imagine a network of several mobility hubs. “A Suitability Analysis maps the factors that influence transportation choice, including an Equity Analysis, to determine areas of the City most suited for clustering transportation choices” (Crowther et al., 2020). Once this network has been mapped out, the city could prioritise the mobility hubs in order to best meet the defined objectives. “A Prioritization Analysis establishes criteria to further narrow areas of suitability based on alignment with City goals” (Crowther et al., 2020). This hierarchy could be based mainly on size, the modes of transport offered and the services provided. The intention is to classify them according to the favoured typology.

Now, given the scale of the project and its potential impacts, it would be wise to **identify one or more test areas**. The choice of these test areas could depend on several parameters to be specified according to the priorities and objectives of the city. A specific area may be chosen for different reasons. For example, it could be a showcase for urban marketing, or it is likely to attract a greater number of users, or it responds to an immediate need of the citizens, or it is estimated that it is there that a visible and positive impact could be reached.

Once a test area has been chosen, the **exact location of the mobility hub** can finally be precisely delineated. It is at this stage that the city could decide on the modes of transport to be proposed, the number of vehicles, the services to be offered... The opinion of private partners providing mobility solutions would be interesting at this stage. Depending on these different parameters, the conception of the graphic documents could be launched (plans, design, brand...)



“The concept plan for the mobility hub is created, which outlines the recommended improvements and elements that should be incorporated in the particular hub. As such, specific designs of the streetscape and transportation network plans are included in this plan. The recommended built form of the area may also be incorporated to help envision the appropriate form of transit-oriented development in the respective neighbourhood. This is often followed by a phasing plan for implementation, which outlines the responsibilities of key stakeholders and the timeline of action items for implementation.” (Aono, 2019).

Step 4: Building the first mobility hubs

Once the above steps have been completed, the building of the first mobility hubs can begin. If the city cannot/won't ensure this step, it is then necessary to identify the most appropriate stakeholders and partners according to the tasks to be carried out, the modes, facilities and services to be provided. Often, it is necessary to use public procurement in order to respect the principles of competition. It should be noted that several partners for the same work package could be selected to foster innovation and competition in the long term. Amongst the different stakeholders and partners we can mention construction companies, landscaping companies, mobility providers, internet providers, display solutions, street furniture providers, sponsors...

This step, where the establishment of public/private partnerships may be necessary, requires a significant amount of time and preparation.

Step 5: Impact measures and adjustment

Now, once the pilot mobility hubs have been built, it is necessary to collect a significant amount of data, negotiated in advance with the operators, continuously or regularly. The aim is to use this data to measure the effective impacts of the mobility hub. These impacts are measured by specific indicators. These indicators can differ depending on the objectives of the city. Commonly used indicators are those related to use, user profiles, environmental impacts, social impacts, economic impacts, accidents, etc. Depending on the results reached, adjustments may be necessary to better meet the objectives.

The duration of the test period of the first mobility hubs may vary from one location to another. It depends on the objectives expected by the test mobility hub, the eventual adjustments adopted to reach them, the feedback from users... Also, a test period that takes into account seasonal variations may be necessary, especially for mobility hubs that offer modes sensitive to this parameter (such as bicycles or scooters). In this case, a minimum test period of one year might be appropriate.

Throughout the lifetime of the mobility hub, communication remains a key point to maintaining attendance at the mobility hub, attracting new users, to raise awareness of local issues...

Step 6: Generalisation and wider implementation

At this stage, the test mobility hubs have enabled the city not only to gain experience in the creation of mobility hubs, but above all to better understand the local characteristics and to adapt to them in order to match the desired objectives.

The city could now better anticipate problems and be better prepared to deal with them.

Based on its experience, the city could at this stage generalize the mobility hubs and thus create a **more complete and more efficient network**. If the city has already planned a network of mobility hubs from the start, it could either stick to it by adapting each mobility hub to the local context or choose some new locations that might be more **relevant according to the results of the mobility hubs tests**.

“Site Design & Programming creates a design concept that fits within the selected site and reflects the appropriate mobility hub type, including such details as access routes, ingress/egress, transit operational needs (e.g., number of bus bays, layover facilities, or similar),

micromobility operational needs (e.g., parking capacity, payment kiosks, loading/unloading for rebalancing vehicles, or similar).” (Crowther et al., 2020).

Step 7: Adaptation and permanent improvement


When developing the mobility hubs network, even if the entire network is completed, it is necessary to return to step 5 “Impact measures and adjustment”. That is, to continue to collect the necessary data for the measurement of indicators and impacts. The aim is to maintain the attractiveness of the mobility hubs and to **reach increasingly ambitious targets**. Depending on the results obtained, improvements (of vehicles, services, facilities, etc.) can continuously be considered. The aim is also to **use the mobility hubs as a showcase** for active, shared and ecological modes of transport.

Choice of partners/providers, the mix of mobility solutions

Like most urban operations, the implementation of a mobility hub often requires the mobilisation of many and diverse participants and stakeholders. “And the processes of implementing mobility hubs is most successful when all responsible authorities for land use planning, urban design, transportation planning, and transportation engineering are all integrated into the design of a corridor.” (O’Berry, 2015). A mixture of public, private, political and associative stakeholders is not rare! Indeed, it is quite the opposite. We recall that the use of a pedagogical approach, a communication strategy and participative and local democracy is also recommended.

In this way, citizens and users are important partners. The several stakeholders involved in the success of a mobility hub should not work separately from each other. They should all be seen as committed partners, mobilising their resources, knowledge, experience, and know-how for the success of the collective mobility hub project. “As a concept that involves several public and private services, a key element in mobility hub implementation is partnerships.”(Aono, 2019).

Among the stakeholders involved in mobility hubs, we can highlight, for instance, the following: “public transport operators, local community groups including residents and businesses, other government agencies and



and transport authorities, landowners and property developers, not-for-profit organisations including disability and other community groups, technology providers, major employment sites and other key trip generators, assets, infrastructure and utility companies, other established mobility hubs” (GO SEStran et al., 2020).

S.Aono states that “the type of partnership and the stakeholders involved can vary across four main categories that are involved in mobility hub implementation.”: planning, services & elements, land development, and funding. It is often the city, as manager of the urban space and project owner, who assumes the responsibility for the creation of mobility hubs. It has the leading role. The city initiates contacts with the various actors and brings them together around the same project. Although some cities could manage mobility hubs on their territory themselves, the majority outsource the service to private partners and providers. The selection of private partners is often a delicate step, as the interests of the private partners have to be reconciled with the various objectives of the city. These include the social objectives of equity, safety, resilience, innovation, competition, etc. Cities often use a call for proposals to ensure competition. It also clearly specifies the conditions, obligations and limits of the various future contractual parties and the objectives of the mobility hubs. The selection is therefore made on the basis of the best responses. Often, at least two (usually three) private partners are selected. The aim is therefore not only to ensure competition and innovation in the long term, but also to foster resilience. Once private partners are selected, this does not usually mean that they have a completely free hand. The city still has the authority to control, adjust and adapt regulations.

Some cities are very sensitive to the reactivity of private partners in solving problems that may arise and adapting to the requirements (temporary parking bans, speed limits in certain areas, provision of data...). Although this concerns shared scooters, we can mention the Norwegian city of Bergen. It has developed an internal software that allows the authority to communicate in a fluid way with private partners. It allows them to locate each of the shared scooters on their territory, to display the information on the identity of the private partner who manages them, the level of their battery charge, the last time they were used, etc. This system makes it possible to detect, for example, a large concentration of scooters in a particular area of the city and a lack of them elsewhere. The city then immediately informs the private partner, who is then required to dispatch the vehicles in a more harmonious manner. The partner then has limited time to meet this request and if he fails to do so, he may be subject to financial sanctions (or even suspension of the partner's license and therefore a ban from operating). The particularity of the system developed by the city of Bergen is that it is a collaborative one. City agents and every citizen can report problems with shared scooters (such as parking problems) via a dedicated application. The priority of solving problems by private partners is obviously given first to the city and the city agents. Through this software, the city can specify on the map of the city the zones of traffic/parking of scooters that are allowed or not, set speed limits, open temporary parking places... These modifications are communicated in a fluid way to the private partner, which allows him to integrate and adapt them rapidly.



Challenges for mobility hub implementation



As with most actions on the urban space, the planners will be confronted with difficulties and opposition when setting up mobility hubs. The difficulties encountered can take several forms (legal, territorial, economical, social, cultural...) and the opposition can come from different profiles (inhabitants, local companies, associations, politicians...). In this sense, some authors such as S. Aono lists several difficulties commonly encountered. Among the possible challenges, we can mention, in a non-exhaustive way, the following examples: parking demand, land ownership, misalignment between transit and development, equity considerations (cost of services, language and cultural barriers, accessibility)... (Aono, 2019). To face these challenges, involving the different protagonists from the beginning of the project, taking into account their opinions and concerns, using pedagogy, diplomacy and seeking consensus, can, generally, be useful to solve many of these problems and improve the overall acceptability of the project.

Throughout this report, we will highlight only the issues that we have identified as being particularly challenging. Other specific issues may still arise. One of the most common difficulties faced when implementing a mobility hub is the parking question. Mainly, two cases can be identified: The first one reflects a situation where there is no sufficiently restrictive parking policy for cars. This means that parking spaces are available in substantial numbers and there is a large proportion of free or low-cost car parking.

Large scale parking creates an environment that discourages active transportation modes. [And] dedicating large parcels of land to parking near transit areas can inhibit development, as land is under-utilised." (Aono, 2019; Metrolinx, 2008). It is necessary to think of reducing the place allocated to the car by promoting more sustainable modes and by introducing a new parking policy in these areas. We must remember here that the design of a mobility hub is strongly linked to the urban and even the wider regional context. The implementation of mobility hubs must be part of a broad and proactive urban policy for sustainable and active mobility.

The second case is rather the opposite of the first. Parking spaces are limited and/or not affordable, and the demand for parking is high. On the one hand, this situation may favor the success of the future mobility hub and encourage the use of the vehicles and services it offers. On the other hand, the implementation of the mobility hub may be confronted with incomprehension and strong opposition to the project from local residents, especially if the future mobility hub intends to occupy/reduce parking spaces that are already highly coveted. In this case, which is becoming increasingly frequent, it is important to use education and communication to present the mobility hub services as a serious alternative to their private cars. For example, we can remind that proposing shared cars helps to reduce the number of private cars parked on the street.



CoMoUK's research shows that, on average, each shared car can take 18 cars off the street as residents sell or defer their purchase (CoMoUK, 2020). In addition, involving local residents and users in the design of a mobility hub to meet their needs and expectations is necessary. Another important issue may also arise. These are inclusiveness and equity considerations, which are rightly becoming increasingly important in local, national, European and even global policies. While some of these challenges can be addressed through technical solutions, others are more complex.

The problems of physical accessibility (for people with reduced mobility, the elderly, pregnant women, parents with baby strollers, etc.) to the mobility hub are among the many issues to be considered. However, they are among the rather easy issues to solve. In this case, "mobility hub elements and infrastructure must incorporate accessibility standards in their design and function to enhance access for seniors and people with disabilities." (Aono, 2019).

Among the most complex inclusiveness and equity issues to be addressed are those related to social and cultural issues, such as language and cultural barriers and cost of services. As S.Aono pointed out, primarily, all features and functions of the mobility hub have to be appropriate and inclusive for the surroundings' community they are intended to serve. This could mean the integration of multilingual signs in the mobility hub or the availability of translation services.

In addition, mobility services can be lacking in adoption in some neighbourhoods where communities are not culturally familiar with the provided mobility service, such as shared mobility models. The issue of the cost of mobility hub services can be a major barrier in some areas where people have low incomes: "Many of the mobility services offered at mobility hubs require payment through smartphone apps or credit cards, which people may not always have access to. Additionally, Mobility as a Service and shared mobility services often utilise a subscription fee, which many users may not be able to commit to. Therefore, subsidising programs and payment structures that take into account low-income households will be beneficial to ensure mobility hubs remain accessible across the social gradient." (Aono, 2019). In addition, when designing mobility hubs and selecting private mobility providers, cities focus on these social issues. In this case, Engagement activity through local charities who already have strong community links can be an important tool (CoMoUK, 2021b). Some cities negotiate and/or condition the selection of private partners by an effective commitment to provide an equivalent service in all areas of the city. Private partners are often reluctant to consider the economic profitability of mobility hubs and the safety of their vehicles. However, some cities take care to minimise these risks by offering subsidies and more privileged locations.

Relevant mobility hub projects

In this section, the aim is to present a compilation of chosen mobility hub projects: Bergen and Stavanger in Norway, Amsterdam in the Netherlands, Flanders and Leuven in Belgium and Bremen in Germany. Each of the presented projects is the result of a literature review as well as participation in the e-HUBS academy event of 2021, which allowed us to learn more about each project and to discuss in more detail with different stakeholders.

Mobility hubs in Bergen

The city of Bergen, member of SHARE-North and e-HUBS projects as well as many international and European projects, is located in the southwest of Norway (SHARE North et al., 2019). With an area of 465.3 square kilometres and a population of 285,601 on 1st January 2021, it is the second-largest city in Norway. The population density of the city reaches 638 inhabitants per square kilometre (Stavnes Hisdal, 2021).

The city is well known for its commitment to sustainable development in general and to sustainable mobility in particular. Moreover, it plays a role as a catalyst for innovation in this field and is therefore hosting a number of mobility hubs. The city furthermore hosted the eHUBS International Academy event in 2021. This event, which was attended by Gustave Eiffel University, was an opportunity to gain a better understanding of mobility hubs and to learn from the experiences of many other European cities.

Of course, many other mobility hubs projects can be mentioned such as in Hong Kong (Zielinski, 2007), Vienna (GO SEStran et al., 2020), Scotland (Intelligent Transport, 2021), Plymouth City Council (Plymouth., n.d.), Manchester (Tague, 2021), Linz (GO SEStran et al., 2020), San Diego (SANDAG, n.d.), Toronto (Aono, 2019), Denver (Aono, 2019), Chicago (Aono, 2019), Vyttila...

The city of Bergen follows an urban policy that aims, among other things, to: improve air quality, improve living conditions, reduce the number of cars in the city, reduce parking pressure, etc. "Bergen has already seen a reduction in emissions from road traffic. From 2016 to 2017 emissions were reduced by almost 12%" (SHARE North et al., 2019). Its aim is an emission-free city centre by 2030 (The Explorer, 2020a). But, "In solving these problems, the general mobility patterns of the inhabitants have to be taken into account. Multifaceted mobility offers should also consider cars, for example via car sharing. By better combining the various mobility offers, areas may be reactivated for social and ecological functions." (Børjesson, n.d.). The city does not engage in a blind ideological opposition to the use of cars. It accepts the usefulness of this type of transport under some conditions, especially when there is no efficient alternative.

In this case, it encourages the use of the least polluting vehicles and attaches particular importance to car-sharing. The latter are proving (at least locally) to be the most effective tools for replacing private car ownership and the journeys made using this mode (Børjesson, n.d.). "A single shared car is estimated to replace up to 10 privately owned cars. In addition, studies show that we could manage with just three per cent of the current privately owned fleet, given that most cars sit unused for large parts of the day." (The Explorer, 2020a).

The city of Bergen has set up a network of 14 mobility hubs, "mostly small urban residential hubs". 6 are already in operation and 8 new planned, ready for construction (Ove Kvalbein, 2021), now "in various stages of planning and implementation in the city". These hubs combine and offer both "car-sharing station on public street space linked to public transport, cycle routes, bicycle parking, real-time transport information and pedestrian facilities" (Børjesson, n.d.).

These hubs combine and offer both "car-sharing station on public street space linked to public transport, cycle routes, bicycle parking, real-time transport information and pedestrian facilities" (Børjesson, n.d.). These mobility hubs are inspired by Bremen's experience with car sharing in mobil.punkt (SHARE North et al., 2019). Bremen's mobility hubs are "designed to host multiple mobility functions, Bergen's mobilpunkte are tailored for different neighbourhoods and feature appropriate infrastructure like bike racks, EV charging infrastructure, shared electrical vehicles and some are conveniently located near larger transportation hubs. Focusing on creating mobilpunkte that are locally sound, well-equipped and safe equate to Bergen's success with the concept" (SHARE North et al., 2019). 5 suburban mobility hubs (figure 6 and 7) are already planned, all-around Bergen (Ove Kvalbein, 2021):

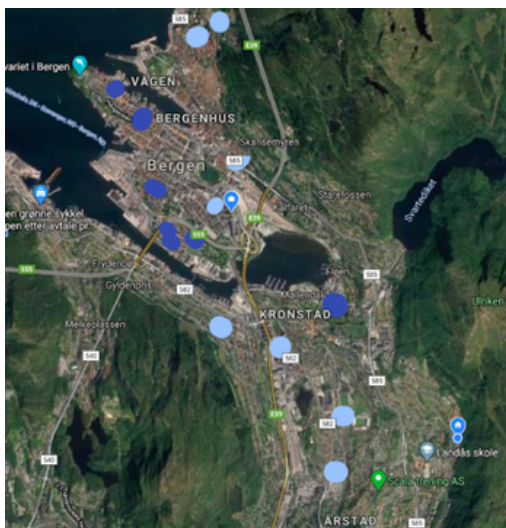


Figure 6: Existing mobility hubs in dark blue, new planned and approved locations in light blue (Ove Kvalbein, 2021).

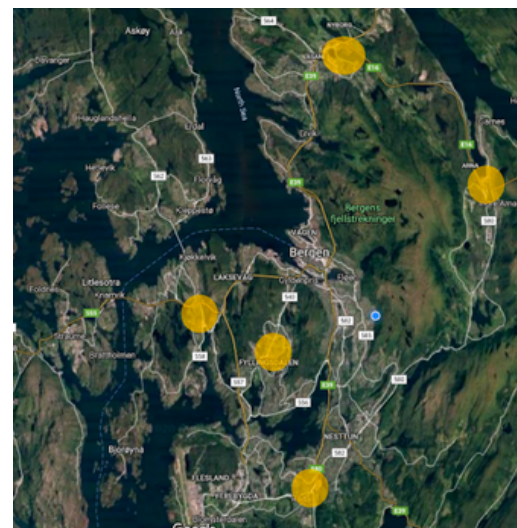


Figure 7: Next phase: Suburban mobility hubs (Ove Kvalbein, 2021).

Lars Ove Kvalbein, mobility adviser in the city of Bergen, states that, “the main objective of mobility hubs is to provide a focal point for and access to different modes of green transportation, so that these become a genuinely competitive alternative to owning and driving a private car.” (The Explorer, 2020a). The first mobility hub was launched on May 8th 2018. It is located in the City’s Møllendal neighbourhood. It represented the first of its kind not only in Bergen, but in the whole Norwegian country. Wherever possible, these mobility hubs are positioned in close proximity to public transport

(Karbaumer, 2018). “Bergen is also meeting the demand of modern, integrated planning and tailoring each mobility hub to meet the needs of the neighborhood in question. In the Møllenpris neighborhood, for instance, the mobility hub also includes underground trash collection facilities and bicycle hangers that can be rented by residents for the purpose of parking high-priced bicycles such as pedelecs/e-bikes. Several of the stations will include spaces for vehicles of more than one car-sharing provider” (Børjesson, n.d.) (figure 8).



Figure 8: Electric mobility hub in Bergen (W.Hached, 2021)

The site visit carried out in 2021 emphasized that Bergen, as well as Oslo, also offers an urban environment that discourages the use of cars (traffic-calming, restrictive parking policy, etc.), but which also promotes active modes of transport, in particular with a rich and diversified urban infrastructure (street furniture). It should also be noted that the city of Bergen has a large network of shared bikes and scooters: “800 shared bikes are available at 80 different locations in the city” (SHARE North, 2020a) and about, 8500 shared electric scooters (Capar, 2021). The shared (docked) bicycles are managed directly by the city, but the shared (free-floating) scooters are managed by private partners.

Both modes are often clustered in the same locations and whenever possible close to public transport or car-sharing stations. Although they do not have any “mobility hubs” label, they still form an important network of minimalistic mobility hubs.

In addition to its experience in mobility hubs, the city of Bergen also provides various learnings in the city-private partner relationship. An internal tool has been developed to manage shared electric scooters. It will be presented in other parts of this document. This tool, which seems to us to have great potential, could possibly be integrated into the MaaS tools and adapted to mobility hubs.

Mobility hubs in Stavanger

The city of Stavanger is located in the southwest of Norway and south of Bergen, presented above. Like Bergen, Stavanger is a member of the SHARE-North and e-HUBS projects. With a population of 144,515 inhabitants in 2021 (Stavanger Kommune, 2021a), it is the fourth-largest city in Norway. It is “Norway's energy capital with the country's most important business hub and one of the country's most important municipalities for agriculture, aquaculture and tourism.” (Stavanger Kommune, 2021b). The extraction of crude oil and natural gas is the leading industry by a significant margin, with 71% of the people employed in this field in 2018 (Thorsnæs, 2020).

The city, which was for years considered to be the oil capital of Norway, is now presented as the energy capital of the country (Stavanger Kommune, 2021b). It aims to become a smart city (Kleiner, 2020). In 2019, “it received the Mobility Award from the Norwegian Public Roads Administration and was simultaneously named Norway's smartest city” (The Explorer, 2020b). Stavanger aims also to “reduce greenhouse gas emissions by 80% by 2030 compared to 2015 and become a fossil-free municipality by 2040”, to reduce air pollution episodes and to ensure clean air for all inhabitants (Dirks Eskeland, 2021; Stavanger Kommune, 2021c; University of Stavanger, 2021). In the same context, the city would like to “establish places for common transport solutions in the districts” (Dirks Eskeland, 2021).

The road traffic in Stavanger is by far the largest emitter of greenhouse gases from 2009 to 2016. 57% of all trips are made by car in 2018. 48% as a driver and 9% as a passenger. Despite the fact that many residents turned to cycling, there was no significant decrease in car journeys between 2013 and 2018. Also, “The municipality is not responsible for local public transport, but involved in many initiatives regarding person mobility”. In this context, and in order to achieve the defined objectives, the city is relying on mobility hubs, among other things (Henrik Haaland, n.d.). “The idea is that residents who travel there will have access to several means of transport in one place and an easier every-day journey. The residents should not feel the need to use their own car” (e-MOPOLI, 2020).

Stavanger considers a mobility hub as “a place where you can find various modes of transport, parking spaces and public transport services to suit your journey. For example, city bikes, car-sharing and scooters located close to a place many people move around”. In order to better understand the needs and uses of travellers, and with the aim of creating a mobility hub model that can be easily transferred, the city of Stavanger has started by setting up a pilot mobility hub, from May to October 2020, in Hillevåg.

The city states that they: “are using design methodology and conducting extensive research in order to understand the needs of those who travel. This involves prototyping various services and functions which are tested in real-life use situations over days, weeks and months in order to see whether they meet the needs of citizens. These prototypes will then be adjusted and tested repeatedly in order to understand how we can solve the problem.” (Stavanger Kommune, 2020). Citizen involvement has been strong all along this project, especially in January and February 2020 during the conception stage. The implemented mobility hub houses (figure 9):

shared city bikes, shared electric scooters, extra parking space for bikes, bus-stop nearby, two electric shared cars, parcel machine, environmental station for garbage delivery, and takeaway options (Dirks Eskeland, 2021; Stavanger Kommune, 2020). Many partners were involved too in this project. We can mention: department for climate and environmental issues (project leader), smart city, road department (traffic signs, security...), bicycle department, department for city and community planning, department for car-parking, regional mobility provider, regional electricity provider (Dirks Eskeland, 2021).



Figure 9: One of the first mobility hubs in Stavanger (Dirks Eskeland, 2021)

For the implementation of such mobility hubs, Stavanger relied on the particular experience of the cities of Bergen and Bremen in this field (Stavanger Kommune, 2020). This mobility hub trial has been a success. The city no longer needs the approval of the region to develop new

mobility hubs. In fact, four new mobility hubs will be launched by spring 2022. The city is now working with several partners on better integration of the mobility hubs in the MaaS applications and on the development of a new chart for future mobility hubs (Dirks Eskeland, 2021).

Mobility hubs in Amsterdam

Amsterdam, a member of various European programs like e-HUBS, is the capital of the Netherlands and is located in the west of the country (eHUBS, n.d.). The city had a population of, 872497 inhabitants in 2021 (Gemeente Amsterdam, 2021). One of the best known particularities of Amsterdam is the enthusiasm of its inhabitants for the daily use of bikes. It is estimated that the inhabitants of Amsterdam own 847,000 bicycles (I amsterdam, 2021). The modal split for this mode is over 40% (FUB, n.d.). According to several rankings, it holds the top spots in the podium of cycling cities since a long time (City Ratings, n.d.; Copenhagenize Index, 2019; Coxa, 2019; FUB, n.d.). In contrast, in 2014, the car ownership was already one of the lowest in the Netherlands with only 25% of inhabitants owning a car (DutchNews.nl, 2014). Despite this, the city continues to actively promote low environmental impact mobility by, among other things, continuing the efforts to discourage the use of private cars.

Amsterdam has ambitious environmental targets that have been mapped out until 2050. The city states that: "We aim to reduce CO2 emissions in Amsterdam by 55% in 2030, and 95% in 2050. The city will stop using natural gas before 2040 and within the next 10 years we will have only emission-free transport by road and water." (City of Amsterdam, n.d., n.d.). Despite the improvement in air quality over the last decade, some of the roads are still exceeding the European standards.

Moreover, the city aims to meet the World Health Organisation's air quality guidelines. These are twice as strict as their European equivalent. Amsterdam has already established six low emission zones and aims to achieve zero carbon mobility by 2030. Among other things, it applies restrictive policies for combustion vehicles and favours electric vehicles (City of Amsterdam, n.d.). In order to achieve its goal, the city has fixed three milestones: *"2022, only emission-free buses and coaches will be permitted in the city centre. 2025, all traffic, including taxis, passenger craft and municipal ferries, but with the exception of passenger cars and motorbikes, must be emission-free within the A10 ring road (the entire built-up area applies for scooters and mopeds). 2030, all traffic within the built-up area must be emission-free."* (Gemeente Amsterdam, 2019). The city is also experiencing significant growth and is becoming increasingly congested. And, "While growth is inevitable, it is important that Amsterdam remains accessible to everyone. There is simply not enough room to accommodate bicycles, pedestrians, public transport and cars side by side everywhere in the city. Choices will have to be made. For example, in the future, it will no longer be possible for people to claim a parking space for themselves. Cars will continue to play an important role, but we have to start thinking of other ways to use them. Amsterdam is moving from individual to collective forms of mobility, so cars are no longer to be owned, but simply to be used." (City of Amsterdam, n.d.).

So, The implementation of electric mobility hubs is also one of the solutions adopted and tested in the framework of the e-HUBS project. Amsterdam is the leader city of the project e-HUBS project. Within the framework of this project, they intended to implement 15 to 20 mobility hubs (figure 10). The particularity of these facilities, is that they are developed in close cooperation with

the inhabitants of surrounding areas. It consists of a “bottom-up approach and focus on first mile of travel, policies focused on reducing parking spots”. The results are promising. Mobility hubs have already enabled some inhabitants of the city to switch from their private cars to shared modes (Intertraffic, 2021; N-W Europe, n.d.).

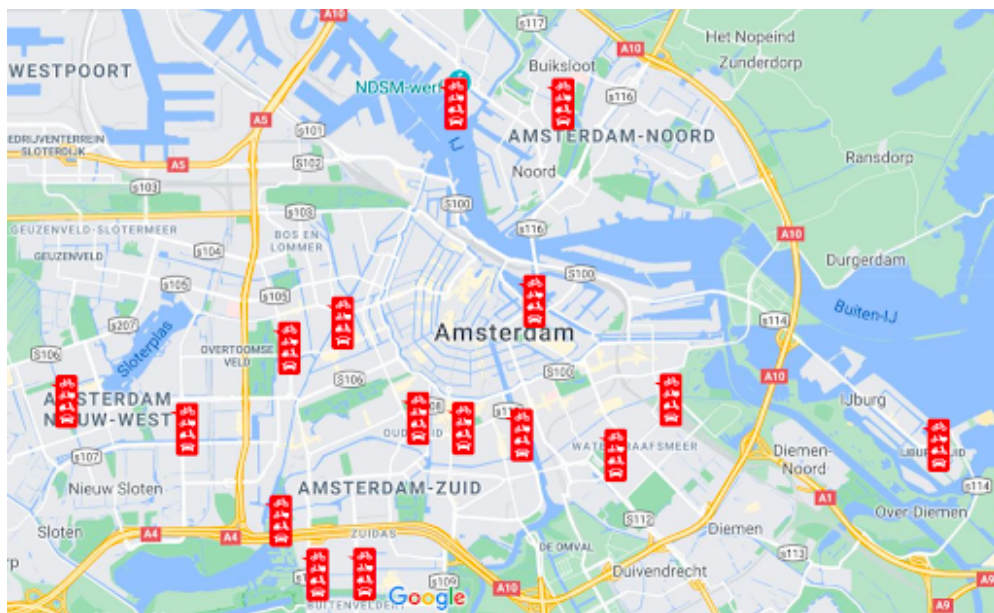


Figure 10: Mobility hubs in Amsterdam (Basta, 2021)

What should be retained from the case of Amsterdam is that the city has been exemplary in involving local residents in the whole process of the project, and in applying the principles of local democracy. The city states that: “When involving and empowering citizens in designing their eHUBS from the start. They will be more inclined in changing their mobility behaviour” (Basta, 2021). The strategy for the implementation of mobility hubs consists first of all in communicating and popularising the concept of mobility hubs.

Afterward, certain areas with a high potential for hosting these infrastructures are selected and virtual modeling of a mobility hub is carried out, emphasising the changes that it brings to the neighbourhood. Then, the objective would be to ask local residents if they are interested in such a hub. If residents express an interest in a mobility hub, a survey is held in the neighbourhood to investigate the acceptability of the project. If more than half of the respondents are interested, the mobility hub project can only start.

It is then developed together with the inhabitants to best meet their needs and expectations. Once the mobility hub is operational, the city keeps listening to its citizens and continues to adapt and improve the project (Basta, 2021; City of Amsterdam, 2020). The city of Amsterdam believes: “that it is important that a [mobility hub] meets the needs of the neighbourhood. If a [mobility hub] is placed in a public space, the

residents, therefore, determine together with the Amsterdam municipality what a [mobility hub] will look like. This allows residents to vote for the preferred means of transport during the participation process. Each [mobility hub] can therefore differ in size, type of transport and associated service” (City of Amsterdam, n.d.). Figure 11 shows the main steps taken by Amsterdam to implement the mobility hubs.

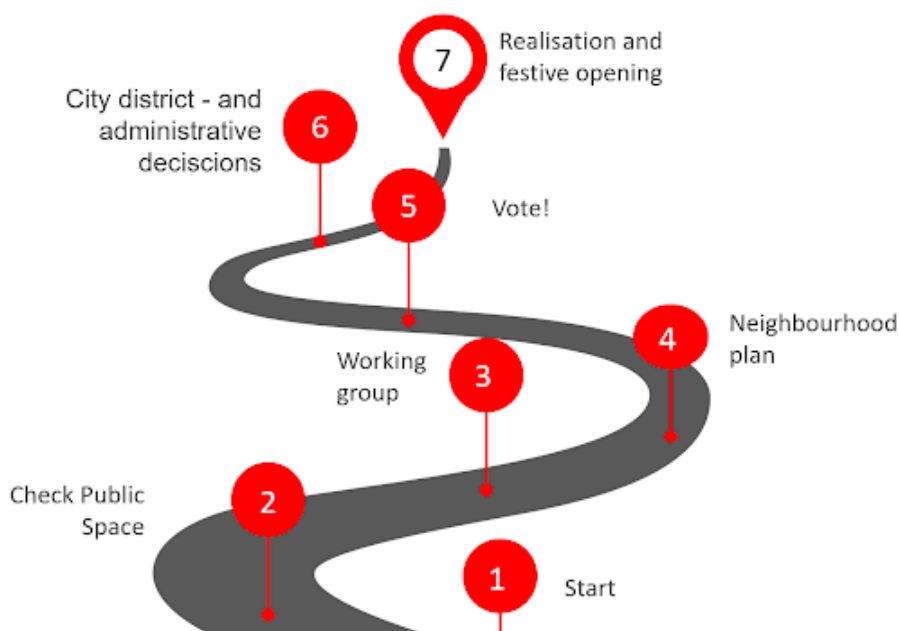


Figure 11 : Steps for mobility hubs implementing in Amsterdam (Basta, 2021)

An expert survey on mobility hub usage intentions revealed the following results:


- “Access time of eHUB is highly significant
- Travel time are not significant
- Travel cost are only significant for shared e-bike
- Public transport users are more likely to switch to eHUBS compared to car users
- Parking search time and cost are highly significant
- Congestion-related variables (both frequency and duration) are non-significant” (Liao and de Almeida Correia, 2021)

Mobility hubs in Flanders

Belgian Flanders is mainly the northern region of Belgium. The population reaches 6,350,765 inhabitants spread over an area of 13,522 square kilometres (Statistics Flanders, 2022a; VISITFLANDERS, n.d.). The population has been growing continuously in 9 out of 10 municipalities since 1990 and has been growing faster since 2005 (Statistics Flanders, 2022a). “The average population density in the Flemish Region was 488 inhabitants per km² in 2021. In 2000, this was 436 inhabitants per km². The population density is highest in and around the 'Flemish diamond', the central area between Ghent, Antwerp, Leuven and Brussels. Population density is also high in a number of coastal municipalities (Ostend, Bredene, Blankenberge and Bruges), in the south of West Flanders (Kortrijk, Roeselare) and in some central municipalities of the province of Limburg (Hasselt, Genk)” (Statistics Flanders, 2022a). Brussels is the capital of the Flemish Region and the host of several European institutions (Be.Brussels, n.d.).

The Flemish Region is suffering from traffic congestion, especially during peak hours. Traffic jams represented 603 kilometres per hour on the main roads in November 2021. This represents a decrease of 36% compared to November 2019, but a 3 times higher value compared to 2020 (mainly due to the coronavirus crisis). In 2021 the average traffic jam was 548 kilometres per hour on working days. Since April 2012, traffic jams are mainly concentrated around Brussels and Antwerp (Statistics Flanders, 2022b).

The Flemish Region registered 254 road fatalities in 2020: “33% of fatal traffic victims fell in passenger cars. Cyclists accounted for 30% of all road fatalities. Motorcyclists accounted for 13% and pedestrians for 11%” (Statistics Flanders, 2021). Although it has been steadily decreasing since the early 2000s, air pollution remains high. It meets most European standards, but still does not respect the recommendations of the World Health Organisation. Many inhabitants remain exposed to air pollution with serious health risks (Flanders Environment Agency, 2018; Times, 2021). The transport sector is largely responsible for this pollution: “Both exhaust emissions (nitrogen oxides and carbon monoxide) and non-exhaust emissions (particulate matter) are important. The transport sector is a major contributor (61 % of total emissions in 2016), for nitrogen oxides in particular. Almost three-quarters of the particulate emissions from road traffic are caused by wear and tear of the road surface, tyres and brakes. As the number of passenger cars and the number of kilometres driven both continue to grow, we see an increase in non-exhaust emissions of particulate matter. The transport sector is the collective name for road transport, rail transport, inland navigation, air and sea transport. Road traffic, with passenger cars in particular, is a major source of emissions within the transport sector.” (Flanders Environment Agency, 2018).



To address the above issues, the Flemish Region has already been developing environmental and mobility policies for some time. However, even though a recent climate plan was unveiled at COP26, it is seen as not ambitious enough by some critics (De Muelenaere, 2021). It aims to reduce CO2 emissions by 40% and focuses mainly on the elimination of fossil-fuelled vehicles in favour of electrically powered ones (Belga, 2021; Saelens, 2021). In July 2021, the Flemish government approved a mobility vision for the horizon of 2040 with the slogan “With smart traffic and transport for sustainably connected people and businesses” (Flandre, 2021, n.d.). The objectives are better connectivity, maximum accessibility, and sustainable, safe, and inclusive mobility. The aim is also to eliminate serious traffic casualties, eliminate transport emissions, ensure smooth and easy mobility, and reduce the material footprint for mobility by 60%. The aim of this mobility vision, developed in a participatory manner, is also to ensure a flexible policy framework at all levels (Flandre, 2021, n.d.). In parallel with an ambitious cycling policy (Flandre, n.d.), The Flemish Region, “focuses on more efficient public transport, adapted to [the] cycle and road network. Train, bus and tram remain fixed values” and encourages multimodality, shared modes and transport on demand (especially in rural areas for the latter) (Flandre, n.d.). Other examples include demand-driven investment in accessibility, addressing mobility in a regional and integral way, preparing the transport networks of tomorrow, attracting, motivating and stimulating behavioural change, making Flanders a pioneer in innovation (Flandre, n.d.).

Car sharing is already a success in the Flemish Region (Mobipunt, n.d.). In this context, since 2017 (GO SEStran et al., 2020), and with an investment of 104 million euros (eHUBS, 2020a; SHARE North, 2020b), “mobility hubs are being developed in Flanders, Belgium [...]. They are presented as, among other things, tools to fight congestion (Galindo, 2019). They are defined as “neighborhood facilities where different sustainable and shared transport modes are linked with each other.” (Bailey, 2020a; SHARE North, n.d.). In the Flemish Region, there are four categories defined for the implementation of mobility hubs: city, village, destination and periphery. The four categories are quite similar to those defined by CoMoUK as part of the accreditation programme for mobility hubs. The programme was set up to guarantee that the mobility hubs in Flanders have a common design and can be identified by the users. The project also seeks to provide regional cohesion by providing a clear set of planning tools for the infrastructure of the mobility hubs (CoMoUK, 2021c). Several of these mobility hubs have been implemented as part of the SHARE-North project (Intertraffic, 2021). The Flemish government is now planning to create a network of more than 1000 mobility hubs throughout the region by 2024 (eHUBS, 2020a; Mpact, n.d.). “Five different types of [mobility hubs] are planned by the strategy of the Flemish government: interregional [...], regional [...], local [...], neighborhood-scale [...] based on a network logic, and neighborhood-scale [mobility hubs] based on a proximity logic.” (eHUBS, 2020a). All these mobility hubs will have the same branding to be easily recognised by users (SHARE North, 2020b).

This Belgian experience, “provides a useful example of calculating scale. The principle was that every residential centre or activity cluster needs at least one local mobility hub. For cores with a regular tram line, the stops are used as the best location, for other centres, a potential node is located which fits with local mobility needs. Their strategy assumes one mobility hub per 1,000 inhabitants outside the main towns and one mobility hub per 2,000 inhabitants in the urban core area” (CoMoUK et al., 2019). Now, given the success of the mobility hubs in Flanders, even if the objective was to reach 1000 mobility hubs in 2024, 1500 are already planned. Since 2019, mobility hubs have been an integral part of the Flemish Region's mobility policy and public transport. The Flemish vision switched from “From a supply-based system to a demand oriented system” (Roelant, 2021). The planned mobility hubs will run in a government (closed) MaaS system and will include public transport, shared bikes and shared cars... (Roelant, 2021).

This Belgian experience, “provides a useful example of calculating scale. The principle was that every residential centre or activity cluster needs at least one local mobility hub. The development of each mobility hub takes into account several well-ordered dimensions: first of all the mobility services, then the (extra) services, then the orientation, then the spatial integration, and finally the spatial development (Roelant, 2021). The spatial integration includes to think about the following parameters while developing a mobility hub : “shared space with multiple use cases, robust and adaptable space, recognition, orientation and visual attractiveness, valuation of public heritage and the landscape, biodiversity and ecology, climate-robust design, renewable energy, health, inclusion, and economic vitality” (Roelant, 2021). Perceived safety, the combination of several modes and accessibility for everybody to mobility hubs are a priority in the Flemish Region (Roelant, 2021).



Mobility hubs in Leuven

The city of Leuven is located in the Flemish area of Belgium and in the centre of the country (VISITFLANDERS, n.d.). It is involved in several European research projects on sustainable mobility, such as the e-HUBS project (eHUBS, n.d.). “In drawing together eHUBS, [...] and MOMENTUM, [...] Leuven has become a shining example of mobility innovation – and it has been crowned ‘European Capital of Innovation 2020’ (Schmalholz, 2021). On 2021, the population is estimated at, 101032 inhabitants over an area of 56.6 square kilometres (Citypopulation, n.d.; KU Leuven, n.d.; NuMIDAS, n.d.). It is known for housing one of the oldest universities in Europe and the oldest in the Low Countries. It accommodates, 50000 students and 10000 employees. (KU Leuven, 2021; VISITFLANDERS, n.d.).

Leuven is “situated 20 km east of Brussels. Because of its high dynamic and the location in the slip stream of Brussels, Leuven is coping with a high level of traffic congestion.” (eHUBS, n.d.; Evenepoel, 2021a). It is the fastest growing city in Belgium. Leuven is also a bikeable city (NuMIDAS, n.d.). But, even if 20% of all trips and 40% of commuting and school trips are made by bicycle (Evenepoel, 2021a), air pollution from transport in Leuven is around 25% of the total air pollution (Evenepoel, 2020). “Cars remain an important mode of transportation, as there are 505 vehicles per 1,000 inhabitants (2017, own estimate based on City Monitor survey)” (NuMIDAS, n.d.).

In order to tackle the environmental challenges in general and the mobility issue in particular, the city has elaborated a climate plan up to 2050 with key objectives to be reached in 2025, 2035 and 2050 (Leuven 2030, n.d.; VisitLeuven, 2020). This plan, approved in 2019, aims to transform Leuven into a climate-neutral city by 2050 (European Commission, n.d.). It has set up a consortium “Leuven 2030” and has changed its urban thinking paradigm from “doing what is possible” to “doing what is necessary”. The targets are: a 40% reduction in pollutant emissions by 2030, a 35% modal share for active modes (walking and cycling), 25% for public transport and 40% for cars. The plan also aims to reduce private car ownership by 10% by 2025, 50% by 2035 and 75% by 2050. The targets also include a 25% reduction in the number of salary cars (Asperges, 2020; Evenepoel, 2021a). H. Evenepoel, project coordinator of eHUBS in Leuven, announces that the city also has three main objectives: the reduction of the need for mobility services, the transition towards the use of more sustainable mobility options, and the application of technological advancements towards the use of renewable energy (Evenepoel, 2020). Among the solutions considered, we mention the encouragement of shared modes of mobility in general and shared bikes in particular. The latter would reduce pressure on bicycle parking and encourage the use of public transport (Evenepoel, 2021a). The e-HUBS project announced that: *“In Leuven, there will be eHUBs on strategic locations, connected to*

other modes (e.g., public transport), but also smaller eHUBs in living area (on neighbourhood level). Strategically, a top-down approach will be utilised. On neighbourhood-level, the end users requests and ideas will be integrated in a bottom-up approach during selection procedure. The user pool will consist of inhabitants, students as well visitors. Within the next three years, 50 eHUBs will be realised. As pilot and prototype development, Leuven will not only become a regional, but also a transnational showcase for the growth and extension of a larger eHUB-network.” (eHUBS, n.d.). These 50 planned mobility hubs (figure 12) (Leuven MindGate, 2019), considered in this project as “more shared and clustered (e-)mobility services” (Evenepoel, 2021b), will provide by the end of 2021 shared electric vehicles: cars,

bikes, and cargo bikes. Their driving forces are liveability, accessibility, equality, and sustainability (Evenepoel, 2021b). Among the challenges facing the city, we can mention the integration of the free-floating model, user-friendly, smart and mobility for all, user data use and management, and space and regulation for (shared) bicycle parking (Evenepoel, 2021a). Among the 50 planned mobility hubs (Ripa, 2019), the city of Leuven has started by setting up 41 in 2017 (eHUBS, 2020b). The choice of the type and size of each mobility hub in Leuven depends on two parameters: the role in the transport network (interregional, regional or local mobility hubs) and the proximity to the inhabitants (neighbourhood mobility hubs) (Evenepoel, 2021b).

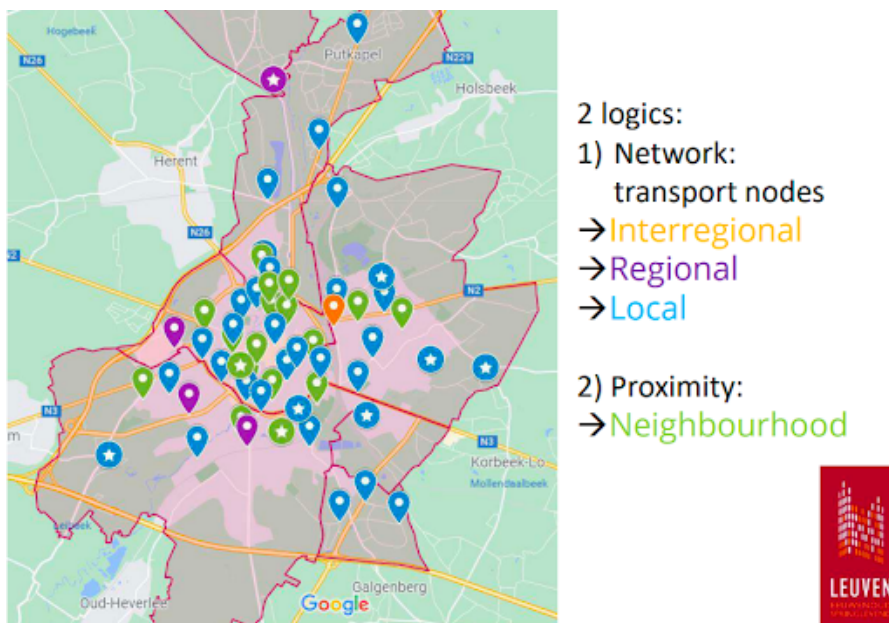


Figure 12: Type and size of eHUBS (Evenepoel, 2021b)

For the choice of locations of the different mobility hubs, the city opted for three different approaches: strategic, hybrid, and bottom-up (participatory). The strategic approach concerned 32 mobility hubs. It aims to meet the objectives of the city and the region in terms of mobility. The choice of the location of each hub is made following the consideration of several parameters, namely the activities' location, the building and population density, the existing circulation plan, the geomorphology of the city, the existing offer of shared mobility and public transport, the opinion of the mobility service providers (private partners), the recharging infrastructure... The hybrid method covered 5 mobility hubs. It mixes the strategic approach explained below with a citizen participatory approach. The bottom-up approach is similar to the Amsterdam strategy. It involves the participation of local residents. It concerned 4 mobility hubs and follows 4 main steps. First, the city submits a location proposal to the residents, then it

creates an extensive submission file, then it organises neighbourhood meetings and swapping information, and finally, it proceeds to the implementation of the neighbourhood mobility hubs (Evenepoel, 2021b). Once the location of the mobility hubs has been determined, the choice of the modes to be proposed and the mobility providers (among those authorised) is made for each mobility hub. Among the city's objectives are 90 electric shared bikes, 30 electric shared cargo bikes and more than 40 shared electric cars. Additional services are developed specifically for each mobility hub. Secondly, a lot of attention is given to the design, look and feel of each mobility hub. Extensive communication and nudging is also used to promote the mobility hubs (Evenepoel, 2021b).

Figure 13 below summarises Leuven's approach to development of its mobility hubs, detailing the steps taken throughout the implementation process (Evenepoel, 2021b).

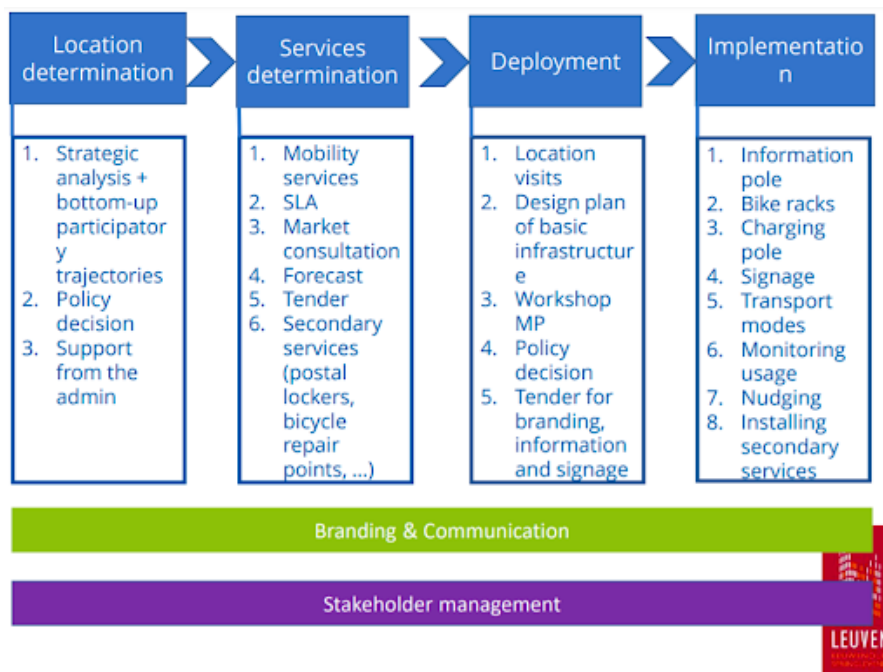


Figure 13: Steps taken throughout mobility hub implementation process (Evenepoel, 2021b).

Mobility hubs in Bremen

Bremen, partner of the project SHARE-North (GO SEStran et al., 2020; Intertraffic, 2021), is a city located in the northwest of Germany. Its population totals, 567559 inhabitants, spread over an area of 325 square km, with a density of 17.4 inhabitants per square kilometre (Britaninica, 2009; Wegweiser Kommune, n.d.). Germany has analysed these municipalities according to several indicators: demographic development, socio-economic situation or regional environment... This resulted in a distinction/clustering into 11 classes, which gather cities and communities that have similar key indicators. "For each type, specific challenges, potential and approaches are described including urban development, mobility, digitalisation, refugees, participation, family or senior policy..." (Wegweiser Kommune, n.d.). Bremen belongs to class 7: "large cities and university locations with heterogeneous socio-economic dynamics" (Wegweiser Kommune, n.d.). Bremen is indeed located 70 km from the North Sea on the borders of the Weser River. It is a major industrial city not only in Germany but also in Northern Europe. The city is host of one of the largest German ports (Britaninica, 2009).

In the early 2000s, the city was facing considerable parking and congestion problems. To overcome this, the city developed a mobility policy in 2003 with the aim of reducing car ownership and overcoming parking pressure in the public realm, and then to reclaim public street space (CoMoUK, 2021d; Intertraffic, 2021). So, the city of Bremen is already strongly engaged in sustainable mobility.

It is "is well known for its ambitious strategies on transport and quality of life in the city. Already, about 60% of all trips in Bremen are done by the sustainable modes of walking, cycling and collective transport, and this number is on the rise" (ITDP, 2012). Through these efforts, it has already reached a modal split of: 36% car, 25% walking, 23% cycling and 16% public transport (Karbaumer, 2021a; Pais, 2019; The Big Move, 2008). The city proudly claims to be a pedestrian, cycling and well-connected city, with a larger cycling network than most German cities. The urban environment is also pleasant for active mobility. The topography of the city is mostly planar and there are many parks and green areas (Bremen, n.d.). Bremen is "a compact city where the bicycle is more than just a means of transport: it's a way of life" (Bremen, n.d.). The city is the most biking city in Germany with over 500,000 inhabitants (Bremen, n.d.). In addition to its investment in public transport (Bremen, n.d.) and active mobility, the city of Bremen is strongly committed to shared mobility (Universität Bremen, n.d.). The city provides shared bikes (Bremen, n.d.), shared cargo bikes (Bremen, n.d.), shared scooters (Bremen, n.d.), and shared cars (Bremen, n.d.). The city is one of the leaders in the field of car-sharing and its car-sharing system is a recognised success (ITDP, 2012).

"Michael Glotz-Richter first came upon the idea of integrated mobility hubs nearly two decades ago, when looking for new solutions to reduce the number of cars on the road in Bremen, Germany and reclaim street space for other uses." (Gray, 2017; IMS, 2019).

Regarding shared mobility, Bremen was one of the first cities in Europe (and probably in the world) to set up mobility hubs since 2003 (Actionfigure, 2019; Austin, 2021; Chamberland et al., 2021; Fairfax County, Virginia, 2013; Lanagarth, 2020; Miramontes et al., 2017; Movmi, 2021). That year, Bremen's network of mobility hubs already counted 10 large mobility hubs and 14 smaller ones (ARUP, 2020).

smaller ones (ARUP, 2020). In 2017, there were around 29 mobility hubs (Gray, 2017). In 2020 there were 10 large mobility hubs and 33 small mobility hubs. The hubs are increasing by 8-10 a year. CoMoUK states that "The goal is to have 100 mobility hubs and a hub at least every 300 m, so if cars are booked out at the nearest hub, the next hub is an easy walk away (figure 14)." (CoMoUK, 2021d).



Figure 14: existing and planned mobility hubs in Bremen (Karbaumer, 2021a)

Rebecca Karbaumer states that "[Bremen's] mobility hubs focus on car sharing as a pillar of sustainable transport just like walking, cycling, and public transport are. The combination of all those modes reduces reliability on private car ownership" (Aono, 2019; Bailey, 2020b; Bremer et al., 2020; Fairfax County, Virginia, 2013; Intertraffic, 2021). On one hand, the largest mobility

hubs in Bremen are connected to public transport and in some cases to taxi stands. On the other hand, "To make switching to ecomobility more attractive, Bremen's municipality encouraged smaller mobility hubs to be planned in the vicinity or integrated in new housing projects." (ARUP, 2020; Intertraffic, 2021; Miramontes et al., 2017).



The same visual and signage design is used for all mobility hubs within the city, making them clearly and visually recognizable. She also explains that every city could develop its mobility hubs around “any mode that fits their users’ needs”. But it seems that shared cars are the most efficient way to replace private cars in Bremen. In this particular case, a single shared car replaces up to 16 private cars (CoMoUK, 2021d; Karbaumer, 2020). The shared fleet has now attracted more than, 21000 users and led to the replacement of 6500 private cars in the public space (Intertraffic, 2021; Karbaumer, 2018; SHARE North, 2018a, 2018b, 2018b; Transit Forward, n.d.). In 2019, “Across all hubs, the project has collectively helped [...] saving, 25850 tonnes of CO2 in 2.5 years and freeing up nearly, 60000 m2 of urban street space once used to park cars” (European Commission, 2019). Cities wishing to implement mobility hubs can base their actions on the seven lessons that can be learned from Bremen's experience with mobility hubs. Without being able to go into detail in this report, we would point out that according to Leslie Gray, Michael Glotz-Richter, has listed: 1, build around strong transit stops; 2, target areas with high parking pressure; 3, get as close as possible to your users; 4, leverage mobile technology for wayfinding and fare integration; 5, use mobility hubs to promote multimodal living, not (necessarily) multimodal trips; 6, make mobility hubs visible; 7, market mobility hubs (Gray, 2017).

Rebecca Karbauer emphasises the role of communication in the success of a mobility hub. A discourse must be adapted to each stakeholder (or user) concerned by the project (Karbaumer, n.d.). The communication strategy will be further developed in another part of this report (Karbaumer, 2021b, 2021c).

Currently, although Bremen is one of the best known cities for its mobility hubs and especially for its successful car-sharing, the city is looking to the future and has developed a new Sustainable Urban Mobility Plan (SUMP) which sets targets for the next 10 to 15 years (starting in 2014). It lists 6 major objectives, which may have an impact on future mobility hubs. These objectives are:

- 1.To enable social inclusion of all people and to strengthen the equality of all transport users;
- 2.Increase transport safety and security;
- 3.Offer and optimise alternative transport options in the entire city;
- 4.Improve the connection of the systems and services for walking, cycling and public transport between Bremen and the surrounding region;
- 5.Strengthen Bremen as an economic centre by optimising commercial transport;
- 6.Reduce the effects of transport on people, health, and the environment in a lasting and perceptible way” (Frei Hansestadt Bremen, 2014)

Ways forward: How can cities advance?

Until now, few cities can be proud to offer a sufficiently solid infrastructure capable of ensuring sustainable, peaceful and equitable mobility. In this context, we can mention the detailed analysis of the ergonomics of access to resources in active modes in the Eurometropole de Strasbourg, which highlighted various disparities and their nature (Hached, 2019; Hached and Propeck-Zimmermann, 2020). Mobility hubs can therefore play an important role at the city and/or regional level that is not limited to more sustainable mobility. The objectives in implementing mobility hubs should go beyond mobility issues to look more broadly at the problems of the city, and thus be part of a more global solution. In order to be part of this more integrative solution, different parameters should be taken into account when designing and implementing mobility hubs.

Following discussions with experts from the partner cities of the Mobi-Mix project, as non-exhaustive examples, we can consider some key parameters:

- Spatial distribution,
- Multifunctionality,

Spatial distribution


We must remind here that “the success or otherwise of a mobility hub is closely related to its location: mobility hubs are more beneficial [mainly economically] in areas with high travel demand [...]. Hence, major

- *Inclusiveness in its broadest sense,*
- *Security and safety,*
- *Comfort and ease of use,*
- *Reliability and resilience,*
- *Adaptation to technology,*
- *Communication*

“All of this should occur within an urban setting designed for the way people and families would like to live, work and enjoy themselves.

At the same time, the mobility hub is only one part of the equation. Because the transit system is the key connector to and between mobility hubs, the mix of land uses in the surrounding area is crucial to making it a destination conducive to transit choice. In other words, when developing the mobility hub concept [...], we need a fundamental shift in thinking — away from land use patterns designed primarily for cars. That is why [...] [the concept of] mobility hub is so important. They are the connection points in a transit-oriented metropolis — a concept very different from the car-based cities and towns we see today.” (CII- Kerala et al., n.d.).

transport hubs, city centres and dense residential areas are considered prime locations for mobility hubs. At the same time, mobility hubs can improve connectivity in rural areas but may not be commercially viable.




It can also be challenging to find space for a hub in the densest urban environments and city centres, which can be mitigated through land use planning or implementation of a network of smaller hubs [...]” (GO SEStran et al., 2020). The difficulty of identifying this ideal location can be particularly significant given that 80% of the buildings in existence today were built in the last 50 years (Kunstler, 1993). To this is added the fact that “when the private automobile became the dominant mode of transportation in developed countries, only a few areas of some cities were designed in a way that facilitates transit, cycling, and walking for utilitarian transportation.” (Waldron, 2007).

The spatial implementation of mobility hubs at the scale of a city or a region will need to follow several steps:

The first one consists on implementing the first mobility hubs in strategic locations that have been carefully thought out in order to give them a strong image in the target audience (the population, people in transit, professional users, etc.) and thus generate positive communication. The latter will not be possible without a significant positive impact. This means that the mobility hub will have to meet the needs of the citizens as well as help the city to achieve its overall objectives, particularly in terms of sustainable development. So “When conducting planning for a specific hub, a key first step is to establish the planning area (i.e., study area) to be considered. The Big Move broadly defines the geographic scope of a mobility hub to be an area within a 10-minute walk or within an 800-metre radius around identified regional rapid transit stations.

However, the planning area should be more carefully determined based on the local context for individual hubs. Key factors to consider include existing environmental features [...], infrastructure barriers [...], development areas vs. stable neighbourhoods [...], regional destinations [...], legislative, policy, and planning framework.” (Metrolinx, 2011). Following the establishment of the first mobility hubs, the developer should take enough time to collect an adequate amount of data and observations. These would allow him to identify the strengths and weaknesses of the proposed models. It will then be possible to rectify and improve gradually the offer proposed to better correspond to the objectives and local specificities. Once the desired balance is reached, a more generalized deployment could be envisaged. Mobility hubs can be implemented in both pre-existing and in new residential areas. While the properties may be similar, the outcomes may be different. While residents of established residential areas are accustomed to their usual travel solutions (and car ownership), those who move into a new residential area with mobility hubs and limited parking are sensitized to this new concept. This may, at the same time, increase the willingness of people to use the shared modes proposed by these mobility hubs. A self-selection bias may exist in such a case, which can lead to greater impacts than in the case of the already existing residential areas. For this reason, the various types of mobility hubs are considered separately for existing residential areas and new residential areas (Claasen, 2020).



The generalisation of mobility hubs should allow the mobility of users throughout the territory of the city and access to any urbanised point of the city, or even allow inter-urban connectivity using only the means of transport offered by these mobility hubs. In this sense, it would be advisable to distribute the mobility hubs on the territory according to a grid where the distance between one mobility hub and another is designed to correspond to an acceptable and well-defined distance/time on foot in the city. Regarding regional or inter-urban mobility hubs, they should offer a means of transport allowing at least reaching the closest mobility hub in the closest urbanised area. Since the overarching goal of mobility hubs were to reduce emissions of greenhouse gases from the use of the private automobile in different cities and regions, the accessibility of mobility services in various neighbourhoods is a necessity. Hence, as mobility hubs are becoming more widespread, the location of mobility hubs and the service area of the hub features must be made accessible to residents of these different neighbourhoods. Thus, mobility hubs must carefully consider services that will help cover first- and last-mile trips for residents who live beyond the

hub's catchment area, where there may be a lack of service opportunities. Equity also means making sure that mobility hubs are located in areas of differing density and are not clustered in city centres. The second aspect of accessibility relates to the affordability of such services. To make mobility services viable for people along the social gradient, fare support programs and initiatives may be necessary (Aono, 2019).


The collection of data and the continuous assessment of each mobility hub is necessary as and when the mobility hubs are deployed, as well as at the end of the generalisation on the whole territory of the city. This would make it possible not only to assess the efficiency of each mobility hub (as well as the entire network of mobility hubs) and to improve it, but also to adapt it more and more to local needs and local specificities. Thus, the establishment of a mobility hub should not be definitive and frozen. It must be scalable to respond to changes (in behaviour, needs, technologies ...). The city would then probably have to add or remove mobility hubs, or even think about developing seasonal or ephemeral mobility hubs.

Multifunctionality



The major goal of mobility hubs “is the reduction in private automobile use and its resulting emissions. This can be obtained by ensuring a seamless and frictionless integration of different private and public mode options.

Therefore, by connecting sustainable transportation options, mobility hubs aim to minimize the ecological footprint in the region.” (Aono, 2019). In addition to this main function, each mobility hub should be attractive.




It should be integrated into its immediate environment, not only by its design, but above all by providing resources previously unavailable and that meet needs previously unmet and that forced citizens to move. This multifunctionality would thus make it possible to create a nucleus of life that revitalizes local life and discourages certain trips by offering substitute offers. "A mobility hub can be characterized as a place of connectivity, where different modes of transportation, from high-speed rail to walking, come together seamlessly (Metrolinx, 2008). It is, furthermore, a place where living, shopping, and enjoyment become part of the transit experience by the user." (Queirós and González, 2019). Mobility hubs are intended to be urban transit interchanges where users can travel and have a good and enjoyable time: riding an electric bicycle to and from work, shopping and taking a high-speed train home would be great samples of what users might be looking for (Queirós and González, 2019).

"Mobility hubs should be designed to improve the quality of place and public realm" (GO SEStran et al., 2020). For example, in what way would it be possible to integrate a bakery in a mobility hub if there is not one nearby? This bakery would make it possible to meet a local need, thus preventing a longer trip (and potentially less ecological) and at the same time preventing the user of the mobility hub from getting bored during a possible wait in addition to offering him a resource located in his path. On the other hand, bakery customers will inevitably discover the mobility hub and this would encourage them to test it or mimic other users and perhaps change their mobility habits.

They will thus ask themselves questions about their current mobility, reassess it, and adopt modes that are more suited to their needs and more ecological.

This multifunctionality must be adapted to each mobility hub to fill a local gap (lack of green space, cafeteria, tobacco press, fast food, bank counter, grocery store ...) without entering into direct competition with already existing resources nor creating additional nuisances that are often intolerable by local residents. The multi-functional mobility hub should therefore both improve the mobility experience of these users, arouse the curiosity of more people and increase the quality of local life. "Thereby, it is intended to be a liveable space that enriches life in the city. It is a system innovation that is adapted to each specific local condition in order to provide the services needed by the people locally. To do so, [MicroCity] is based on modular architecture and integrates different means of transport in a way each is used best, ranging from car- and bike sharing to public transit to private cars. [...] The [MicroCity] building is designed to optimize passenger flows while offering attractive services like office spaces, shopping, and apartments. [...] The various services are bundled in central software such as an app or a mobility card. By combining all these factors, the MicroCity improves urban mobility in a targeted manner, repositions the car in the urban context, improves urban life for people and is attractive to private investors." (Vahle, 2014). In this sense, mobility hubs can potentially become the origin and the destination of urban activities. For this reason, it is essential to foster a sense of place in order to strengthen the hub



as a location where people can feel at home and where their values as a community are illustrated. Such a sense of place may be achieved by providing a mix of activities within the hub and by creating an attractive and interactive public area (Aono, 2019).

The services offered in mobility hubs generally relate to facilities that help to make travel via the proposed mobility services both efficient and convenient. “In addition, the mobility hub will serve [users] and pedestrians as well as the vehicular traffic parking.” (O’Berry, 2015). Thus, some amenities focus on making it easier to transfer between different mobility options. Such services also contribute to turning mobility hubs into more than just a transportation hub, as they include amenities like storage lockers, retail shops, and delivery services, which contribute to highlighting mobility hubs as a multi-use facility. Some mobility hubs already provide retail kiosks and Wi-Fi on transit. We can also take into account other considerations such as promoting safety and security for all users, prioritizing elements that operate sustainably or incorporate sustainable features (LA Urban Design Studio 2016) or incorporating different options to access these services for customers that do not have access to smartphones (Aono, 2019). According to (Queiros & Gonzalez, 2019), when it comes to the features, services, and infrastructure that constitute hubs effectively, there are many possibilities and options. Some basic elements can now be seen in the majority of mobility hubs: bike parking, bus stop areas, Wi-Fi connectivity, and real-time information are typical examples (218 Consultants et al., 2015).

Combining with ride-sharing services is also typical, whether it is bike-sharing services (Midgley, 2009), carpooling zones, and car-sharing services, all of which have significant potential to solve the first and last mile problem commonly associated with not using the railroad. Some other potential infrastructure includes electric vehicle charging facilities, commercial areas, and public recreation spaces. When assessing the upcoming possibilities of hubs, other less evident types of services may be envisioned for mobility hubs, such as virtual supermarkets (Arup, 2014), where the commuters can shop by scanning QR codes for same-day delivery, or co-working spaces integrated into large shopping areas, making hubs the true destination for travel. As well as the criteria for defining and selecting locations, in different existing research, various configurations of hubs are studied and characterized. They aim to establish which possible configurations and features can have the best impact in terms of increased revenues, whether through increasing revenues from users or through indirect revenues introduced by additional services such as retail (SmartRail World, 2017; Yeates and Jones, 1998) or other service providers who would pay to be present in the hub. (Queirós and González, 2019). The multifunctionality of a mobility hub could also be enhanced by broadening its user target and not be limited to the mobility of people but also to the mobility of goods and merchandise (parcel delivery, provision of stores, etc.), *“where sustainable alternatives to delivery services are made available at these hubs.”* (Aono, 2019).




Inclusiveness in its broadest sense



Today the principles, defended by Europe and its citizens, of democracy, human rights, the state of law and equity must be represented and tangible and thought out in every single intervention on the territory. In this context, a mobility hub project must be inclusive in a very broad sense, from its design to its use. "Accessibility is very important, as the hub should be visible and easily accessible by all types of users." (GO SEStran et al., 2020). This means that it takes into account and ensures the same ease of use (and comfort, safety...) to all users (citizens, tourists...) regardless of their age (elderly, teenagers, parents with babies...), their gender, their origins (tourists who do not understand the language of the country), their physical abilities, their disabilities, their income, their intellectual level (people who cannot read for example)... "Accessibility measures refer to ensuring the services and infrastructure within and around mobility hubs remain accessible to people of all ages and abilities. Therefore, elements and efforts to increase accessibility often include following universal design guidelines and incorporating responsive and inclusive street and transit elements. As a foundational element that is already considered by many transit organisations, the provision of accessible elements in mobility hubs do not differ greatly from what is provided at existing transit stations." (Aono, 2019). Among the existing and frequently used practices we can mention wheelchair accessibility, barrier-free access, priority shelter areas, universal fare gate access,

tactile information, tactile walking surfaces and guideway... In addition to that, other considerations should be taken into account. We can mention: including facilities and services that make it easier for people with disabilities to switch between different mobility services (Metrolinx 2011), matching arrival and departure times between public transit services and accessible public transit services (Metrolinx 2011), giving priority to space in the design in order to minimise the distance from accessible transit pick-up and drop-off locations to other transit services, with the minimum interception of other modes of transportation (e.g., bike lanes, vehicle traffic, heavy pedestrian traffic) in the pathways linking the accessible transit services to transit stations (Aono, 2019).

It is true that getting to an inclusive project can be difficult. For this, it is necessary to have a fairly precise idea of the population and the users of the proposed service. It is also necessary to be aware that certain populations are disadvantaged, identify them and understand how they are disadvantaged. For this reason, among others, local democracy is important and direct communication with users and citizens, local associations is necessary. "It is important to engage with the local community/ residents at the early stage of delivering mobility hubs to evaluate the demand and hence, viability of the service. They should also be engaged in determining the type of services to be included in the hub. The hubs can cause tensions from local communities as they can be perceived as taking away parking spaces for private cars.



It is important to increase awareness of the benefits and advantages of the hubs and engage with local community throughout all implementation phases.”(GO SEStran et al., 2020)

It may be that the mobility hub at these early stages will encounter some weaknesses and some populations will be disadvantaged. But to overcome this problem, the mobility hub needs to take into account the opinions of citizens and users, especially those who encounter difficulties in using the service. However, sometimes including certain populations remains impossible due to the nature of the service or the vehicles available in this case, an alternative service should be considered.

Security and safety




Safety and security is an important issue “in mobility hubs, as it is integral in helping passengers feel comfortable travelling and using the available services during all service hours” (Aono, 2019). The aim of a mobility hub is to provide users with several vehicles and/or means of transport that are less polluting than the car, grouped in a single location. In order to keep service users and to attract new ones, the mobility hub must, among other things, inspire confidence and increase user’s sense of security. A considerable effort must be made to make users feel safe. This issue must be taken into account from the very beginning of the project design. The design and layout of the mobility hub can play an important role (clear perspectives, unobstructed views, shelters, non-slip coating...).

Let's take the example of a person who is blind. It made it impossible (and prohibited) for him or her to ride a shared bike or scooter or, worse, a shared car. It would then be necessary to think about either adapting some vehicles offered by the mobility hub (here, fully autonomous vehicles may be a solution but do not seem to be on the immediate agenda) or offering an alternative service, for example, a kind of bicycle cab, or a transportation-on-demand service?

“Another facet related to accessibility is the cost of these services. In order for mobility services to be viable for individuals across the social gradient, fare subsidising programs and initiatives should be considered.” (Aono, 2019).

But, “Within a mobility hub, the transportation, and land use conditions and opportunities typically vary as one moves farther from the transit station. For example, direct and safe walking connections are most important in proximity to the station, where there is often the highest levels of pedestrian activity. Farther away from the station, transit, bicycle, and auto connections become relatively more important to ensure convenient station access.” (Metrolinx, 2011). Being highly pedestrianised, the design and infrastructure of mobility hubs have to enhance a strong feeling of safety for the users. Therefore, safety within the mobility hub context refers to a pedestrian-oriented design, where the movement of travellers is secured from surrounding vehicular traffic.




Safety should also be taken into account for all ages, genders and abilities, so that people with different abilities and familiarity with mobility services can move around and use a diversity of services with ease. The perception of safety and security can also be improved by implementing security measures that help to decrease crime in these areas. Security also involves addressing bicycle theft by ensuring secure storage facilities to promote bicycle travel to and from the centre (Aono, 2019). Aono identifies a number of factors to avoid transit stations and mobility centres from becoming crime zones. Furthermore, appropriate security measures are needed for bicycle parking facilities to reduce bicycle theft and promote bicycle use to and from these centres.

Among the existing practices, Aono mentions transit police, surveillance cameras and footage. Some practices commonly used include transit ambassador programs, lighting, designated waiting areas, emergency telephones, first aid stations... Other considerations include monitoring and reviewing the current conditions of transit stations in terms of their safety and security (Metrolinx 2011), ensuring pedestrian and cyclists facilities are visible, and having natural surveillance from surrounding areas during all hours of the day (Metrolinx 2011), providing consistent lighting throughout areas of the mobility hub, promoting mixed-use development within and around the hub as a way to enhance “eyes on the street” (LA Urban Design Studio 2016) (Aono, 2019). User safety must be considered throughout the entire period of use of the mobility hub and the services it offers. Under no circumstances should the user's experience be compromised by incivility, verbal or physical aggression.

In addition to the police force services, the service managing the mobility hub must do everything possible to avoid such incidents (video monitoring, uniformed or undercover security guards, safety instructions and warnings on the screens...). However, in case a problem does occur, it is necessary to be able to react quickly in order to avoid the worst and to ensure the safety of other users (alert service, first-aid kit, defibrillator...). The user who has been harmed must obtain a repair and the responsible parties prosecuted to regain the trust of all users.

The mobility hub should help to ensure safety for slower modes and smoother mobility in the city. From this point of view it contributes to the reduction of accidents or at least serious accidents causing serious injuries or deaths. For this reason, the mobility hub should make users aware of road risks in general and those of the mobility mode they choose in particular. This awareness can be achieved in various ways, for example through visual communication (screens, posters, pictograms...), oral communication (loudspeakers...) or safety campaigns (animations, workshops...). Users must also be informed of the recommendations, limits, and restrictions of use. The mobility hub service should also ensure that the vehicles it offers are safe, comply with regulatory and normative requirements, are well maintained and do not present any anomaly that could cause an accident. It should also provide all the safety equipment necessary for the use of the modes of transport it offers (bicycle helmets, fluorescent vests, baby seats...). Particular attention must also be paid to digital security. The goal here is to ensure, on the one hand, the software system (program, reservation service, payment service, location...)



of the mobility hub from any intrusion (hacking) that could slow it down or paralyse it, and, on the other hand, the security of user data. Mobility hub users continuously provide, consciously or unconsciously, a huge amount of personal data (identities, routes, means of payment...) which may be sensitive and could be harmful to them if they fall into the wrong hands. In order to limit the risks and maintain a minimum of trust on the part of users, it is necessary first to raise awareness, but above all to make serious, continuous and progressive efforts to ensure digital security. It should also be noted that the digital world is changing so rapidly that even experts cannot keep up with everything.


For this reason, it is advisable for the services that manage the mobility hubs to collect the minimum necessary data and above all to anonymise it and why not only keep it in internal servers. As repeatedly stated by the experts, no digital system is totally reliable. In the case of a suspected or actual data leak, the mobility hub services should not only do everything possible to solve the problem, but also immediately notify the authorities and users to try to reduce the damage (users can change their passwords, notify their banks...). Finally, "The implementation plan should take into account future operations and maintenance and ensure there is a budget and a partner responsible for these activities." (GO SEStran et al., 2020).

Comfort and ease of use



Human beings tend to favour easy actions requiring the least effort and offering the most comfort. The technologies in use today are for the most part the result of the continuous simplification of people's daily tasks. Here the car has an advantage: it provides flexible, adaptable and comfortable mobility. The car makes it easy to move not just between two points — an origin and a destination — but also anywhere. All of this can be achieved in the comfort of a single mode of transportation. While considerations of cost and travel time will increasingly reduce the relative advantages of the automobile, a competitive public transport system must provide attractive levels of service and comfort that are similar or better and that are based on greater modal choice in the mobility hubs and the network that connects them. (RTP, n.d.).

To offer the same or greater advantages (comfort and ease of use) as the car and to ensure the attractivity, the mobility hubs should offer a good level of comfort in the widest sense. "The goal of the [...] mobility hub [...] is to close these gaps and lower barriers to sustainable transportation by making it simple and convenient to combine regional transit, municipal transit, cycling, taxi, and shared cars in a single trip." (Waldron, 2007). A comfortable mobility hub, takes into account several parameters such as, in a non-exhaustive way, comfort of access to the mobility hub itself especially for disabled people, comfort of access to the vehicles, adaptability, and comfort of the vehicles (ergonomics), easy access to the information of use and technical assistance (clear information and recommendations).



Ease of use and comfort must be taken into consideration at different levels, from the most general, city-wide infrastructure to the most detailed, such as the booking of a vehicle or the comfort of the waiting areas. It is also necessary to remind that “a transit route is only as good as its weakest link, and potential users may be lost because of a lack of options at the beginning or end of their potential route, or by the cost and inconvenience of changing transit systems across municipal boundaries.” (Waldron, 2007). In the same context, the ease of use of the vehicles proposed in a mobility hub should be equivalent or as close as possible as using a private vehicle or easier. This can take into account several parameters such as the availability of a sufficient number of vehicles, the ease of parking... Also, “A mobility hub should have coherent branding across the whole region. A clear, recognizable logo associated with the hubs will increase visibility and user’s awareness.” (GO SEStran et al., 2020).


The payment of the service must also be simple (like taking public transport), usable by all (residents, tourists, people who do not have a credit card...) and offer several alternatives without obliging the user to create an account or a specific card or specific subscription. In the same sense, “It is important to have an information pillar which can be digital or analogue. Digital pillars can have high implementation and maintenance costs and may not be viable in locations with lower population density or potential user demand.” (GO SEStran et al., 2020). Other services should also be provided like “legible wayfinding, universal payment systems, and comfortable passenger waiting areas.” (Aono, 2019). Obviously, any other urban furnishing, intervention on the urban environment, artistic installation... are welcome. That also allows some originality and creativity appropriate to the local context when designing the mobility hub (Aono, 2019; LA Urban Design Studio, 2016; Metrolinx, 2011).

Reliability and resilience



The first aim of a mobility hub should be to participate in the reduction of car trips (especially solo car trips) by proposing alternative modes of transport, less polluting and less urban space consumers. Mobility hubs are very often (but not necessarily) managed by private companies that act in collaboration with local authorities. The latter integrate these new travel models into their public policies, regulate them and encourage them to participate in achieving local objectives, especially with regard to environmental and social objectives.


Building opportunities for shaping successful collaborations when it comes to the implementation of mobility hubs, public-private partnerships are fundamental to enabling seamless integration of various mobility services. Such partnerships can help to create new opportunities that make travel more convenient and more unified, such as integrated payment services and comprehensive data sharing systems. In addition, partnerships may differ across the real estate sector, the commercial sector, private mobility services, and public



transportation suppliers and operators. These collaborations may contribute to optimizing land value by generating economic development potential in these hubs (Aono, 2019).

For this purpose, the selected private partners must assume the role of a strong “mobility provider” in the same way as public transport should. They must ensure the quality, viability, and continuity of the service offered under any circumstances. They should even foresee and propose solutions in case the service is stopped for one reason or another, such as considering a handover of the service to the city or to another private partner. So, reliability and resilience must be guaranteed. The ASQ (American Society for Quality) defined reliability as “the probability that a product, system, or service will perform its intended function adequately for a specified period of time, or will operate in a defined environment without failure.” (ASQ, n.d.). In the same way, “reliability refers to the probability that the system will meet certain performance standards in yielding correct output for the desired time duration. Reliability can be used to understand how well the service will be available in the context of different real-world conditions.” (Raza, 2020). In this research, by reliability, we mean that the quality and quantity of services offered in the mobility hubs is adequate to the needs of the different users, stable, and not randomly changing. However, the services can/should improve over time. The resilience is defined by the United Nations Office for Disaster Risk Reduction (UNDRR) as “The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a


hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management” (Géoconfluences, 2015; UNDRR, 2007). So, with resilience, we first refer to financial sustainability and resilience: mobility hubs should have strong business models. Resilience also, means that the services supplied by the mobility hubs recover to their initial level after having been disrupted by unforeseen events (accidents, natural disasters, economic crises, etc.). It is also preferred that the mobility hubs are able to adapt during these periods of disruption. The partner managing the mobility hubs in a city as well as the local authorities should also propose solutions to respond to unforeseeable events and the uncertainties of the territory and the time. These unforeseen events can take various forms. They should consider the resilience of the service offered and even propose continuous improvements and adaptations to better match the local context and objectives. In order to ensure a behavioural change of users and a definitive shift from the car to other greener modes (at least for some trips), mobility hubs users have to be constantly convinced to ensure a lasting transition. So, as with cities, mobility hubs must also be a resilient and reliable service for users. Mobility hub operators must ensure a constant or even increasing quantity and quality of service over time.



Adaptation (technology and data)

Mobility hubs are seeking to give prominence to low-emission transportation solutions by integrating new technologies for transportation. Nevertheless, moving away from the private automobile remains a developing concept. Especially, emerging technologies and sustainable services such as car sharing, electric bike sharing, and autonomous vehicles are developing modes that are still in the early stages of adoption. Consequently, as transportation technology will continue to advance, the success and sustainability of mobility hubs will be dependent on their ability to evolve, expand and adapt to these changes. Hence, these unprecedented changes in transportation need to be considered in the design and infrastructure of mobility hubs. For example, designs must be flexible to respond to future growth and changes in transportation technology. The ability of mobility centres to adapt to technological changes will encourage a sense of resilience that will contribute to their long-term viability. (Aono, 2019). The mobility hub is, on the one hand, an urban infrastructure, and therefore, by its own nature and for the common interest, it has a vocation to last as long as possible without undergoing major modifications that generate significant costs. On the other hand, for an increasingly sustainable mobility, it must maintain or even improve its attractiveness and increase its activity and the number of its users. The concern is that, nowadays, technology is evolving rapidly and at a galloping rate. Adapting to these technologies can sometimes be advisable and even necessary.

The mobility hub administrator should consider this parameter. The technological changes could be either physical/technical or more virtual, or both at the same time. The physical/technical changes could, for example, concern the vehicles proposed, either for more adapted or more efficient vehicles or for new mobility tools. They could also concern the energy used, such as electricity or hydrogen, or the equipment of the mobility hub... We consider, as virtual changes, those which are not visible to the user in his daily use. We can evoke in this sense the way to collect data, to secure them, to share them (within the framework of a growing policy of transparency and of open data), to inform or to guide the users in their choices and their uses... Concerning the evolutions, both technical and virtual, we can evoke those which are visible by the user and which could change his usual uses. However, these visible changes imply imperceptible evolutions for the users. We can mention for example MaaS services. "Both physical and digital integration of transportation services through a mobility hub will support adoption of MaaS. In Austria, the WienMobil station illustrates physical as well as digital integration through the Wiener MaaS platform." (GO SEStran et al., 2020). Another clear illustration is the way of identifying the user or the way of paying for the trips, in cash, by card, by subscription, or without any particular action (like the stores without cash registers that are starting to appear).



Moreover, in this particular case, we would like to remind that it is recommended to facilitate the identification of the user and to avoid unnecessary registrations or subscriptions (e.g., simply proposing to scan/photograph an identity card) and to offer as many payment methods as possible (at least by cash and credit card). In fact, identification, and payment are part of the first interface between the user and the mobility hub. It is fundamental that this first contact becomes easy and fluid, especially since users are more and more sensitive to the vulnerabilities of private data and avoid registering each time to different services that subsequently invade them with unwanted emails or calls.

It should also be mentioned that the adaptability is not only limited to the technology or to the relationship with the users. Furthermore, it is also necessary in a very broad sense, especially between the partner in charge of managing the mobility hub and the city (evolution of policies, uses, formats and details of exchanged data...). Despite the evolutions, the mobility hubs' managing partners have to ensure backward

compatibility, whether it is towards the users (way of paying for example...), towards the cities (data formats...) or towards the vehicles (ways of recharging, parking...). The goal here is to maintain or even increase the attractiveness of the mobility hub while avoiding the possibility of obsolescence. This means not forcing users or other partners to give up their usual methods in order to keep up with the evolution of mobility hubs.


Also, in the context of respect for urban space and the broad principles of sustainable development, the mobility hub, as an urban installation, should be submitted to the principle of reversibility and recyclability. For example, if the service is stopped (for one reason or another), the changes made during the implementation of the mobility hub should be reversible with the minimum impact on the urban space. Thus, the urban space should be restored to its original state or improved. Within the wider framework of reducing negative impacts during the entire life cycle of the mobility hub, the design of the mobility hub should allow it to be easily removed and recycled, or its components used in a new manner.

Communication



As we already mentioned, the creation of a mobility hub goes through several stages. From the idea to the creation and management..., communication is essential at every step for the mobility hub to reach its objectives. R. Karbaumer and F. Metz emphasize that shared mobility requires intelligent as well as systematic communication and marketing carried out over a long-term horizon:

“A main lesson from the case studies [...] is that stakeholder engagement and communication over a longer period of time are essential to implement shared mobility measures and to attract target groups to using shared mobility” (Karbaumer and Metz, 2020). As mobility hubs are above all locations that provide various shared modes, the communication strategy therefore also has to follow a similar path (Karbaumer, 2021c).



A well planned communication strategy tailored to each stakeholder or user is necessary. Three types of stakeholder and two target groups can be distinguished. Stakeholders can be politicians and policymakers, public interest groups, or shared mobility operators. The aim is to gather stakeholders to support the project of mobility hub. And here, “active engagement, transparency, consistency, positivity, and storytelling are essential for effective communication with different stakeholders. This makes a positive outcome more likely” (Karbaumer and Metz, 2020). According to R. Karbaumer and F. Metz, The stakeholders will need to be aware of the key elements of shared mobility and will have to address the evidence-based and reasonable claims of shared mobility. This means that they have to be committed to the advantages that can be gained for the local environment, spatial challenges, the economy and social issues. These stakeholders may also need to be aware of why they have to act, as they may assume that market actors will take the initiative. “In many areas, the concept of mobihubs proves to be interesting for politicians.” (Karbaumer and Metz, 2020). As far as the operators are concerned, they are interested in whether there are areas where profitability is assured. Their objective is above all to ensure that there is a strong political will to develop shared mobility and that there is an action plan for shared mobility with allocated budgets. Operators are also interested in policies that restrict cars, such as pressure on parking. In general, communication between the city and the operators should be made transparent and fluent. The expectations of the city and the operators, their needs, requirements and objectives should be clearly defined (Karbaumer and Metz, 2020).

The second group targeted by the communication strategy is the users group. They can be for business purposes or for private purposes. The objective of the business community is to ensure that the shared mobility service can be used during working hours. The city's aim is then to demonstrate that the use of shared mobility could be an alternative to the company fleet. It is important to stress the possible savings, including savings on parking space. Companies can also subscribe to long-term, more advantageous group contracts... (Karbaumer and Metz, 2020). Private users are quite diverse. Their expectations of the mobility hubs are therefore wide-ranging. A communication strategy adapted to one group of individuals is not necessarily adapted to the other. It is then necessary to study the characteristics of the user group (age, income, etc.) and monitor its evolution in order to adjust the communication: “Shared mobility is mostly still at the early adopter stage. Early adopters generally consist of young and middle-aged persons with higher education and a higher income. However, shared mobility is becoming available for a growing number of target groups. Target group characteristics may change quickly, therefore, when promoting shared mobility, the aim should be to get the interest from a growing public.” (Karbaumer and Metz, 2020). R. Karbaumer and F. Metz, consider that daily mobility is not always dictated by rational or economic reasons. It is why, communication and discourse on emission reduction or health or savings is not very effective. There are three communication priorities in particular: strengthen motivations (convenience, comfort, safety, emotions of travel), remove barriers (perceived cost, complicated, loss of freedom...)

and provide triggers (provision of free carsharing membership or a travel budget for shared mobility and public transport). However, “Marketing and communication do

not need to be complicated or expensive. In any case, they need to be based on an understanding of behavioural psychology and behaviour change.” (figure 15).



Figure 15: Encouraging use by thanking users for participating in the success of the project (Karbaumer, 2021c)

The authors have developed a method for supporting changes in mobility habits that they named EAST for: Easy, Attractive, Social, and Timely. The aim of the communication strategy is then to highlight the effort made to meet the EAST objectives. As cited by R. Karbaumer

and F. Metz, these objectives are, without going into detail:

- “Make it Easy:
- Make it attractive
- Make it Social:
- Make it Timely”

(Karbaumer and Metz, 2020).


Conclusion

Within the framework of the Mobi-Mix project, we have taken a close look at the mobility hub concept. To do so, we carried out a literature review, attended specialised presentations, and discussed with experts from several cities. Two partner cities, Norfolk and Valenciennes Métropole, have chosen to implement mobility hub demonstrators and are studying their impact on CO2 reduction and the adoption of more sustainable modes of transport.

So finally, what is a mobility hub? As far as we now know, no author claims authorship of the term. The concept seems to have emerged from the reality of the field. However, various definitions exist. Some are more restrictive than others. They depend strongly on the project, the city, the status of the person who defines it... This multitude of definitions could lead to confusion with other clear and well-established terms, such as a multimodal hub. For this reason, we advocate for a discussion between stakeholders to find consensus on a definition that leaves a large margin of maneuver for the planners and offers the flexibility of implementation. As the term “hub” expresses a centrality and thus a plurality of objects, we can then concede that a mobility hub is a “place that regroups shared mobility modes while integrating or being connected to public transport”. Thanks to its flexibility, the mobility hub concept can become a facility that allows the city/region to meet several objectives simultaneously. The primary objective is to enable a more sustainable and less polluting mobility while reducing the use of private cars (especially private ICE vehicles).

Depending on the location and design of the mobility hubs, other objectives that are part of the city/region's policy may be reflected in them. In particular, inclusiveness (for all, without depending on abilities, ages, genders...), equity (spatial and income equity...), safety (for users and others, data safety), etc. These parameters should be monitored to help do continuous adjustments to the mobility hub. A method of impact monitoring (focusing on CO2 and taking into account the aforementioned parameters) is being developed within the framework of the Mobi-Mix project.

Each mobility hub is unique, but many of them have similar characteristics that allow them to be classified. Several different typologies exist. However, most classifications consider the users for whom the mobility hubs are intended (individuals, professionals, tourists, etc.), their temporality (temporary or permanent), their location (city centre, suburbs, etc.), their functions in the mobility network, their size and the vehicles they provide. The size of a mobility hub is often correlated with the surrounding density and the number of users. The type of vehicles provided often depends, among others, on the location of the mobility hub and the length of the expected trips. We believe that the classification of mobility hubs is relevant in the context of a network of mobility hubs and in contrasting mobility hubs from different cities or countries. Therefore, each city/region could adopt its own classification according to local specificities or objectives. However, the target users, the temporality, the geographical location, the size, the



type/number of vehicles and services offered all remain important parameters for defining a typology. Although the mobility hub concept is flexible, the implementation of a mobility hub adapted to the needs and objectives can sometimes be complicated as it requires going through several steps and may face difficulties at each one. Among these steps, we can mention first of all the emergence of the idea of creating a mobility hub and convincing both citizens and politicians of its usefulness. Then we can mention the feasibility study and the verification of the correspondence to local regulations (if not, it will be necessary to plan the modification of these regulations). An analysis of the urban area enables a mobility hub network to be planned and adapted to meet the particular objectives of each city/region. The creation of first mobility hubs that serve as demonstrators may be necessary. Depending on the learnings from these demonstrators, adjustments can be made and considered for future mobility hubs. Once the network of mobility hubs has been built, the process is not finished, and continuous adjustments and modifications are recommended. The main difficulties that may arise are generally linked to the opposition of local residents, the choice of locations for mobility hubs, the choice of private partners if there are any (some cities can manage mobility hubs themselves, but the majority rely on private partners), the modes of mobility to be provided. Despite the possible challenges in implementing mobility hubs, the whole process could be worthwhile to allow cities/regions to meet several objectives at the same time. To support cities in this approach, we have proposed in this document some recommendations and guidelines for implementing better mobility hubs.

First of all, it is necessary to create (or establish) features within the urban environment that support the implementation and the functioning of mobility hubs (pedestrian and bicycle facilities, reduced traffic speeds, strict parking policy, pleasant urban environment, etc.). Secondly, it is important to consider mobility hubs as a network, where each node is adapted both to its function in the network and to local parameters. A mobility hub can be functional and provide additional services to meet the needs of local residents or users (ATM, café, snack bar, pick-up of deliveries...). The mobility hub should also be inclusive, helping everyone to meet their own mobility needs, regardless of their physical condition, age or income... Safety and security within the mobility hub itself, and when using the vehicles it provides, is also important. In addition, to compete with private cars and be more attractive, comfort and ease of use are key considerations. When creating mobility hubs, cities/regions should ensure the reliability and resilience of the partners with whom it collaborates, as well as the flexibility of the infrastructure and its ease of adaptation to future technologies and compatibility with older technologies. Finally, the involvement of all stakeholders and communication are key when implementing mobility hubs. They should support all steps and be adapted to the different stakeholders. Mobility hubs are a complex and challenging topic to investigate. A thorough and accurate impact analysis of this type of infrastructure is still to be fully achieved, as it requires the collection of a multitude of data and their combination in a judicious way to obtain realistic results. It should also be remembered that mobility hubs are part of a wider urban and regional context, which needs to be considered for a full understanding of spillover effects.

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