Research paper

An exploratory study of Mobility Hub implementation

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A B S T R A C T

Mobility Hubs (MH) have been developed, as multimodal interchanges focussed on public transport, active travel modes, and shared mobility, with the aim of encouraging more sustainable forms of travel. There is emergent evidence of MH development and implementation across an increasing number of international cities often with different interpretations of the concept. The aim of this paper is to analyse the decision-making factors behind MH implementation. 11 semi-structured interviews were conducted with transport professionals involved with MH implementation in the United States, mainland Europe and the United Kingdom. The interviews revealed common elements in the decision-making process categorised under four headings, namely: Purpose, Process, Place and Performance referred to as the 4 Ps. These are used as explanatory factors to understand the variety of MH implementation globally. Furthermore, they have utility as a decision-making guide for prospective cities considering MH implementation. This enables exploration of how MHs develop and are implemented responding to the specific aims, opportunities, challenges, and contexts of a move from private transport to more active and shared modes of mobility.

1. Introduction

With concerns over the environment as well as social and economic issues, new and innovative transport solutions are being sought by all levels of government to aide in the movement from internal combustion engine vehicles to cleaner and greener forms of transport (Department for Business, Energy and Industrial Strategy, 2020). The concept of a Mobility Hub (MH) or eHub was developed and allied to technological advancements which have contributed to the promotion of shared mobility, active transport, and electric modes of transport in order to address these concerns. It is through the need for access to these modes of sustainable transport that MHs, a type of interchange, have been developed. The focus on sustainability and in particular shared modes of transport has led to the requirement for a specialised, accessible, and visible interchange that allows the traveller to seamlessly connect from one mode to the other. Rongen et al. (2022) highlight the point that despite the increase in MH projects and associated literature they are still in an early phase of their implementation. It is due to the embryonic stage of MH development that this paper provides an exploratory study with the aim of analysing the factors that determine MH implementation

across a diverse range of geographies and proposing a framework to be used as guidance for those authorities thinking of implementing Mobility Hubs in the future.

1.1. Mobility Hubs as a node and place

Despite the relatively recent development of MHs as a specialised interchange, they have emerged as an iteration of nodes within transport networks. Shared transport has a need for nodes or interchanges where the passenger can access or egress a variety of these transport modes. Transport nodes are designed to be efficient and convenient connectors of different transport modes with the aim of aiding travel between two different destinations often with specialised facilities. The value of a node can be measured by its network accessibility (Bertolini, 2008). Historically nodes and specifically interchanges have taken many forms with one of the earliest examples being ports. As technologies have advanced more multimodal meeting points have come in to being through the necessity of attracting and helping move passengers and cargo (David et al., 2019; Dwarakish & Salim, 2015; Indriastiwi, Hadi-wardoyo, & Nahry, 2021). The development of railway stations and

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airports being relevant examples. Ports, railway stations and airports have a primary focus of transport namely boats, trains, and aircraft but must be accessed by other forms of transport to complete any journey. This multimodal nature affords them to be categorised in a similar way to MHs, each being considered as a node in transport networks and, due to their specialised nature, being subcategorised as interchanges. Ports, airports and MHs offer enhanced facilities, information features and transport connections intended to facilitate the process of getting from one point to another, relating either to passengers or freight.

The similarities in these large-scale examples highlight the difficulties in defining a Mobility Hub. It is further complicated when considered in conjunction with smaller nodes such as tram stops and bus stops. There are shared characteristics with each including public transport connection (Aono, 2019, Northwest; Arnold et al., 2022; CoMoUK, 2019; Interreg North-West Europe, 2021; Bosehans et al., 2021) whilst Rongen et al. (2022) also highlights the similarities between Park and Ride and MHs with regards to land use and transport interactions.

It is not only the value of a MH as a node that needs to be considered but also that of its place value. Bertolini (2008), when proposing a node-place model for classifying railway stations, described stations as both 'nodes' and 'places' and stresses that due to the increase in demand for connections the potential for infrastructure development will increase. Rongen et al. (2022), through their analysis on the concept of MHs, highlight them as an example of Transit Oriented Development (TOD) hubs which are focused on connectivity and mixed land use surrounding the MH with the aim to "improve urban liveability by making public transport the core feature of a dense area of mixed land use, increasing the appeal of public transport over cars." (ibid, p.5) whilst also improving access to other economic activities. Zhou et al. (2023) also highlight the potential for more economically favourable conditions with the balance between node and place value being achieved. It is the aim of these TOD hubs to improve liveability around a walkable city model in these areas with urban transit the main feature whilst also improving economic development. Consideration should not only be taken of the places surrounding the interchange but also the interchange as a place in itself. Guidance has proposed that MHs contain amenities that allow them to be considered as destination themselves and not just a connecting point (Arnold et al., 2022; Metrolinx, 2011). The multifaceted nature of MHs leads us to the question of what is the concept of a MH?

1.2. Concept

First appearing in Bremen, Germany in the early 2000s, the past decade has seen the development of MHs as part of local and regional transport plans (Karbaumer & Glotz-Richter, 2021). Termed *Mobil. punkts* early examples sought to address a shortage of parking through encouraging shared mobility by clustering sustainable transport options around key points across the city. As the idea has spread defining a MH has been attempted by academics (Anderson et al., 2017; Aono, 2019, Bösehans et al., 2021) and practitioners (Interreg North-west Europe, 2021; CoMoUK, 2019). A useful list of definitions for MHs is provided by Geurs et al. (2022). Within this list can be found the definition by CoMoUK, who are a major contributor to the development of shared mobility in the United Kingdom. CoMoUK have created various MH guidance documents as well as an accreditation scheme. Their definition is:

> "A Mobility Hub is a recognisable place with an offer of different and connected transport modes supplemented with enhanced facilities and information features to both attract and benefit the traveller".

Others go on to define Hubs through the lens of placemaking, network access through seamless connectivity and shared mobility (Anderson et al., 2017; Aono, 2019; Coenegrachts et al., 2021; Miramontes, Pfertner, Rayaprolu, Schreiner, & Wulfhorst, 2017).

1.3. Mobility Hub characteristics

While there is no standardised concept of MHs the current guidance that exists points to several recurring themes including multimodality and connectivity (CoMoUK, 2019; Interreg North-west Europe, 2021). Several guides highlight key areas to consider when implementing MHs, these include consideration of physical characteristics such as mobility and non-mobility components and location selection (CoMoUK, 2019; Sandag, 2020; Sandag, 2021). Additionally, Arnold et al. (2022) in a review of MHs highlight the need to consider objectives as well as the physical characteristics. As with any public policy initiative or intervention there is also a need to consider evaluation.

To begin, the mix of modes made available within Hubs vary considerably and are dependent on (City of Minneapolis Public Works, 2021; CoMoUK, 2019; Evenepoel, 2020):

- requirements of the local population;
- the ability to provide these options;
- the local objectives they are required to contribute to.

CoMoUK (2019), provides an overview of the most common features of a MH. The first point to note is that Hubs often use a vertical sign or column known as a totem to identify the central point of the Hub to provide visibility, branding, and often information (Shared Use Mobility Centre, 2020; CoMoUK, 2019). The importance of information on offer for the perceived quality of urban interchanges was highlighted by Hernandez & Monzon (2016). Additionally, technology-based services such as MaaS (Mobility as a Service), are seen as some of the most important design features for Mobility Hubs by Seker and Aydin (2023) whilst also being incorporated into practical guidelines as demonstrated by a report from Arup (2023). Additionally, CoMoUK (2019) classify Mobility Hub components as follows:

1. Mobility Components
- Public Transport: typically, a combination of Bus, Tram or Rail depending on the local circumstances;
- Non-public transport: this categorises facilities to make active travel more accessible via shared mobility options for Bikes, e-bikes, e-scooters, and cars;
2. Mobility Related Components: supporting infrastructure such as bike lockers, EV charging infrastructure, cycle maintenance facilities and digital display features providing real time transport info. The latter could be integrated into features such as 'smart bus stops.';
3. Non-mobility and Urban Realm Improvement: Often the provision of Hubs provides an opportunity to improve the public realm which in turn adds to the attraction of the hub motivating travellers to use the transport facilities thus providing a virtuous cycle.

The inclusion of shared mobility, including car sharing and micro mobility, merits further consideration (Liao & Correia, 2022). Machado et al. (2018) note that shared mobility is becoming more common in cities around the world and car and bike sharing is a common manifestation of this within MHs. Arnold et al. (2022) investigated 20 examples of Hubs based in Europe and North America and revealed that 14 feature car-sharing and 10 contain bike share. The concept of shared mobility also provides the opportunity for transport authorities to showcase electric modes to promote widespread adoption in the private fleet.

Locating MHs has been approached in different ways, currently there can be found a focus on implementing MHs into urban or suburban areas (Sandag, 2021; CoMoUK, 2019) with a little focus on MHs in a rural context (Arup, 2023). More pertinently location selection criteria is driven by what the MH will serve, for example tourist locations, business districts, or suburban households (Sandag, 2021; CoMoUK, 2019). Another factor is the size of the Hub that is proposed which will affect individual and network choices. Wang et al. (2020) consider a tiered

Hub structure with ancillary, sub-centre and centre sized Hubs proposed, Bremen and Bergen also have a two-tiered system for their Mobil. punkt (Arnold et al., 2022), when examining location and Hub size options, consultation with the local population and other interested stakeholders is required (Arnold et al., 2022).

Whilst selecting a location near a place of interest is a consideration for the guidelines, catchment areas for MHs is a topic that needs further consideration. When considering the place value for a node Bertolini proposes a 700 m catchment area (1999) however Wang et al. propose for MHs a 250 m zone of catchment around the MH. Anderson et al. (2017) have gone further and proposed an 800 m access radius for a Hub. Furthermore, CoMoUK has proposed that a MH should service 1000 inhabitants in a rural context or 2000 inhabitants in an urban context which are generalised figures that need to be expanded on with reference to densification and context.

1.4. Mobility Hub objectives and evaluation

While clearly all MHs aim to achieve mode switch away from the private car and improve overall accessibility to transport, this feeds into some variation in emphasis with regards to the medium-term policy objectives and in turn will impact implementation. The objectives which MHs seek to address can be assigned to two overarching categories: addressing either environmental issues, primarily a reduction in carbon dioxide emissions or encouraging socio-economic improvement.

MHs can contribute to environmental policy objectives aimed at improving air quality and reducing carbon emissions by promoting mode shift from the private car and also by promoting electric powered transport via shared mobility (Bösehans et al., 2021; Interreg North-West Europe, 2021). MHs aim to achieve socio-economic objectives through improving equality of access especially for those who may have financial or practical constraints in using existing transport modes. This objective is common across many of the existing and planned MH networks throughout the United Kingdom and Europe (Plymouth City Council, 2020; Nottingham City Council, 2020; Gray, 2017).

Congestion also incurs significant economic cost as well as contributing to environmental and health problems, this is a key objective of not only local city and regions but also on a national level (Department for Business, Energy, and Industrial Strategy, 2017).

Whilst the history of transport node and interchange development is broad, due to the recent developments in sustainable transport modes and a change in focus of policy makers towards sustainable transport the requirement for MHs is relatively recent and as such they are still in their infancy. Consequently, to understand and further our knowledge of whether they are achieving the policy objectives of the implementing areas and regions it is necessary to consider evaluation (United States Department of Transportation, 2022). The Treasury in the United Kingdom (2020) considers evaluation as a key point in understanding whether an intervention has achieved its goals, as a means of improving future intervention design, and whether there are unintended consequences (HM Treasury, 2020).

As this introduction has revealed, at first sight there is considerable variation with respect to a definition of a MH and why, how, and where MHs are implemented. This research investigates practitioners' views as to how MHs should be defined, what objectives they contribute to, and what facilities they need to contain to achieve these objectives, in order to identify commonalities and put forward a framework to focus decision making for those considering a similar implementation strategy. The following section provides the research methodology, followed by the findings and discussion of semi-structured interviews undertaken with professionals from 11 different local or regional public bodies and finally a conclusion.

2. Methodology

A qualitative enquiry approach was constructed to investigate the implementation of MHs. Such an approach entailed methods which allow "deep" and "rich" insights to be gained in relation to the phenomena of interest (Bryman, 2016). Semi-structured interviews were seen as an appropriate method for such an exploratory enquiry due to their flexibility and scope to discover areas of interest and to allow the researcher to probe emergent and new areas of knowledge (Bryman, 2016).

From the literature and guidance on MHs four overarching themes were identified, relating to MH implementation, that were explored in the semi-structured interviews. These were development objectives, location selection, MH design (including modes of transport), and evaluation.

A purposeful sampling approach was followed to ensure that the sample of MHs contained variations in key characteristics, including context, design, and location factors, and would thus elicit rich information. In this instance the researcher sought to identify a sample of MHs that represented different geographic regions and at various stages of development – in reality, the full potential variance between cases is not fully known due to the relative novelty of MHs and due to the difficulties in obtaining contacts in global south regions. MH cases were initially sought from a previous study (Arnold et al., 2022) that collated examples across Europe and North America of developed or planned MH networks. From which, a web search resulted in identifying named individuals associated with each of the MHs who were then invited to interview. Further cases were identified by means of snowball sampling integrated in the interview to identify additional cases of interest.

Participants for each MH case were represented by the local government authority or responsible transit authority. In each case, the representative needed to have a high degree of responsibility or oversight of the MH project and have intimate knowledge of the development activities. A total of 11 interviews were conducted based on local government or transit authority areas, one of the interviews undertaken consisted of two interviewees (see Table 1).

The interviews and analysis were completed in a 4-step process. The first step involved contacting the identified interviewees and arranging the interview. The second step was the interviews themselves; These were conducted online to maximise participation and lasted between 30 min and 90 min. The interviews were all conducted in English and followed a semi-structured interview process. Questions were not sent to the interviewees beforehand to ensure an open and free flowing interview process that allowed for tangential or emergent issues to be explored. For the third step each interview was in the first instance auto transcribed through the Microsoft Teams software and then each interview was reviewed multiple times, and the transcription was manually amended when errors in auto transcription were discovered. The fourth step involved the coding of the data, which was done through Nvivo, initially through an open-coding process. Subsequent iterations of analysis identified categories and themes through the coding of the data. The development of major categories and subcategories were refined through discussion and debate amongst the research team.

Table 1

Sets out the assigned ID number and the job titles for each participant in the interviews.

ID Number	Job Title	Location
ID01	Senior Project Manager - Mobility and Technology	USA
ID02	Future Transport Officer	UK
ID03	Mobility Manager	USA
ID04	Low Carbon City Officer	UK
ID05	Policy Advisor	Netherlands
ID06	Sustainable Transport Advisor	Norway
ID07	Senior Mobility Strategist	USA
ID08	Ecological Transition Project Manager	France
ID09	Planner, New Mobility	USA
ID10	Climate Protection Manager Mobility Manager	Germany
ID11	Innovative Transport Manager	UK

3. Findings

Through iterative analysis of the interviews the influential elements of the decision-making process and implementation were identified and grouped under four headings, namely Purpose, Process, Place and Performance, the 4 Ps. Within this framework further classification of topics and recurring themes were identified. Purpose, consists of an examination of what are the driving factors behind MH implementation, including objectives; Process focuses on the subcategories of consultation, operational and organisational elements; Place analyses the responses to the physical elements of MHs including amenities, design, and location; and the Performance component focuses specifically on evaluation.

3.1. Purpose

This section focuses on how MHs are defined and the reasons for the existence of Hubs under the category of purpose and what their objectives are.

3.1.1. Definition

On the basis of the interviews there would appear to be no clear, uniform, or consistent definition of MHs, although key themes were identified relating to MHs. One of which was the focus on multimodal transport. As stated:

"the ehubs [Mobility Hubs] are locations where multiple forms of electric shared mobility are made available to the general public." ID05.

"main opportunity for us to make them more multimodal" ID07.

The idea was posited that the focus of MHs should be one based on sustainable transport: *"it's a sustainable transport hub or kind of a place where you can reliably go to either obtain information or actually use some form of sustainable transport"* ID04. This accords with the environmental objective identified by the majority of those interviewed. The focus on environmental policies and targets, alongside the offering of sustainable transport formed the initial basis on which MHs were developed.

Additionally, a transport feature frequently cited in the interviews was the notion of connectivity, allowing sustainable transport forms to be used, namely: *"it's a place where people can connect to multiple modes of transportation to make their trip as safe, convenient, and reliable as possible"* ID03. This serves to underline the sustainable nature of Hub transport, with the aim being to provide the most appropriate form of transport at that point of the journey whether it be active, micromobility, or public transport for longer journeys. The modes identified at Hubs will be explored in more detail later in the paper.

Another consideration when defining a MH was the promotion of a sense of community and what services should be considered as part of this: *"It's a community hub"* ID01, *"It could be a space for parcel lockers, thinking about expanding access to composting could be a space to host compost bins … It's sort of making it a place that's known that people can go to"* ID09. This sense of ownership is a recurring theme that is encapsulated in the definitions, expanded by ID09: *"I think it's really … the placemaking and the community space making, which is something we need to work on and build for future installations."*

3.1.2. Objectives

All the respondents regarded MHs as a relatively new concept in the transport infrastructure landscape. As such, it is perhaps unsurprising that 7 of those interviewed viewed them as experimental in nature, namely pilot programs. ID11 stated: *"We're looking for projects that were experimental in nature that some harnessed future mobility in future technology [sic] to improve customers experiences and made it more easy for them to be able to travel around [sic]"*.

The focus on environmental sustainability challenges was prominent in the mindset of the practitioners interviewed, with 9 out of the 11 highlighting these as an objective, the focus of which is encapsulated by ID04: *"it's a sustainable transport Hub."* Emissions also featured, with ID07 highlighting the specific goal of a *"19% carbon emission reduction target"*. Other issues were also raised such as noise: *"it's like emissions. It's noise. It's … the use of space, it's so visible through traffic and cars and trucks … people want to have a change in this section"* ID10.

Concerns relating to social integration was another factor that featured prominently, with 8 out of the 11 respondents seeing this as an area that MHs were trying to improve whether through addressing the lack of community space: *"We kind of have an absence of Community space in the public realm"* ID03, or through the targeting of those who most need access to transport: *"then continuing to work on providing better access to transportation in those neighbourhoods"* ID01. This feeds into the larger question as to whether MHs are being targeted at those who could most benefit from enhanced accessibility provided by the MHs or those already receptive to the idea of using sustainable transport and thus have a greater propensity to switch mode.

Another social aspect that was highlighted and, as such, was incorporated into MH design is that of safety, ID03 stated with regards to this: *"also the safety aspect in that we have so many car crashes and traffic accidents that we have our vision of a zero policy of trying to reduce traffic fatalities that are unusually high"*.

ID08 encompassed all the above-mentioned objectives including what could be considered as a necessary element in achieving the removal of the internal combustion engine (ICE) from our streets when they stated: *"and as long as it fits the … carbon emission reduction objectives, so that's the main objective is to reduce the use of the individual car."* From this it can be concluded that behaviour change was a significant underpinning aspect to achieving objectives. Not only would this help to achieve environmental but also economic goals through the reduction of congestion. Economic success was a significant consideration with 7 of the respondents mentioning this as an objective.

The objectives are inextricably linked as summed up by ID04: *"Reduce congestion, reduce carbon emissions, improve air quality, improve access for certain groups and certain areas to better transport sustainable transport."*

As such, the implementation of MHs is driven by its defined purpose: introducing new modes of transport, a location to facilitate the connectivity between modes, or a broader social purpose space facilitated by the provision of transport.

3.2. Process

Characterizing elements of the process both for implementing and running the MHs is derived from an analysis of the differing approaches adopted by the interviewees. Recurring themes were identified and are examined in this section, including consultation and operational elements.

3.2.1. Consultation

A recurring theme emanating from the interviews was the need for consultation with respect to the implementation of MHs to achieve concept approval and for input on practical elements such as design, service offerings and location selection. These consultations were focussed on stakeholders, primarily members of the public, community groups, and to a lesser extent local representatives. 10 of the interviewees highlighted this as an important factor in the development of the MH projects.

"They explained what services they would like to see and what community services … also fed back to any kind of security and safety measures they would like to be in place" ID02.

"I think Community engagement is really critical, because without somebody who they recognize or feel safe with, who was engaging with them, it's harder to explain what it is like. People just say I see a

box and I see more bikes. What does this mean and without having that dialogue about what it could be, it's harder for people to get comfortable with it and to feel some ownership with it. I think that's really important" ID03.

As can be seen, the need to feel comfortable with what is an experimental concept is seen as being critical to obtain 'ownership' of the Hubs especially with respect to the community. Contributions from the local community increased a sense of ownership and involvement. Embracing the MHs through taking ownership also helped to provide better results: *"sometimes they would say 'hey this is the wrong location. Everybody usually hangs out a block this way* [referring to an alternate geographic location]. *Move everything' they say and we did"* ID03. Consulting with, and listening to local groups helped to foster a sense of community involvement with the aim of ensuring continued usage: *"we really had a robust public involvement plan where we engaged community and then as we set forth in design and implementation, …multiple meetings with each of the site locations because they all had some wishes and thoughts to want to make sure we met their needs you know community organizations, churches, community leaders Councils etc to pass on the information and really get the word out"* ID01. This link between ID01 and the community was crucial in ensuring that the components were satisfactory and used. ID06 highlighted the need to listen to both municipal organizations and the inhabitants to avoid any potential issues: *"What's possible in the area? Traffic has a lot to say. We always have to run this by our traffic people and the Streets Department and like I said, the needs of the inhabitants"*. From this, it is clear that consultation with local groups and residents is an implementation factor that was important and can be seen as an element that should be considered carefully in any future project.

ID07 was one of the few respondents to cover the impact of political will: *"one issue that we've come across is maybe less political support for the site than expected"* which although clearly an important consideration, in this case may not have been as important for others as it was not to the fore. With regards to implementation partners, it was indicated that this was a time consuming but necessary feature: *"So for instance, universities or the developer … for example, we've done quite a lot of engagement and got their support and endorsement and ideas as well, in terms of crafting the concept of Mobility Hubs"* ID11.

3.2.2. Operational elements

The operational concerns were far ranging with some issues compounded by the COVID-19 pandemic such as delays in MH implementation. The availability of e-bikes at MHs was also affected by supply issues: *"the company that provides the electric cargo bikes has had issues with availability of cargo bikes with the fact that, well, the delivery from the factories where they're being built was delayed through COVID measures and through blocked major shipping routes"* ID05. Other issues were unexpected such as the vandalism and theft of e-bikes: *"the company that provided the electric bikes had a national problem of increased vandalism and theft, which really limited the number of e-bikes that were available for the public to use"* ID05.

Additionally, implementation and operational factors were influenced by the complexity of interdepartmental relationships which is highlighted by ID03: *"Multiple government entities and coordinating across them. So, we are a city that has to work with a regional planning authority at a regional transit system. But within our city we also have county and state roads that go through the city. So, say you were like I want this location. It's a state road and County Road with a regional Transit Authority, but then we operate the right away so … every location requires coordinating potentially across like four other organizations"*. Practical issues such as working with utility companies also added to the difficulties in implementation as stated by ID06.

Marketing and advertising were mentioned by the majority of respondents. For instance, the use of social media to promote the MHs as identified by ID05. It was not only online advertising that was required but also the physical impact of the sites themselves, ID02 highlighted the

need for *"common branding across the whole network … like having a totem"* for their MH network. ID08 also mentioned implementing physical advertising rather than other forms of promotion, however this was done by having events at the Hubs to promote their use. ID09 used a combination of advertising methods including flyers, a website, and the branding itself.

However, there were concerns, ID07 wanted the MH implementation to take place before a concentrated advertising campaign and interestingly one of the respondents, ID03, indicated that advertising was contrary to the culture of their area, showing how the diversity of attitudes within the interview pool can preclude any concrete statements on importance to be made.

3.3. Place

This section focuses on the physical elements of MHs under the umbrella term of 'Place'. This includes location selection, amenities, and design.

3.3.1. Location

Locating MHs was a topic that was of particular focus during the interviews. It is seen as a crucial element in achieving objectives, for instance by targeting areas that haven't traditionally had access to transport infrastructure to achieve social equity objectives. These gaps in the wider transport infrastructure were highlighted by ID09 *"the goal here is to improve access and to do that, you know, in an equitable way"* as such focus was placed on implementing MHs where the needs for infrastructure already existed. The need of inhabitants was a recurring theme when discussing placement. ID03 emphasised that Hubs were targeted at areas of *"concentrated poverty"*. ID05 specifically targeted *"not the usual suspects"* and others were equally concerned with areas that have been underrepresented previously in terms of transport infrastructure. Contrary to this ID02 did highlight that in their location consultations they looked at pragmatic areas where MHs would complement existing attitudes which were favourable to adopting sustainable modes of transport, with ID05 also stating that they had received information from an academic partner on *"locations that were most likely to actually be successful in terms of shared mobility and that sort of thing"*. Interestingly, there is a common aim across all the regions to target areas, through MH placement, that have previously been underserved by transport with the aim of tackling social equity goals ID03 and ID09.

The idea of 'opportunity' arose when discussing locating MHs. This covered a wide spectrum of considerations. The first consideration is whether there is space available in a desired location and, if not, can it be acquired: *"we'd like to place the e-Hubs … a bit pragmatically, just based on locations where we thought, oh we actually have some public space available here where we actually have room to place these bikes, and these cars"* ID05. Added to this is the consideration of which public transport services existed in the vicinity of potential sites. As previously highlighted this connectivity is a crucial consideration when defining MHs and as such it is a natural progression to consider this when locating a Hub: *"First, we thought, you know, let's look at the region and let's get a sort of data set of all of our bus stops"* ID02. Thoughts over practicality when discussing location selection were seen as a contributing factor in some decisions and also as an issue in other cases.

Opportunities were sometimes presented to interviewees as highlighted by ID11 where consultations with local taxi drivers showed a lack of electric vehicle charging points in one section of the city prompting consideration of a MH in this area when one hadn't been considered before. This type of positive opportunity is contrasted against those opportunity issues such as considering utilities provision to a potential site: *"first thing is where's electricity?"* ID10. Electric modes being a key pillar of MHs ID04, ID05, ID06, and ID11 making the provision of electricity consequently a necessity. The lack of opportunity with regard to utility or space provision at acceptable sites emphasises opportunity consideration. Additionally, an interesting issue in location selection

came from ID10 where consideration had to be made not only for the usual practical issues mentioned but also archaeological ones, due to the potential to disturb historical sites, revealing how issues can be context specific.

Connectivity to different modes of transport is a key element of MHs and part of many area's objectives, therefore public transport connectivity is a necessary consideration of location selection. This was demonstrated in the interviewee responses:

"68% of people either agreed or strongly agreed that they would like a Hub at their local railway station" ID02.

"most of the locations were adjacent to at least a local bus line, if not a bus, rapid transit line or a light rail transit line" ID03.

"there was an objective as well, but to implement close to other public transportation" ID08.

"We know where our public transport interchange points are, so the existing tram platforms or bus stops. And I t*hink what we want to do is to try and overlay those things together"* ID11.

The need for public transport infrastructure connectivity underscores the multimodal nature of MHs, this was a theme that spanned the interviews with 9 of the 11 respondents raising this as an important factor. Targeting certain populations or services was a predominant consideration in location selection. What became apparent was that there was a focus on residential or commercial areas targeting primarily inhabitants of the areas and not visitors: *"we took in a lot of factors regarding population and employment density."* ID07. There was limited interest in locations at tourist destinations or other city landmarks. This tallies with the definition of MHs being part of the community and enhancing the lives of those who need access to either sustainable transport or for social integration considerations.

3.3.2. Amenities

In addition to a sense of place and community there is naturally some focus on having an area that could be used by the community in addition to their transport needs. Therefore, there was a consideration for services and amenities that could improve the community or sense of place:

"a lot of folks use the library system to connect to Human Services, and it's our librarians and our workers Vrs where the inhabitants can grow their food or vegetables or flowers" ID06.

An additional consideration was that of commercial services, after consultation ID02 highlighted the request for *"pop up catering"* and ID03 wanted to have a *"coffee cart"* or other amenities to help in *"food deserts"*. ID11 highlighted the potential for a community area *"where people can come and work remotely … grab a cup of coffee or cake"*. As shown these commercial services linked into the residential community deliberations. The integration of information provision into the design and the place of MHs was a recurring idea identified by the interviewees, ID02 underscored the idea that information provision could aid with wayfinding and public transport connectivity: *"We want to sort of present the network again at Mobility Hubs, so whether that's like a way for public wayfinding maps, making sure people can see where their local bus stops are, making sure they know about the service frequencies on those routes."* This aid to public transport connectivity and wayfinding links to the objectives previously highlighted. ID03 also pointed out the potential benefits that real time messaging could bring serving to highlight the importance of the MH and public transport network coordination through the provision of travel information. Whilst significant, to some interviewees, concerns were raised about information provision especially with the abundance of personal mobile devices that could potentially provide the same services thus questioning the benefit of providing these services over potentially other, more useful services such as charging for devices, this was a point of view held by ID04. This was backed up by ID06 who although introducing touchscreens at their MH locations stated that they

were not used very much. Another topic surprisingly not covered by the interviewees was the integration of a payment solution alongside the MHs although there was mention by ID07 of the potential to include this in future.

3.3.3. Design

When considering the design of MHs the function and how the Hubs could achieve key objectives was a crucial factor, as such there was a focus on which transport modes should be made available. With environmental objectives playing a prominent role in the implementation of MHs sustainable modes of transport were integral to the design of the MHs:

*"By adding differ*ent sustainable alternatives together make them visible and accessible in a better way for people so that they see that as a really viable alternative" ID06.

The new and experimental ideas could be seen in the mode provision with ID01 stating: "we did have an autonomous vehicle running between two Hubs." This, in combination with the electric modes being promoted, underscores the move towards future transport solutions to help tackle the social and environmental objectives.

Interestingly, although the move towards electric transport modes was a key criterion in mode selection, traditional forms of transport are also being used and promoted at the Hubs:

"We would like Mobility Hubs to offer … cycle hire … e-scooter pilot and support for active travel. So, if you know like the kind of it's not really a mode I guess, but sort of things like secure cycle storage" ID02.

This includes active travel and public transport, indicating that the move towards electric vehicles is not the only option required to achieve the objectives of each of the areas: *"Connections to public transport and that is getting more and more important as you expand the scheme to a move away from the city centre"* ID06. ID03 suggests that a MH as a minimum requires *"that you have bikes, scooters and a bus"* underlining the combination of new mobility and traditional forms. The idea of connectivity was a key principle in defining MHs and this is played out in the practical example of mode selection where the combination of personal mobility and shared public transport whether rail, light rail or bus is a key theme (ID03 and ID07).

The aesthetic design of the MHs is integral in attracting users as well as enhancing the environment. To aid with increasing usage numbers the signage both incorporated the branding and had practical elements. The branding can be seen as serving a purpose of *"selling itself it's there in the street"* ID06, thereby the MHs have become their own advertising. The majority of comments focused on the practical elements of the signage with ID03 highlighting that *"signage … explained what modes were available there. Sometimes how to safely ride them, how to use them."* This practical consideration of the MHs signage linked in with other design elements such as bright colours and comfort elements including seating and coverings were mentioned: *"we reviewed a lot of different types of seating and structures"* ID09. Concerns were raised however with regards to the abundance of signs and branding that could potentially be found at a location with *"too much considered to be overbearing with a lack of clarity"* ID07 and resulted in a need for *"a unified feeling"* ID04. Signage, branding and consistent colour usage were clearly an important consideration in attracting users but one that was not overwhelming.

A crucial factor in the design stage of the implementation was the consideration of safety. 10 of the respondents had considered this issue including ID02: *"We've received quite a lot of feedback related to the safety of being on the street. If you've got new enclosed spaces and just not creating a piece of public infrastructure that meant that people could lurk or hide"* this resulted in pragmatic considerations for ensuring safety features were included such as: *"one of the things in neighbourhood and stakeholders wanted was an emergency call button on the kiosks at the Hubs in case, there was an emergency. So, we had them added to those kiosks, so it directly dials 911"* ID01. User safety was also a consideration for ID04: *"CCTV making sure they're in a good place that's well lit, and it's easy to kind of get onto the*

cycling network from as many places as possible". Examples of these practical safety considerations recurred with ID06, ID09 and ID10. Additionally, the need for safe access and use of the different modes available was a consideration for the majority of the interviewees: *"if we're encouraging these as destinations, or people ride a bike, or walk to go* [sic] *transfer between another mode that they should be the pinnacle of safety,"* ID09. The need for safety was already ingrained in the modes of transport in use for ID05 however there were new elements to be considered: *"with the theft and vandalism of electric bikes, this was something that we had not anticipated."* The spectrum of what had been considered for safety amongst the interviewees can be seen in the examples given. An important aspect to consider is the attractiveness of safe transport to users, highlighted by IN03 who states that: *"By putting in the Mobility Hubs, it increased scooter ridership and if we also did additional amenities, safety improvements in community engagement at that site, it further increased ridership at those locations".* Safety in this case led to more usage which would have impacts on the health of the population and the success of the program.

Although each element can be separately analysed there are occasions when crossover occurs. For example, with regards to how each region or city aimed to achieve their respective objectives and what the focus for each was. It is understood that each region aimed to improve social equity through the implementation of MHs. In considering the value of a MH it is noteworthy that the focus of the mainland European projects is accessibility to the wider transport network through the provision of more modes of transport. Whereas American and UK interviewees, whilst equally stressing the importance of the personal accessibility to a wider range of modes for multimodal trip connectivity, also highlighted the need for MHs to have an economic influence as well through either the provision of commercial activities such as coffee carts (ID03) or to be located in areas that already contain some of these elements which could be then considered as an "added amenity" (ID01). TOD highlights how MHs can make more vibrant, liveable communities around the transport node (Amini Pishro et al., 2022; Zhou et al., 2023), the introduction and implementation of MHs can be seen as promoting and aiding this, however the focus has been found to be contingent on the region asked. The US and UK interviewees through adding in commercial and social elements e.g., coffee shops or locating near libraries are aiming to promote the placemaking elements of a Hub which in turn would stimulate TOD whereas the European elements are aiming to regenerate areas or improve social and economic prospects of inhabitants through location selection of MHs (ID05, ID08).

3.4. Performance

It is necessary to ask the question, how have MHs performed in relation to the aims and objectives set out? The question of performance is integral to understanding what has been achieved with the implementation of MHs. As such, it is necessary to consider how the Hub projects have been implemented and what the impact has been. The next step in the evolution of MHs is to assess what can be improved through a thorough evaluation. The response to questions regarding the evaluation of MHs revealed insight into the work that was progressing whilst highlighting a potential area for further work in the understanding of MHs and how they perform as a transport intervention. Performance, and evaluation strategies were identified as heterogeneous across the sample as a result of the varying project timescale and funding models. When discussing performance and evaluation the importance of data collection was recognized, however this was primarily focused on usage numbers, 10 of the interviewees expanded on usage as a metric for MHs with some comparisons of before and after data being completed, for example ID03 stated that: *"Before we put in the Mobility Hubs, what the scooter ridership was, and then after we put in the Hubs how that impacted ridership and we basically found that by putting in the Mobility Hubs, it increased scooter ridership and if we also did additional amenities, safety improvements in community engagement at that site, it further increased*

ridership at those locations." This gives an insight into the potential effectiveness of MHs in increasing scooter ridership numbers however it also reveals the limitations of the evaluation process due to the focus purely on ridership numbers without taking into account contextual factors. In addition, it also reflects the requirement for baseline data collection when implementing MHs. Due to the fact that MHs integrate multiple modes and non-mobility components (e.g., parcel lockers) a range of Key Performance Indicators are required as highlighted by ID04 and ID05. The need for an evaluation process was acknowledged by ID04 and ID07 however it was stated that this was not a current priority. The acknowledgement of a need for thorough evaluation was highlighted through employing academic institutions to undertake research (ID01, ID04, ID05, ID08, ID11) however there was a lack of detail and clarity from some of the interviewees: *"is based upon kind of our feeling about what we need to monitor, but in terms of a systematic monitoring plan, we don't have it yet"* ID04.

Some of the key questions with respect to performance were highlighted by ID05 *"the evaluation is … more qualitative in terms of well, what do we actually see are the e-Hubs being recognized? Do people know about the project? Are they positive about the project or not?"* which also served to underscore that although much of the analysis being worked on currently is quantitative in terms of numbers of users there is an element of qualitative research required.

4. Discussion

The interviews suggest that the differing geographical contexts produce heterogeneous decision making factors for MH implementation. What is important for one region or city is not necessarily a requirement for another, however, that does not prevent there being recurring themes in some crucial decision making areas. The 4Ps framework (Purpose, Process, Place and Performance) has been developed both as a lens to facilitate the examination of MH implementation and as a starting point for future MH projects.

The literature presently proposes no singular definition for Mobility Hubs (CoMoUK, 2019; Anderson et al., 2017; Nottingham City Council, 2020). However, as highlighted by study participants, there were multiple examples of MH definitions which were driven by the varying contextual priorities. Environmental sustainability was a key factor for several of the participants and this was reflected in both the definition and objectives. For instance, ID08 and ID10 focused on the electric offerings in their definitions with the concurrent objective of reducing climate impact. A similar point occurred when looking at the community aspect of Hubs: ID01, ID07 and ID09 all highlighted community in their definitions and had strong social objectives. Both examples suggest that how MHs are defined can be influenced by what objectives are being set out. This underlines the lack of clear and consistent definitions as shown by the variety of offerings from the existing guidance (CoMoUK, 2019; Aono, 2019; Anderson et al., 2017; Nottingham City Council, 2020; Plymouth City Council, 2020). Even with differing contextual factors the importance of defining MHs, either generally or on a case-by-case basis, is evident: Firstly, it creates a common understanding of the issues that MHs are looking to combat, secondly it breaks down and identifies the components required for the MHs to succeed, thirdly without a definition evaluation is significantly affected through an inability to effectively measure success indicators. Finally with a clear definition, communication with stakeholders is improved and promotes engagement with the MH project. Consequently, it is possible to see the effect of a clear and precise definition (or not) across all of the 4 P elements.

A further recurring consideration was whether MHs should be directed at those with an existing appetite for sustainable transport and as such would see immediate usage or to target those who are underserved by transport in their communities. This would then have a knock-on effect as to how much attention should be paid to behaviour change, many of the respondents focused on behaviour change as a means of achieving environmental and social objectives. However, if MHs are

being aimed at those with limited access to transport, further consideration should be given as to whether the aim is to provide transport or facilitating a modal shift or both. Behaviour change is an objective that feeds into several of the MH implementation projects. All the interviewees identified the negative effect of ICE cars on their transport landscape and cited this as a motivation for instigating behaviour change. However, the question needs to be asked as to whether Hubs are reducing car numbers from car intensive societies such as those in the US (ID03, ID07, ID09) or whether they are cannibalising already existing sustainable transport users (Liao & Correia, 2022), which may be the case in European cities where we have seen more sustainable transport options (ID05, ID08, ID11). When discussing other transport modes, it is necessary to consider the issue of site selection and the role opportunity plays. Public transport links are a necessary element of MHs, guidance on location selection has shown this (Aono, 2019; CoMoUK, 2019) underscoring how MHs are complementary to existing transport networks. Understanding the level of behaviour change and the attribution of modal shift to the intervention of MHs can only be tackled through thorough evaluation of the implementing areas, each of which will help to build consensus on the attributing factors. As can be seen from the Performance section of the 4Ps, evaluation is being given some attention specifically in regard to data collection, specifically usage statistics and surveys. The importance in determining the success or failure of a project is reliant on an evaluation (HM Treasury, 2020) and as such this is an area that needs further investigation.

Preliminary results have tended towards the idea that MHs are having a positive influence on the usage of sustainable modes which although from a small sample size, is found in both the US and Europe with IN03 and IN06 highlighting the improvements they have seen in user numbers and in lowering car ownership per household respectively. Interestingly, IN03 indicated that it is not only the availability of modes but also the offering of amenities and safety improvements that have resulted in an increase in user numbers. This corresponds with Hernandez et al. (2016) who specify that Information provision, one of the amenities offered, was of great importance in perceived quality of Urban interchanges and backed up by Seker and Aydin (2023) who also promote the importance of more information whether that is regarding options available or real-time information. On the other hand, they put pedestrian connections at the bottom of the list in desired characteristics which is noteworthy as this would be a key safety consideration, thus contradicting the perceived effect of safety on user numbers as stated by IN03. Attribution though is a consideration when examining the results, user numbers may only show one side of the evaluation and require further work with respect to context. Further research on what works and why with regards to MHs, is a factor that requires more detailed investigation.

5. Conclusion

The interviews demonstrate that MH implementation is driven by the context in which they are being developed and deployed. Despite this diversity, the decision-making factors with respect to implementation can be broadly generalised. As such, this paper has identified the decision-making factors of MH implementation which can be broadly categorised as the 4Ps namely: Purpose, Process, Place and Performance. The 4Ps offers a novel lens through which to examine the implementation of MHs. As such, they can be used to explore existing MH implementation as explanatory factors which have shaped MHs or by prospective city authorities to shape their MH deployment strategy. City authorities can use the 4Ps to aid the decision-making process in defining, developing, and deploying MHs.

Principle among the recurring factors are:

Purpose – This factor includes the aim and objectives of the MH. Most commonly this includes encouraging modal shift towards active and shared modes, and subsequent environmental impacts of private car use. However, MHs may be implemented for their placemaking purpose and

creating new community space.

Process – The process of implementing MHs involves consideration of public consultation in designing individual MHs and their incorporation into the transport network of which there may be multiple Hubs, including the modes and amenities offered by the individual Hubs. Furthermore, challenges may be faced with external organizations and practical operational considerations.

Place – one of the key factors in MH implementation is decision making around the location and network structure of MHs. This is heavily influenced by the *Purpose* of the MHs and their aim and objectives and level of funding.

Performance – Understanding the long-term performance of the MHs against the stated aim and objectives is often an overlooked element of MH implementation. Evaluation approaches vary dependant on scope and funding models.

It is acknowledged that there are limitations with this research for instance in the limited sample size of those interviewed, which could be expanded on as part of any future research allowing for more generalisable findings, this would include information from global south countries and regions. Unfortunately, due to the lack of availability and relative novelty of the projects undertaken this was an area that could not be expanded on in this paper. However, the findings and proposed framework from this paper are nonetheless applicable when considering implementation of MHs.

There are several important points that emanate from this research. The contextual factors behind implementation account for many of the differences in priorities when looking at objectives and definitions. There are also potential differences when looking at the requirements of location selection through the opportunities available and the desire to locate in certain areas such as those connecting to public transport. There is also the need to consider the requirement for behavioural change and who should be targeted and whether modal shift from ICE cars is being achieved.

CRediT authorship contribution statement

Thomas Arnold: Conceptualization, Methodology, Investigation, Data curation, draft manuscript preparation, Writing – review & editing. **Simon Dale:** Conceptualization, Methodology, draft manuscript preparation, Writing – review & editing. **Andrew Timmis:** Conceptualization, Methodology, draft manuscript preparation, Writing – review & editing. **Matthew Frost:** Conceptualization, Methodology, Writing – review & editing. **Stephen Ison:** Conceptualization, Methodology, Writing – review & editing, All authors reviewed the results and approved the final version of the manuscript.

Declaration of competing interest

None.

Data availability

The data that has been used is confidential.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.retrec.2023.101338.

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