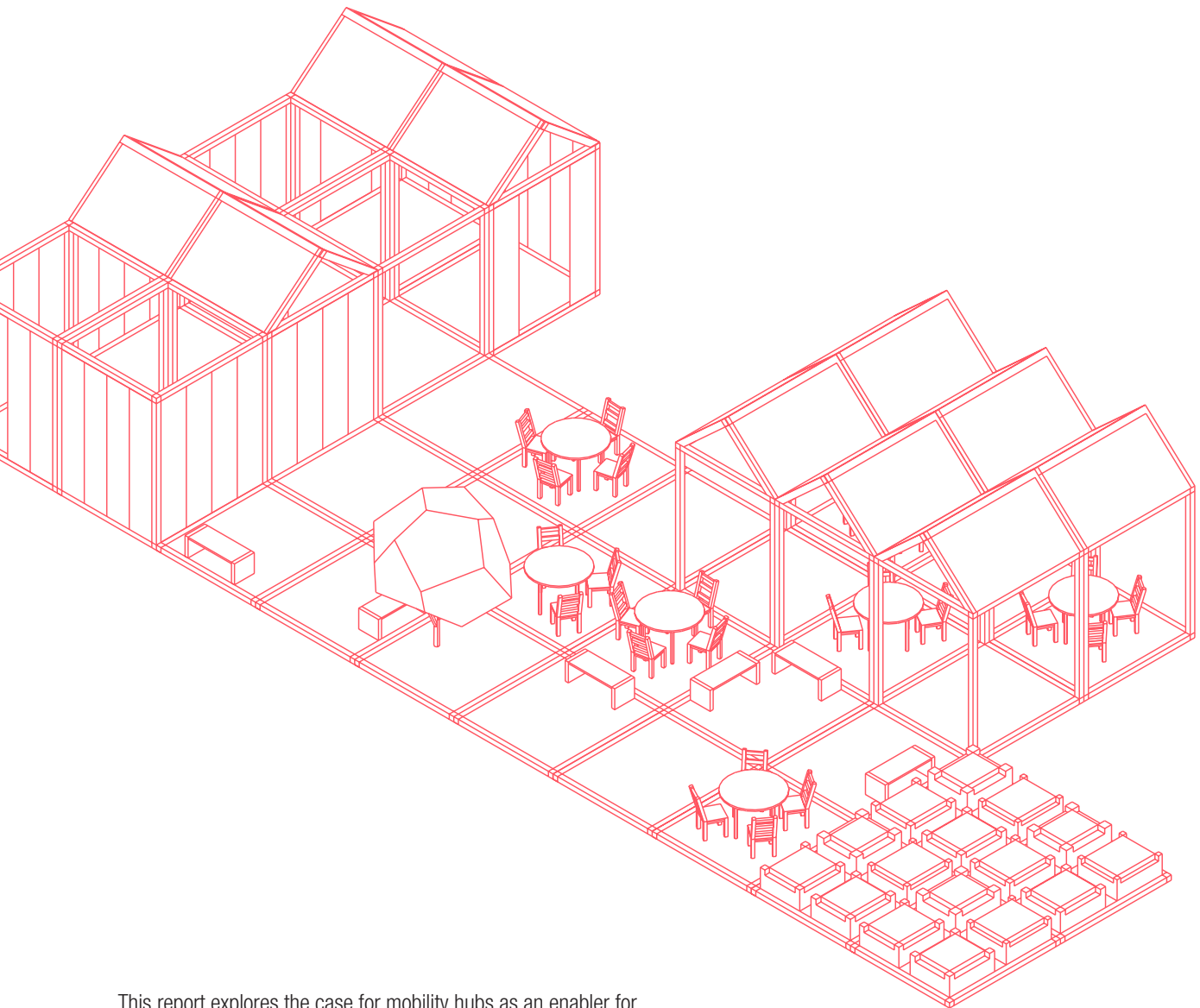


MOBILITY HUBS OF THE FUTURE

TOWARDS A NEW MOBILITY BEHAVIOUR



This report explores the case for mobility hubs as an enabler for a changing mobility pattern. A mobility hub framework and its potential application in a Swedish city is outlined.

The research is part of the Innovation Programme InfraSweden 2030 on sustainable and resource-efficient transport infrastructure.

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Executive Summary

Mobility plays a vital role in our daily lives and has become a defining factor of current society, the way we live and move. Mobility, or the ability to move from one location to the other, links cultural, economic, social and political aspects of our global society.

The global mobility demand continues to grow, along with the mobility systems' carbon impact. In order to manage future mobility demand, and a much-needed transition to sustainable, low carbon mobility, it will be crucial to achieve seamless transitions from one transport mode to another. The sole provision of transport options will not be enough.

Beyond providing the modalities necessary to manage a shift to more sustainable transport options, mobility behaviour needs to shift in order to enable a successful adoption of these. Mobility hubs can constitute the missing piece – they can make alternative options easier, more attractive and more convenient to use. The design, location and specifically the associated services of a mobility hub can influence this.

Mobility hubs in the current transport system are often public transport nodes such as stations, airports and park & ride facilities. They can however be more than that. Through a considerate integration in existing transport systems, they facilitate everyday mobility and increase the overall efficiency of transport systems, enabling seamless travel alongside access to additional services.

The proposed mobility hub framework is based on a catalogue of elements. Transportation and urban development challenges are analysed as closely linked topics, and, while starting from a mobility perspective, the future mobility hub becomes more than a transportation hub. It serves a specific purpose within each respective neighbourhood. Through becoming a new community centre, exhibition, event or office space, the hub becomes a vital part of the urban fabric. It transforms from a place of transition to a destination.

Mobility is a fast-changing landscape, both in terms of technological and usage changes. As such, the mobility hub cannot be static. It has to be flexible and anticipative to changes, fast to implement and easy to use. Considering the value of the hub over time becomes a defining principle for the proposed framework.

This requires the adaptability and flexibility of the building itself. Value over time considerations are an integral part of the development – through designing a building that is flexible to adapt to changes, we lay the foundation for designing with the extension of a building's lifespan in mind, while retaining the highest possible value.

Mobility Hubs of the Future explores the conceptual basis behind this and the ways in which a new generation of mobility hubs can unfold and be applied to a variety of contexts. In the next steps, further considerations, especially around construction methods, material and resource choices, will need to be elaborated.

In close collaboration with a Swedish municipality – Linköping – and the gas station operator OKQ8, location-specific applications of the proposed hub framework were developed that outline a base for a demonstration or pilot project later on.

The Case for Mobility Hubs

Towards a Modal Shift

A wide range of globally relevant long-term changes along with sector-specific drivers are transforming the mobility system. They reshape the context in which mobility takes place. One of the main drivers is a continuing increase in global mobility demand, while global emissions need to be drastically reduced. While human-made carbonisation levels require concentrated action, mobility still holds one of the largest shares. The mobility landscape is thus one of the places to bring forward significant change when it comes to sustainability.¹

The dual necessities of reducing emissions, while providing increased levels of mobility, may fundamentally transform how mobility systems will operate in the future.

Beyond the associated climate change impacts of emission levels, current mobility systems create an array of other challenges – from economic costs of increased congestion to increasing air pollution levels and associated health impacts.

Decarbonisation necessities and a refocus on the quality of public life can move planning approaches away from the prevailing car-centric planning paradigm. Environmental considerations require an increasing number of people to be moved in an ecologically-friendly way. Additionally, higher populations, especially in urban areas, require a rethinking of the current high demand for space due to infrastructure based on the private car.

What is a Mobility Hub?

In the current transport system, mobility hubs are commonly seen as physical places that connect a variety of transport modes. A mobility hub can be anything from a bus stop and a bike sharing station to an inner-city main train station.

To meet current and future mobility demand, while supporting the transition to a low carbon transport system, a system based on a variety of mode choices is key. Mobility hubs are a prerequisite for this mobility ecosystem of the future. Mobility hubs need to enable the physical co-location of modes. A functioning mobility hub needs to provide a variety of modal options and act as an interchange between these modes. It needs to effectively integrate in existing, planned and future transport systems, and cater to various and changing user needs. Mobility hubs are the places where different transport modes and services meet, so that people and goods have access to mobility solutions and a seamless journey.

In the context of this report and the developed mobility hubs framework, a mobility hub becomes a driver for sustainable mobility behaviour and transforms from a place of transition to a destination within a city's fabric. A mobility hub is as much defined by its provision of a variety of environmentally-friendly transport modes, as by its ability to actively influence user behaviour towards adopting these alternative transport options.



The role of mobility hubs

Mobility hubs can enable a modal shift. They cater to the necessity of multi- or inter-modality as a way towards sustainable mobility solutions. Beyond the provision of mobility offers, the design and location of mobility hubs can nudge towards a changing mobility behaviour – as an initial step towards this, they can make alternative modes of transport easier and more convenient to use. The other side of transport behaviour change considerations – making non-environmentally friendly modes less attractive and more difficult to use – is something that needs to be addressed through infrastructure planning or repurposing, rather than mobility hub developments. To achieve this, mobility hubs will need to focus more on designing for users, not functions. If designed with the thinking in mind, that the sole provision of transport options will not be enough to create a change in mobility behaviour, they can become more than a transport interchange.

Trends shaping the design of mobility hubs

Along with incentivising a changing mobility behaviour, mobility hubs need to respond to a range of sector-specific trends. While they are a prerequisite for connecting various existing transport modes for seamless and intermodal travel, they also need to be able to cater to further, not yet existing transport modes as well. This is highly relevant, as the life cycle of built infrastructure usually exceeds that of transport/vehicle technologies.

Further sector-specific trends that shape the development of future mobility hubs include a transition towards alternative engines, such as electric and hydrogen vehicles, causing the need for new charging infrastructure. Users pose higher demands on the convenience of their modality chains, as well as on the information, options and suggestions they receive for the optimal planning of these. And lastly, emerging business models around



Clermont-Ferrand, France

Between 2013 and 2018, the municipality of Clermont-Ferrand improved four existing interchanges, including the central station, to be intermodal mobility hubs in the inner city, as well as residential and peripheral areas.² The hubs connect urban and regional public transport (train, bus, tram), taxis, bikesharing and private bike parking, Park&Ride facilities with increased parking capacities. Pedestrian access was improved significantly, making mode interchanges more secure, barrier-free and easy to navigate. Three additional mobility hubs are in the planning stage.

Trams and buses are operated by several public and private transport operators. Financing was provided through the European Union, the French state and the municipality itself. A new ticketing system was developed for integrated pricing. Additionally, the municipality set targets to coordinate transport mode interchanges more efficiently, and provide on-site multimodal travel information of display panels, as well as online.

sharing services and on demand transport options increasingly complement established transport options and transport management approaches.

The goal of encouraging people to use a broader range of transport modes and reduce vehicle use in their daily travel has already become a motivation for infrastructure owners and transport planners, amongst others, to make the places of transition more attractive and effective.

Requirements for functioning mobility hubs

A functioning mobility hub of the future will need to:

- Attract users to transition from private vehicles to more effective forms of transport, more environmentally-friendly mobility behaviour
- Effectively and conveniently move people from one place to another
- Serve users the right mobility at the right time and facilitate seamless travel
- Be integrated into the existing transport system
- Be planned as part of larger mobility and urban development strategies
- Be able to adapt to changing needs and conditions
- Use transport infrastructure and (public) space effectively
- Become a public space and provide access without the need for consumption – a “third” place within the neighbourhood
- Be human-scaled and offer a sense of place and community

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Bremen, Germany

Bremen's mobility hub concept dates back to 2003. With ten larger (mobil.punkt) and 14 smaller hubs (mobil.pünktchen) spread across the city, Bremen was able to incorporate car-sharing as a transport mode, with 14.000 users in 2017. Next to the large fleet of shared (electronic) cars, the hubs connect buses, trains, private (e-)bikes, and bike sharing and also include a newsstand and other amenities.³

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. Subsidized tenant mobility tickets substituted a number of regular car parking spaces, being able to reduce the amount of private car parking spots by approximately 4,000.⁴ The municipality concludes: “This means [...] regaining public street space for people with the added benefit of saving the community the cost of expensive new parking garages.”⁵





Freiburg, Germany

Freiburg, a forerunner in sustainable urban planning, installed mobility hubs in eight locations in its residential city districts.⁶ Thus, allowing for less privately-owned vehicles and easier intermodal changes. The hubs include boxes for bikes, bikesharing and carsharing, as well as connections to public transport modes. Furthermore, all hubs are designed barrier-free, with weather protection, have an integrated lighting system and security cameras, seating and often a small shop or newsstand, as well as an ATM and a letter box.

To ensure that the mobility hubs were sustainable well into the future, planning ensued through an adaptable "radial system", which allows for multiple locations throughout the city and its periphery to be integrated into the planning process over the course of time (approximately 15 years). Adaptability of the hubs is achieved by ensuring that space in the vicinity is available for later expansions (e.g. e-mobility). To make the planning over time more efficient and find suitable locations, the municipality devised a analysis framework. It consists of three sizes of hubs, which include differing designs and services, depending on the needs of the specific site.

Price-efficient ticketing is available through mini, midi and maxi versions of the "+pol Card", including different transport options depending on user needs.

The hubs include a WIFI hotspot and "information terminals" for tickets, to access carsharing offers and a "bring-me-home" function to choose the best intermodal route to a destination. Further plans include navigation with augmented reality, embedded through the LAYAR system.





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Offenburg, Germany

In 2015, the municipality of Offenburg in Germany started to offer car- and (e-)bike-sharing services at mobility hubs located at major attractions throughout the city.⁷ The hubs also connect buses, trains, private bikes and cargo bikes. The user card "Einfachmobil-Card", simplifies access to all services at the hub through a combined payment and subscription service. The hubs come in three sizes with different transport modes and services incorporated. Their modular design ensures flexibility, as it becomes easy and cost-efficient to place them in many sites around town.⁸ Space utilisation and flexibility are very high in this building component approach. It also leaves room for additions later on and allows for the relocation of hubs once demands change.

Next to transport options, the hubs include a wide range of offers (some human-serviced and some self-serviced), depending on their size and local demand. These range from newsstands, bakeries, info terminals with user interface, to parcel delivery stations, WiFi spots, and ATMs.

An extensive marketing campaign with a strong visual branding on all modular hubs, buses, roads, the roadside, shared (e-/cargo) bikes, and shared cars ensured visibility of the sustainability aspirations of the municipality.

Currently, plans are being developed to expand the project regionally and digitally. This is to incorporate other municipalities of the region and connect the public transport and sharing offers for citizens, as well as make the offerings accessible to a wider audience.

Utrecht, Netherlands

Mobility management changes came about in Utrecht when the ten largest companies and the city's inhabitants demanded more sustainable mobility in their city.⁹ The municipality of Utrecht had already been aware of problems in its mobility offerings, and thus (re)designed a mobility hub for each of these zones: inner city, residential area and periphery. The hubs are meeting points at different activities, such as shopping centers, a football stadium, and the university area. Intermodal changes are possible for users of all public transport and bicycles, as well as Park&Ride customers.

Utrecht's mobility hub scheme is embedded in its Sustainable Urban Mobility Framework (SUMP) and follows the city's masterplan "Utrecht Attractive and Accessible 2030", which aims at improving air quality and space issues, while mitigating climate change drivers.¹⁰ The plans furthermore aimed at creating attractive and creative public spaces to enhance the quality of life for its residents.

Today, public transport authorities cooperate across municipal boundaries to provide more integrated mobility management.

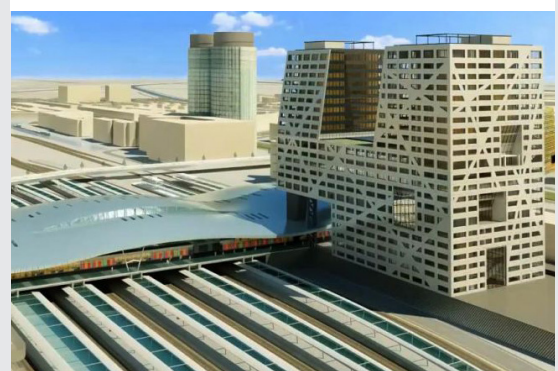


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Gent-Sint-Pieters, Belgium

The train station renovations that are taking place from 2007 until 2024 will turn Ghent's central station into an intermodal transport hub. With 50,000 visitors daily in 2014, the station connects regional trains, buses, trams, bikes and cars.¹¹ The station offers Park&Ride spots, Kiss&Ride spots, 10,000 bike parking spots and 2,700 underground car parking spots. Additionally, Ghent started its initiative "Autodelen.net", a carsharing platform inspired by Bremen's carsharing scheme, as part of the Car-Sharing Action Plan aiming at 20,000 members by 2020.¹²

The project is financed by the railway and local public transport operators, as well as the Flemish government and the municipality of Ghent. The mobility observatory Elvis concludes, that "[t]he project may well be transferred to other countries and cities, but it has to be kept in mind that the realisation of similar projects requires several partners and a long preparation time. Early and continuous communication is vital and public participation is necessary to make the project acceptable to commuters and residents."¹³

Ballarat, Australia

The integrated mobility hub project was fundamental for the development of Ballarat, which had competing transport, heritage and re-development priorities.¹⁴ Building upon an investigation of the existing conditions, Arup developed a series of short, medium and long-term master plan options.¹⁵ The preferred option was incorporated into the master plan and provides for a new transport hub with equitable access for all modes of transport that aims to meet the transport needs of Ballarat and Western Victoria over the next 50 years. The transport modes include bus interchanges, trains, end-of-trip bike storage facilities, bike parking, Kiss&Ride, and staff and commuter car parking.

The mobility hub also offers a wide range of services: A café, small retail stores, small commercial office spaces, passenger waiting, an open-air market, and weather-proof pedestrian walkways.



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Developing Mobility Hubs of the Future

A Framework

The mobility hub framework presented here is intended to demonstrate an approach to move away from the centralised provision of often expensive, and space-intensive, infrastructure. Especially within the mobility landscape, fast changes – new technologies, changing user behaviours – can be observed. The proposed framework is a direct response to this. A modular and standardised approach to the design of the mobility hub enables the development of highly location-specific solutions, based on fast implementation, flexibility and adaptability.

Additionally, we believe that mobility hubs should be designed as a third place, a place that acts as an anchor for community life and that provides spaces that encourage interaction and informal encounters, easily accessible for everyone.

The spatially flexible arrangement of the proposed hub elements, limited space requirements, along with the service elements introduced as part of the mobility hub framework, set the basis for the mobility hub to contribute to placemaking efforts within communities.

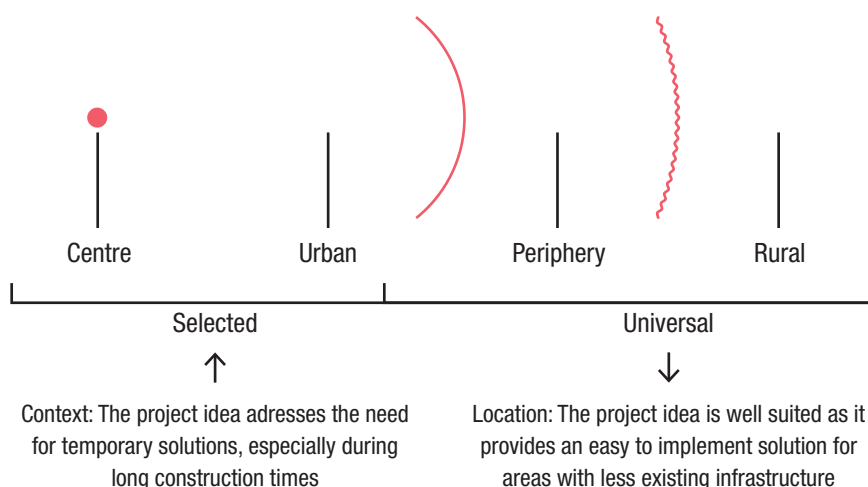
The mobility hub framework and its programming are based on the idea of mobility and service elements complimenting each other. As a result of this, along with the need for flexibility and adaptability, we developed a catalogue of mobility and service elements to choose from. The service elements are not merely an additional element, a commercial add-on. We see them as a fundamental instrument for achieving the desired changes towards environmentally-friendly mobility behaviour. They play a key role in making things easier, more convenient, and faster.

The framework was developed in close collaboration between the project partners – it came out of the research on future requirements of a mobility hub general and is directly influenced by specific requirements raised by the case study locations. The developed mobility hubs framework does not follow a one size fits all approach, but is able to continuously adapt to local requirements, changing throughout its lifecycle. A defining element of the framework is the consideration of the mobility hub over time. It is not planned for one time and place at some point in the future, but utilises life cycle consideration in its design and functionality to ensure it remains useful and at its highest possible value.

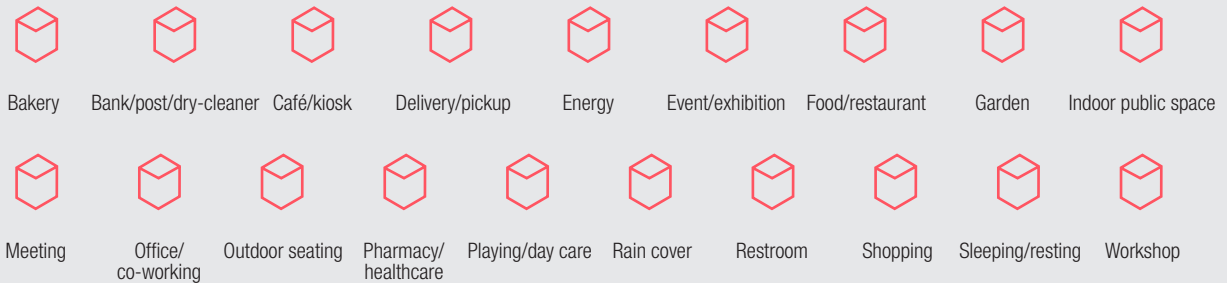
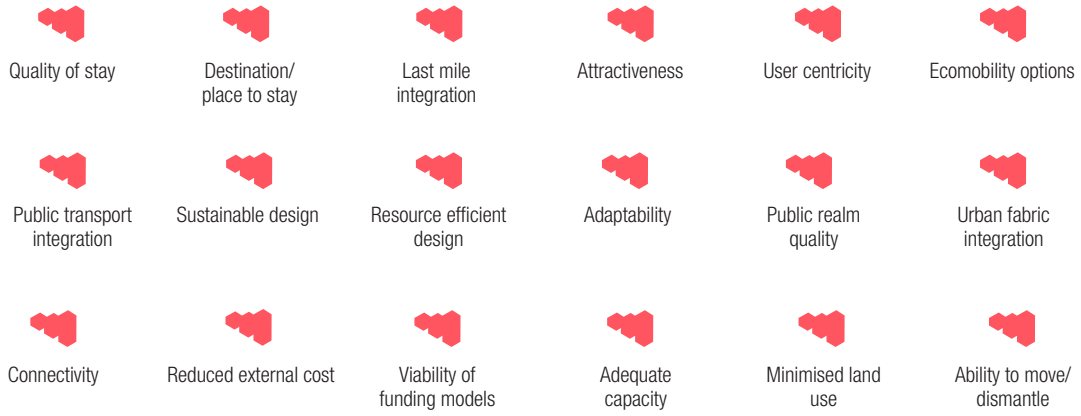
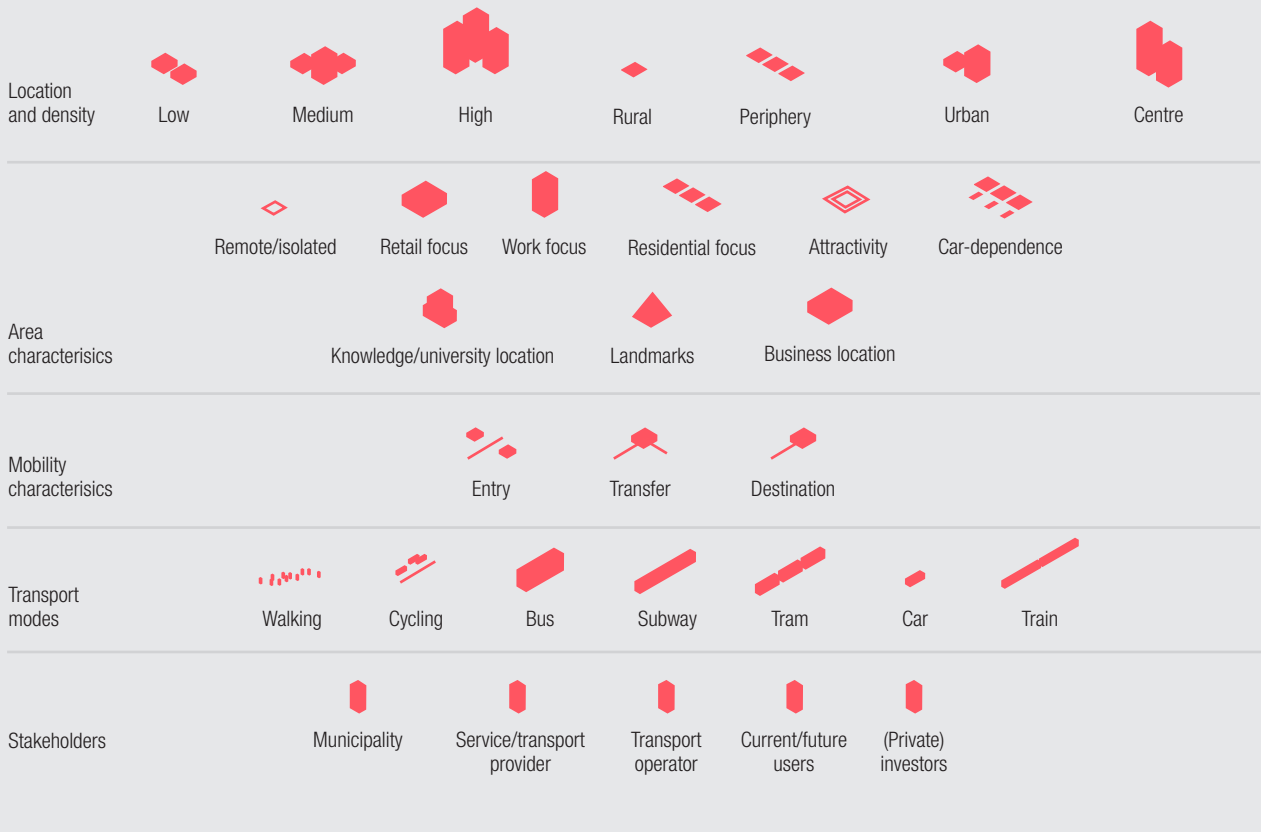
The associated development framework illustrates the thinking behind this. In order to choose the appropriate modules and location of the hub, we start with an analysis of the context. What are the external drivers, local needs and preconditions? This analysis encompasses mobility and general urban planning considerations. In a second step, we define the key objectives of the hub for the chosen location. Again, these will include mobility objectives and urban/neighbourhood development considerations. The third step is then the choice of modules in order to serve the identified needs and meet the desired objectives.

Applicability of the mobility hub framework in different contexts

In denser urban areas, where transport infrastructure projects are often planned as larger stations, the mobility hub framework offers a solution for selected contexts. This can be a temporary solution, especially during longer construction times of larger stations and infrastructure. In peripheral and rural areas, the framework is more universally applicable, as there is often less large-scale infrastructure in place, or planned. In this context, the framework can offer a small-scale, easy and fast to implement solution.



The development framework



The Catalogue of Elements

The catalogue of elements serves as a baseline for the mobility hub development. The catalogue is divided in two parts: mobility and service elements. As part of this, the mobility elements serve as the foundation for each hub, while the service elements support the mobility functions of the hub.

This necessity to develop mobility and service elements together are a fundamental part of the framework. While the mobility elements provide the necessary means, and are an enabler for sustainable mobility, the service elements can act as an anchor and draw users to the hub, and the use of the provided mobility options. The service elements support the hub's ambition to become a destination and fill in the missing pieces within the development area.

The elements can be combined in a variety of configurations and adapt to a range of contexts. While the elements themselves are highly standardised and modularised, there are developed flexible enough to hold a variety of different functions. Each location has different characteristics, and therefore, the modular approach to the catalogue of elements, along with its flexibility over time, enables to directly react to these. Its modularity is what makes the system scalable, resilient and adaptable to existing, and future, conditions.



The foundation

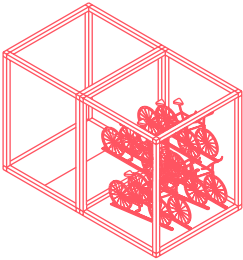
The foundation elements constitute the mobility-related services necessary for a functioning mobility hub. These elements form the foundation of each mobility hub, providing users with the appropriate mobility solution at any time. They are chosen depending on the mobility modes each hub aims to cover.



The supporting

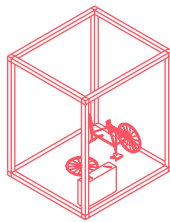
The supporting elements provide additional, non-mobility, services to the users of the mobility hub. They are more than a commercial-add on, but are necessary to make the mobility hub work. The supporting elements make it easier and more convenient to choose sustainable mobility options, while contributing to the public realm quality in and around the hub.

The foundation



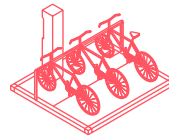
Bike parking

The bike parking element provides users with a safe space to park their bikes and enables easy changes from bike to public transport.



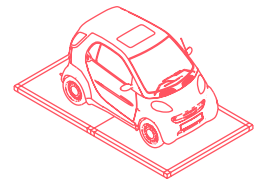
Bike repair

The bike repair element enables bike maintenance directly at the mobility hub. Bike repair elements can either be self-service or serviced workshops.



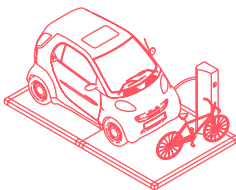
Bike sharing

The bike sharing element encourages active transport through integrating the convenience of rental bikes into the local mobility chain.



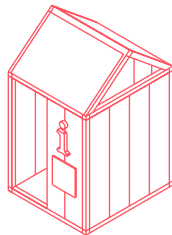
Car-sharing

The car-sharing element enables the use of an individual vehicle for specific needs, without the necessity to own a private car.



Charging

The charging element enables the integration of electric and hybrid mobility in the mobility system, and serves bikes and cars, amongst others.



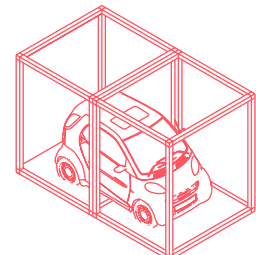
Information

The information element provides location-specific mobility information in real time. It can include incentivising measures for sustainable mobility options.



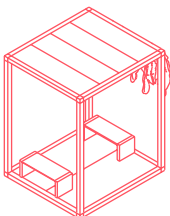
Micro mobility

The micro mobility element provides flexible mobility options to cover shorter journeys, especially valuable for the last mile to and to the mobility hub.



Parking

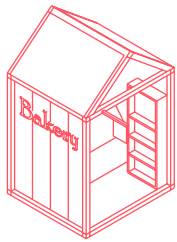
The parking element facilitates park & ride uptake and reduces individual car reliance. It extends the hub's service area by catering to users from car-centric areas.



Waiting/shelter

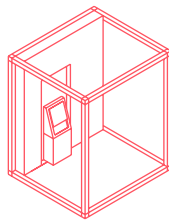
The waiting/shelter element provides a secure and inviting meeting and waiting space, accessible for everyone 24/7.

The supporting



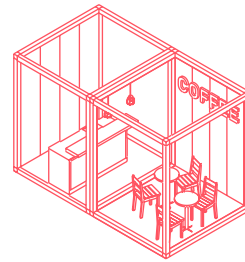
Bakery

The bakery element, along with the other hospitality modules, aims to make the travel experience more convenient and enjoyable.



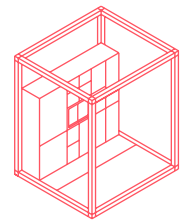
Bank/post/dry-cleaner

The bank/post/dry-cleaner element adds the convenience of running small errands at the hub as an integrated part of a user's mobility chain.



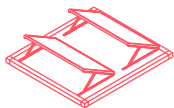
Café/kiosk

The café/kiosk element can be a reason for users to come to the hub. It promotes the use of the hub area, providing space for longer stays and informal meetings



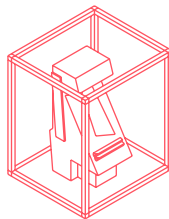
Delivery/pickup

The delivery/pickup element acts as a central point for deliveries. It aims to minimise delivery vehicle as well as additional user trips.



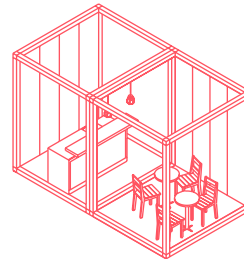
Energy

The energy element can be integrated in most elements, mobility and service. It supports the reduction of the hubs carbon emissions.



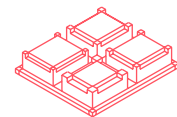
Event/exhibition

The event/exhibition element offers the opportunity to integrate cultural programming into the hub, independent from established institutions.



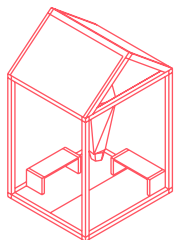
Food/restaurant

The food/restaurant element, along with the event/exhibition element, extends the usable time of the mobility hub, and attracts additional users.



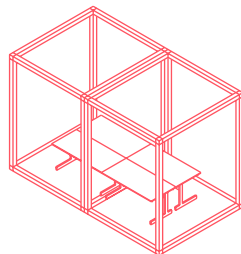
Garden

The garden element provides a green and healthy space to the hub area. It can be the starting point for community activities or markets.



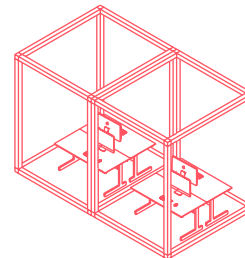
Indoor public space

The indoor public space element offers a secure, publicly usable space to read, rest and linger, without the need for consumption.



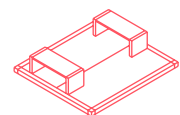
Meeting

The meeting element provides meeting spaces, for example for small and large business and knowledge institutions in the surrounding area.



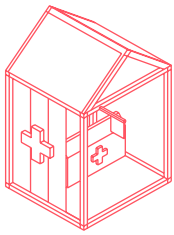
Office/co-working

The office/co-working element provides fully-equipped working spaces for the surrounding community, often for temporary or short-term use.



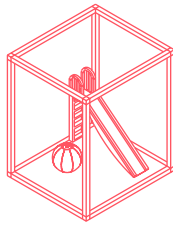
Outdoor seating

The outdoor seating element allows to linger and use the public space without consumption. It supports the hubs role as an integrated part of the neighbourhood.



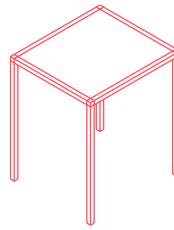
Pharmacy/healthcare

The pharmacy/healthcare element adds pharmacy and basic medical services to the hub.



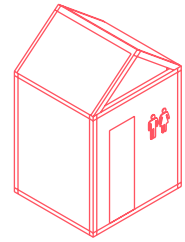
Playing/day care

The playing/day care element provides spaces for children in the urban environment. It can serve employees in the vicinity.



Rain cover

The rain cover element allows for the introduction of a roofing structure as a protection from the elements. It extends usage times of public spaces.



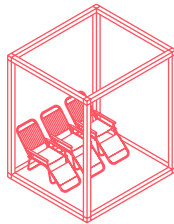
Restroom

The restroom element adds convenience to the hub and also serves adjacent elements. It can also include showers for cyclists and runners, for example.



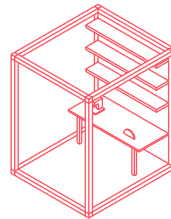
Shopping

The shopping element provides a variety of shopping and convenience elements.



Sleeping/resting

The sleeping/resting element caters to longer waiting times or layovers and can also act as a small-scale hotel-like facility.



Workshop

The workshop element provides spaces for manufacturing and repair/maintenance, either self-serviced or small company operated.

The Development

Sustainable design principles

While the mobility hub of the future aims at the transition of the current mobility system towards a sustainable mobility system, the hub itself needs to be designed accordingly as well. From mobility sustainability to construction sustainability.

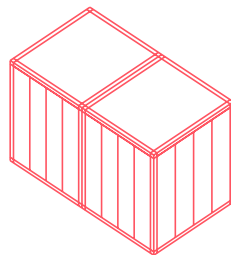
Current approaches to construction are characterised by high carbon emissions, and unsustainable use of resources, amongst others. The circular economy challenges this paradigm, proposing a shift from our current linear approach towards a system where assets are designed and built to be more durable, materials reused or recycled, and natural capital preserved and enhanced.

Alongside this, design for disassembly supports the recovery and reuse of materials, components and whole buildings at the end of its life at a certain location.

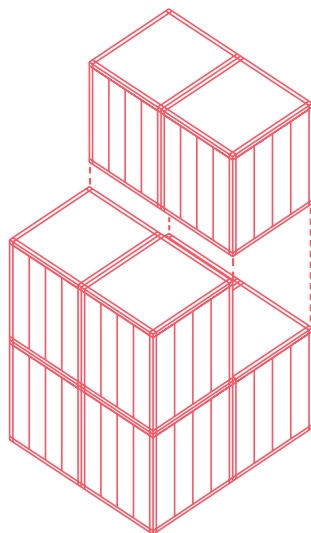
Design for disassembly and reuse is supported by modular construction methods and the use of standardised and prefabricated components. Modularity forms the base of the future mobility hub's adaptability paradigm, as such the mobility hub of the future is based on a modular and standardised design. Modularity guarantees that the mobility hub can be tailored to local needs. It enables the deployment of the hub framework in various footprints and offers the means to add or remove elements from the hub. Ultimately, the aim is to achieve a system, in which the mobility hub of the future can be disassembled without leaving any traces on-site, at the end of its life.

Modularity options

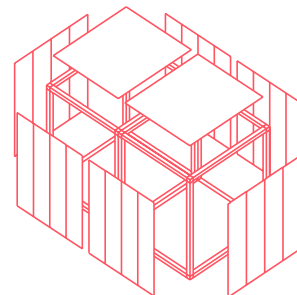
Elemental system



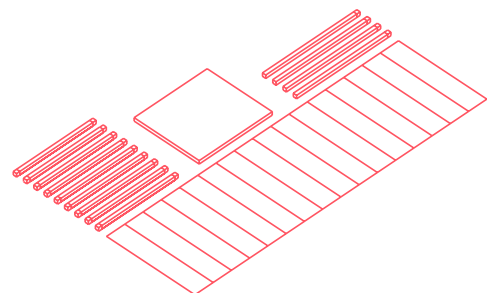
Unitised, individual elements, assembled on-site



Component system



Prefabricated modules, assembled on-site





OONEE Pod

The OONEE Pod, while not a typical intermodal mobility hub, reinvented modularity for micro-mobility and its uses for public space.¹⁷ Customers can rent a secure spot for their bike or scooter for 5 USD per month. In return, they are offered a variety of services on top of their parking spot. These include e-charging for bikes and scooters, repairs and tune-ups, access to accessories and parts, as well as insurance and registration.¹⁸

The hubs are composed of approximately 150 parts, which can be configured into different shapes and sizes of variable colors. A small crew is able to assemble the pods in less than a day. As they stand alone and can be made to fit in almost any niche in public space, the concept is free-floating all around the city.

To add value for all the citizens who do not park their bikes or scooters in the pod, the designers added benches, lighting, green roofs and colorfully designed wall modules. Thus the pods become placemaking elements with high quality-of-stay all throughout the urban realm.

In line with the outlined circular economy and design for disassembly approaches, the following considerations become important for the development of the hub:

A focus on minimising the sealed surfaces created through the hub. This can on the one hand be achieved through the modularity of the system, that allows the hub to move elsewhere, without permanently sealing a surface during its use. And on the other hand, the introduction of green roofs and garden within the hub, green infrastructure can be added.

The materiality of the hub is a key consideration to be further developed. Beyond ease of assembly and disassembly, circular economy considerations are again a key factor. Materials should be either part of the biological or technological cycle, meaning having the ability to biologically degrade at the end of their life, or to remain in a continuous loop without creating any waste. From a material and energy resource flow perspective, a circular economy approach can be operationalised by combining the following business and design strategies: closing loops, narrowing and slowing down resource flow through material recycling, improving resource efficiency, and extending the product life through reusing, upgrading and remanufacturing.¹⁶

Energy considerations are further criteria the future mobility hub needs to meet. Beyond energy efficiency and passive design measures, that will be considered in the detailed development of the hub, an energy element is already introduced. This enables the hub to generate some or all of its energy, renewable and on-site, further contributing to carbon saving measures.

Future adaptive design – keeping the value over time

The proposed mobility hub framework has a strong focus on future adaptivity, in order to increase the longevity of the structure and reduce the need for new construction. The Mobility Hub of the Future is designed as a flexible construction, consisting of modular elements. This allows for (faster) iterations and adaptation to future scenarios. It applies to emerging economic realities, future mobility technologies, as well as an evolving surrounding environment.

The adaptable design of the mobility hub of the future allows to reuse elements at different hubs, rather than producing waste. In addition, the hub elements are designed with general adaptability in mind. In contrast to a specific adaptable product or design, which allows for adaptability to foreseen changes and applications, general adaptability means the design of a product to adapt to unknown – at the point of design – needs and requirements in the future.¹⁹

Beyond sustainability and resource considerations, a future adaptive approach to mobility hubs is relevant because it responds to the need of the operator or owner of the mobility hub, that the hub remains attractive and at high utility over time. Through being able to upgrade and reconfigure the mobility hub over time, this approach contributes to lowering initial business risk, while increasing the potential to meet user demands and needs over a longer period of time. Thus keeping the value of the investment.

In contrast to established building development models, the future mobility hub is designed from the onset with upgrades and changes in mind. This reduces the risk for premature obsolescence – preventing the mobility hub to reach the end of its life, which could happen due to an inability to adapt to changes.²⁰

Various risks for premature obsolescence have been identified, and the development considerations of the mobility hub have been designed with these in mind. Layered and future-open modularity define the design of the

hub. The mobility hub concept is based on a modular design, where the hub and its elements can be relocated, resized, reassembled and repurposed. This modularity enables the hub to continuously evolve its service offering. The catalogue of elements outlines an initial set of elements. These can, however, hold a large amount of other services when needed. The same principle applies for the repurposing of modules to follow multiple customer loops, beyond the initially planned-for customer. In terms of financially-grounded adaptability, considerations have been placed on the dependence of commercial stakeholders on future possibilities for revenue, or continuous revenue streams. As the elements can be easily relocated or adapted, this could outline a viable offering for commercial actors. They will be able to relocate obsolete elements, or elements that do not meet expectations, to a more suitable location. This might increase the willingness to participate and invest early-on.

Lille, France

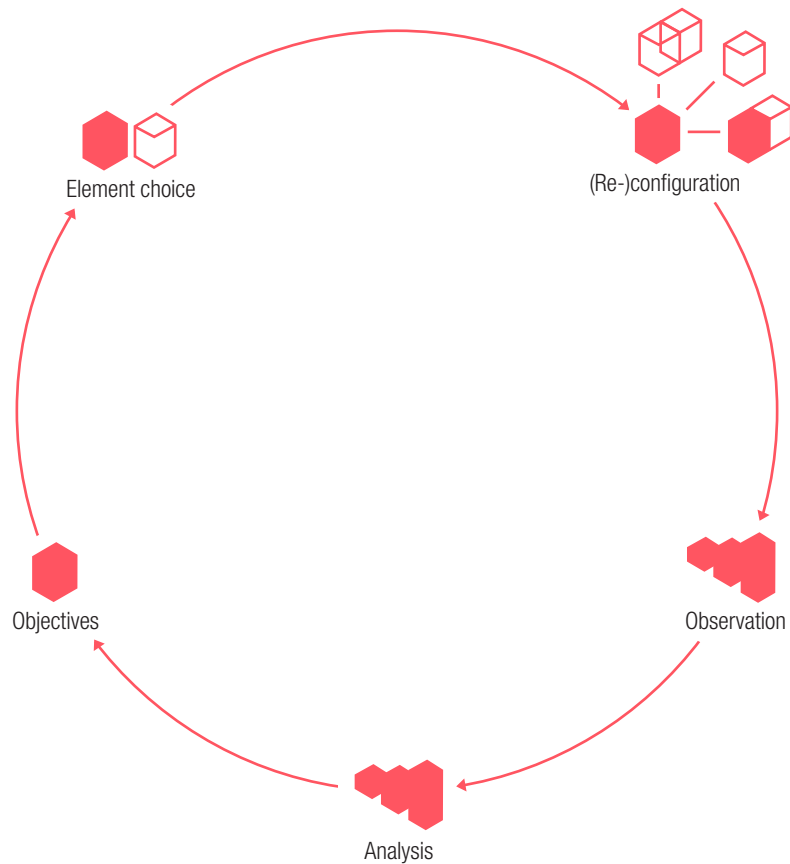
The metropolitan region of Lille started its project to foster intermodal mobility in 2006.²¹ Other aims were limiting the growth private car usage, and doubling the use of public transport until 2010. The focus of transport modes of the hubs lay on trains, subways, Park&Ride, and private car parking. Ticketing consists of one single ticket for all transport modes within the wider city. And the planning design improved public spaces, such as street spaces, green spaces, and pavement textures.

Plans are to have five subsequent implementations over time, each preceded by an implementation study to monitor room for improvement and best practices. In a larger context, the mobility hubs are built alongside the major remodelling of Lille's central train stations, connecting the city with many other regional and European urban centers.²²



Image Credit: CC-BY 2.0 dronepicr (Wikimedia Commons)

The development framework - Closing the loop



The development framework for the hub, consisting of analysis, setting objectives and element choice, is expanded to achieve a closed loop, following the circularity, value of time and future adaptivity design considerations. Once the elements are chosen, the hub can be configured. In a next step, it is essential to observe the functioning of the hub. This can happen through quantitative and qualitative measures, ranging from observation, consultation, to data collection.

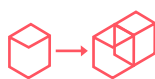
Following the observation of the hubs performance the cycle of analysis, setting objectives, and module choices can start again. In this iteration, the elements of the hub can then be reconfigured – through relocation, resizing, reassembling, or repurposing. It is possible to move through this circle in several iterations and test different options. In a closed loop, the hub can continue evolving, or become a permanent element.

Reconfiguration of elements



Relocate

Elements can be easily relocated to a different location. This can be done with specific elements as well as entire hubs.



Resize

Elements can be added or removed from an existing hub. As such they can cater to increasing demands or changing needs.



Reassemble

An existing mobility hub can be used in a different way through reassembling elements in the same location to better suit local needs.



Repurpose

The purpose of elements can be changes, either by retrofitting or exchanging existing elements.

The Swedish Context

According to the Climate Act, passed by the Swedish Parliament in 2017, Sweden aims to become carbon neutral – net zero greenhouse gas emissions – by 2045. As part of this, the transport sector is expected to reduce greenhouse gas emissions by 70 percent until 2030, compared to 2010.²³ According to the Swedish Transport Administration, a sole focus on technical measures will not be enough to achieve this. A major focus has to lie on a move away from car-based travel, towards encouraging the use of low-emission, public and active transport modes.²⁴ Government, businesses and the research and innovation sector are all working to accelerate this shift towards zero carbon. Most of the measures around a zero-emission transport sector are, however, allocated on a local level, often leading to varying performances in terms of modal split improvements across the different municipalities.²⁵ Additionally, Mobility-as-a-service (MaaS) offerings are increasingly on the agenda of various stakeholders within and outside the transport sector. A variety of transport modes are combined into a single mobility package, which aims to replace private car use.²⁶ Another driving factor in terms of sustainable mobility measures can be observed in efforts to reduce the number of parking spaces in public, residential and office developments. This has led to a rise of car-free or low-parking developments along with the reduction of available parking spaces within existing residential and commercial units throughout the country.

Mobility Hub Stenpiren, Gothenburg, Sweden

The mobility hub Stenpiren was built in 2016 as a key element of the future development of Gothenburg's public transportation system. It contributes to new patterns of movement in the city and across the river to re-unite the two parts of the city which are physically divided by the river. The hub features gates for trams and buses, as well as docking space for ferry boats which are part of the public transport. Stenpiren serves as a connecting hub for a wide variety of users with a throughput of approximately 12,000 users per day.²⁷ The hub combines city buses, trams, ferries, bike rental, e-scooters, car parking (nearby), car hire (building opposite) and walking, while integrating additional services.



Central Station, Växjö, Sweden

From 2018 to 2021, Växjö central station and the surrounding city centre will be re-built to increase the attractiveness and accessibility of public transport while also revitalising the city centre. Once finished, the station will provide train and bus connections, waiting area, cafes and restaurants, ticket sale, ATMs, housing and commerce, and community meeting spaces. The so-called “living room” of Växjö will act as a new public space within the city centre. The station aims at a combination of increasing the capacity of public transport, and the attractiveness of the city centre.²⁸

Image Credit: CC-BY-SA 4.0 Arild Vågen (Wikimedia Commons)



Sustainable mobility efforts can be observed across Sweden. Cities such as Lund and Uppsala have long been advocates for a shift away from car-centric planning, and Stockholm and Gothenburg both introduced some form of urban vehicle access regulation. Most Swedish cities have city wide bike sharing infrastructure, and economically-viable station-based bike fleets in place. Cycling infrastructure in general is widely rolled-out, and adopted, in nearly all major Swedish cities.

Rapid transit systems across Sweden continue to increase in capacity, and train travel as a mode of transport grew in the last two years. The latter is often attributed to the introduction of a flight tax in 2018. Sweden's share of active and public transport respectively was already observed above European average in 2014.²⁹

While current efforts present a significant step, in order to reach emission targets, additional measures will become necessary. Particularly less urban and more disconnected areas are not keeping up with the urban transition towards multi-modal offerings.

Along with the upgrade of the country's transport infrastructure, Sweden also focusses on the modernisation and future-proofing of transport hubs. Stations often feature high capacity multi-modal transport options alongside park & ride facilities. Also bus terminals are increasingly developed as attractive places. The Nils Ericsson bus terminal in Gothenburg, for example, is located adjacent to the central station and provides access to long-distance buses, while city buses can be found at nearby Åkareplatsen, trams and buses (including airport buses) at the adjoining public transport stations, and other transport options like rental bikes, taxi, and rental cars are placed within the central station area. The three hubs Centralen, Åkareplatsen and Nils Ericsson terminalen are visually linked through a yellow line on the pavement, making wayfinding easier. And in Stockholm, the area Slussen between Old Town and Södermalm, is being re-built to serve approximately 300,000 passengers per day and better connect bus, metro, pedestrians, cycles, boats and cars.

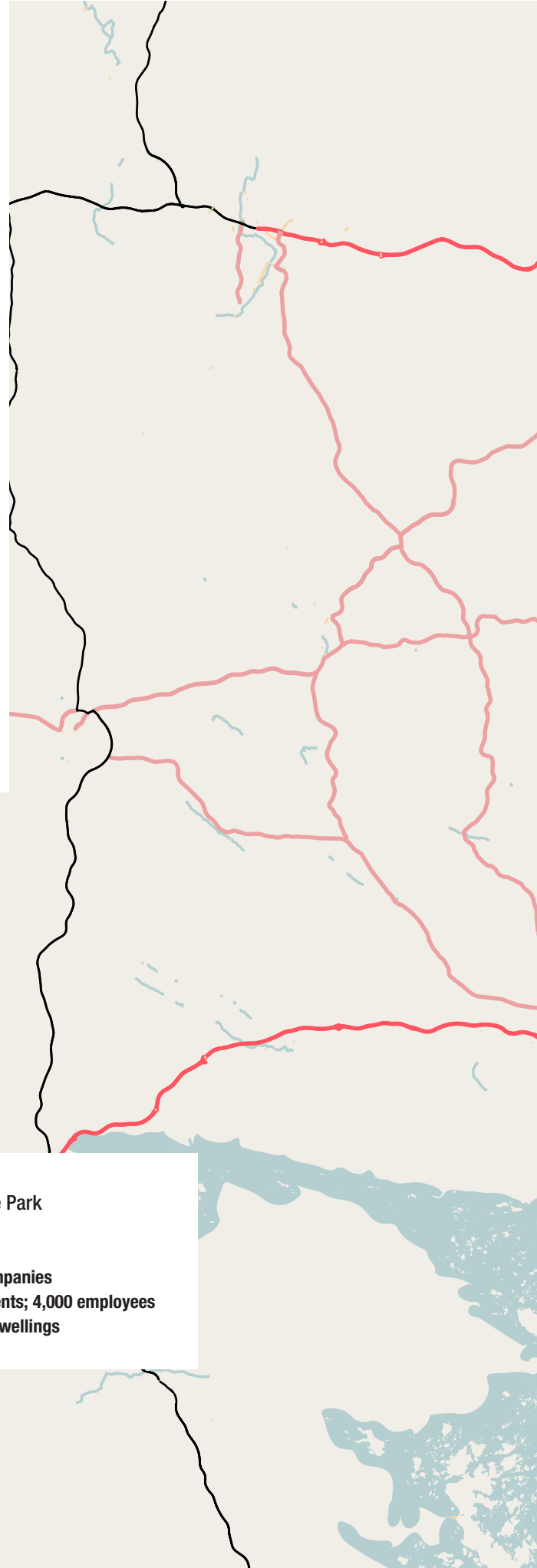
A Swedish Case Study

The Application

The following case study illustrates the application of the mobility hub framework in an exemplary location in Linköping. In a science park outside the city centre, the challenge of transitioning to a more sustainable mobility system is addressed.

The application of the mobility hub concept demonstrates the adjustability of the developed concept to changing, often unforeseeable, needs and requirements. The outlined concept originates from an analysis of mobility objectives along with urban planning, or community, objectives, followed by a choice of site-specific mobility and service modules. The mobility hub becomes a destination by itself within the urban fabric. Connecting people and capitalising on convenience, while adding social value to the local community.

As such, the case study illustrates how the framework can become a resource for further locations, aiming to adopt a more seamless, multimodal and flexible mobility system.



Creating a public space in Mjärdevi Science Park

Population Linköping Urban Area: **114,300**

Mjärdevi Science Park: **7,000 employees, 400 companies**

Proximity to Linköping University with: **32,000 students; 4,000 employees**

Adjacent planned residential developments: **2,300 dwellings**

Mjärdevi Mobility Hub

Linköping



Background Linköping

Linköping aims to achieve carbon-neutrality by 2025. As part of this, a substantial decrease of motorised individual transport will be needed. In terms of active transport, the city aims to increase the share of bike trips in the modal split from 27% to 40% by 2030. This will be supported by the bike link between Linköping centre and the outer districts and the introduction of an electric bike pool. Mjärdevi Science Park – the future location of the mobility hub – introduced a sustainable mobility action plan in line with Linköping's climate goals. The plan focusses on more sustainable mobility solutions, especially for commuting, in collaboration with local companies.

Case Study Linköping

A Mobility Hub for Mjärdevi Science Park

The context

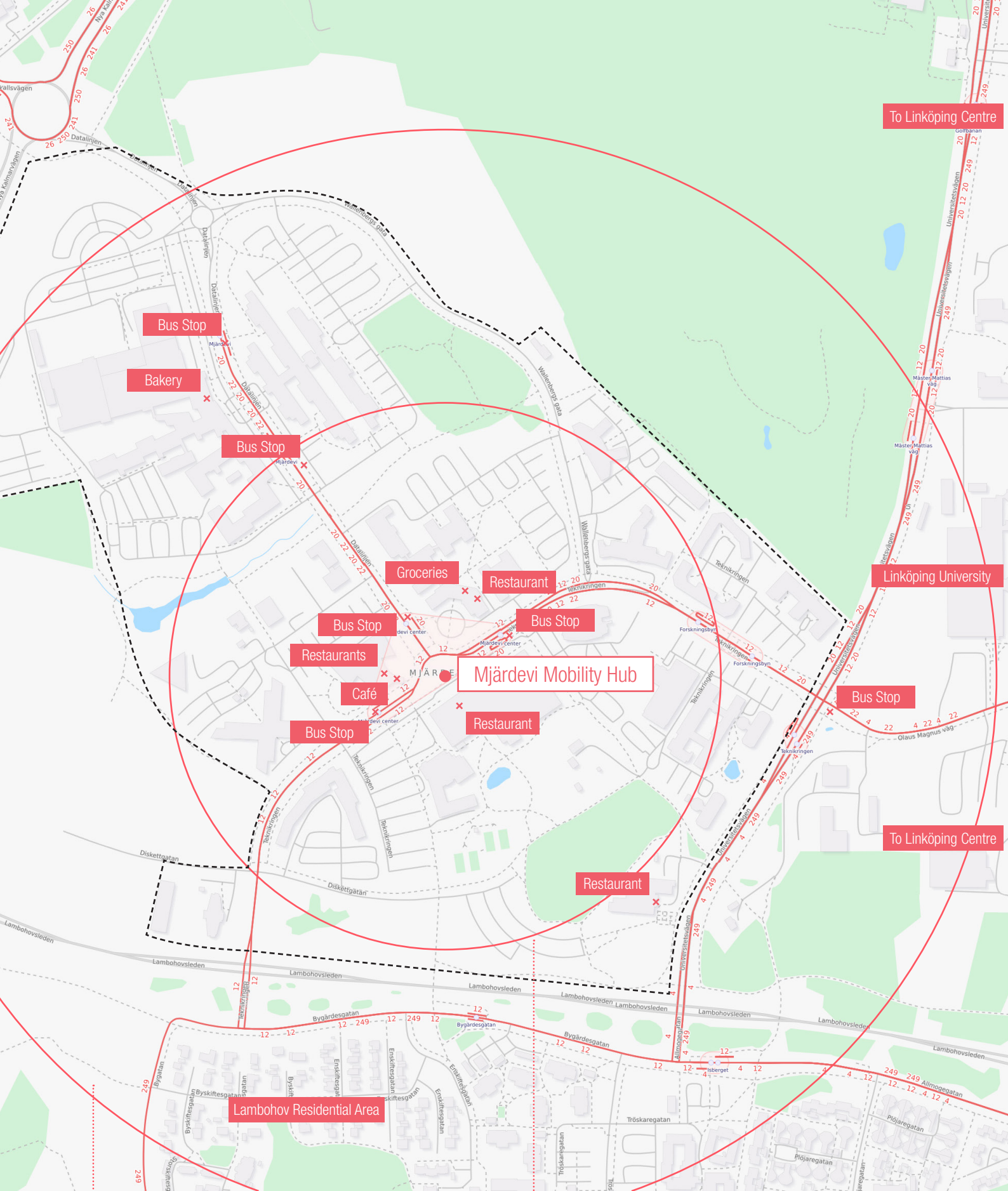
Mjärdevi Science Park is a workplace for over 7,000 people.³⁰ About 58% of these arrive by private car. Large car-parking spaces and retracted office blocks define the area – together with split functionalities and a heavy reliance on private motorised vehicles. The science park currently hosts a large amount of free car parking spaces and is conveniently connected to larger regional roads.

A desired shift towards more environmentally-friendly behaviour requires the introduction of different, more sustainable transport options. As part of this, city planning needs to be rethought in order to accommodate and enable the use of these transport options. Formerly un- or underused spaces can be repurposed to support such a transition. In Mjärdevi, apart from introducing, and above all, enabling more sustainable transport options, there is a need to foster synergies between employees, students, the university and companies in and around the science park. It is therefore necessary to improve public life and create enjoyable public spaces. A focus on placemaking, together with the city's plans to introduce housing in and around the business-only science park, can play a key part in this.

The following opportunities for the further development of Mjärdevi Science Park, to enable a changing transport behaviour, were identified:

- Creating a meaningful connection to Linköping's transport and planning systems
- The addition of services to improve the convenience of environmentally-friendly mobility options
- Valuing the human scale and public life through putting people at the centre of decision-making
- Introducing a central "destination" to the area





Lambohov Residential Area

5 min. walking radius

10 min. walking radius

The concept

Currently, Mjärdevi Science Park is connected to Linköping through 15 bus lines, all of which arrive at the central square – the future location of the proposed mobility hub. 20 buses are passing by per hour, catering three bus stops around the square. There is not a large amount of shelter available at the bus stops (half-open shelter for about ten people and seating for three people per stop), and all stations are directly facing traffic. Especially after typical working hours, longer waiting times can lead to longer layovers, with little shelter and unattractive waiting areas.

Adjacent to the square are secure cycle lanes in four directions. These cycle lanes are connected to Linköping's larger cycle network. With the city centre being between 4 to 5 kilometres away, a cycle-trip can be completed in about 17 minutes, underlining the potential of cycling as the transport mode of choice. There is currently one shared-cycle station introduced in the science park. Additionally, the science park has triggered an action plan to reach certain sustainability goals, amongst which switching to green mobility plays a main part.

Apart from mobility infrastructure, some services, like a café, restaurants and a shop are spread between the buildings around the central square. Many of these have limited operating hours, and the lack of public realm quality in the park offers little incentive to stay in the area beyond working hours. Additionally, few attractive spaces are provided that offer sheltered public space or cater for leisure activities.

In order to change behaviour, the Mjärdevi Mobility Hub will need to add quality and ease to people's life. Accordingly, the hub will need to be able to provide environmental-friendly sustainability options in addition to service offerings in a central, easy-to-reach location. The hub has to cater to the needs of businesses/employees that might require to quickly move around within Linköping as well. The flexibility and modularity of the hub's design allows for adjustments and re-location throughout its life cycle - this might be due to changing behaviours, business models, the addition of new transport modes or changes in land use (the future implementation of a rapid bus line, for example, might necessitate adjustments). The hub will be planned as an adjustable construction on the square, with the ability to expand or shrink, depending on uptake and requirements.



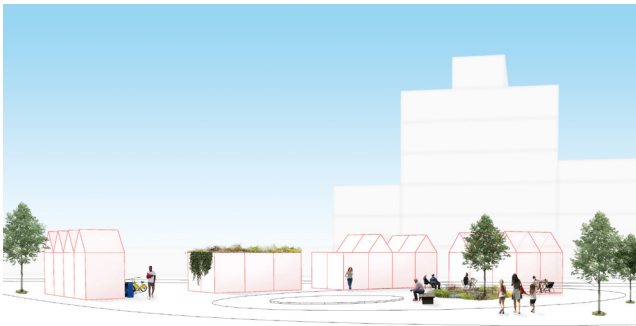
Development surrounding Mjärdevi Science Park

A number of residential developments are planned in the surroundings of Mjärdevi Science Park. Additionally, there are options for densification of the science park itself. Infill developments and repurposing of parking spaces are options. This will result in Mjärdevi evolving into a mixed development of office and residential spaces, and will pose additional requirements on the hub.



Mjärdevi Mobility as a central destination within the park

In order to act as an ideal gateway to the commuters to Mjärdevi Science Park, the mobility hub is placed at a natural point of entry and exit to the Science Park. The clustering of services along with mobility elements at this location will strengthen the strategy of the hub and spark the creation of a neighbourhood centre for the area. Taking public transport to and from the hub, along with making use of the services provided, will become the more convenient option over taking the car.



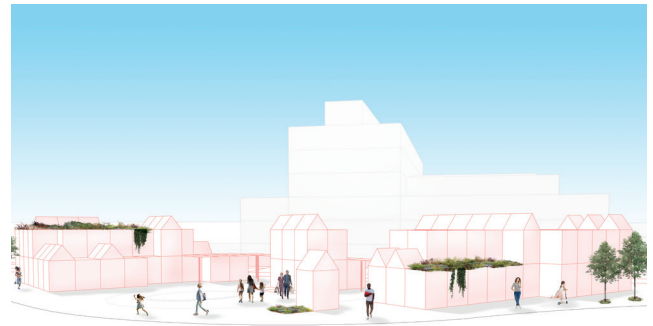
Configuration A

The hub is designed as public place, adding to an area with a lack of commons. In this set-up, the Mjärdevi Mobility Hubs serves as a central anchor point within the science park, while adding to the convenient use of adjacent transit. The central services unite the more scattered offers in the area and bring the public space back to life.

Elements:

- Information
- Waiting/shelter
- Bike repair
- Bike sharing
- Event/exhibition
- Indoor public space
- Garden
- Outdoor seating
- Energy

Depending on the development of future demands, two options for the development of the hub seem feasible: Option A as the starting point and Option B as a potential expansion once uptake of mobility options and the public space, densification of the area, and service requirements increase.



Configuration B

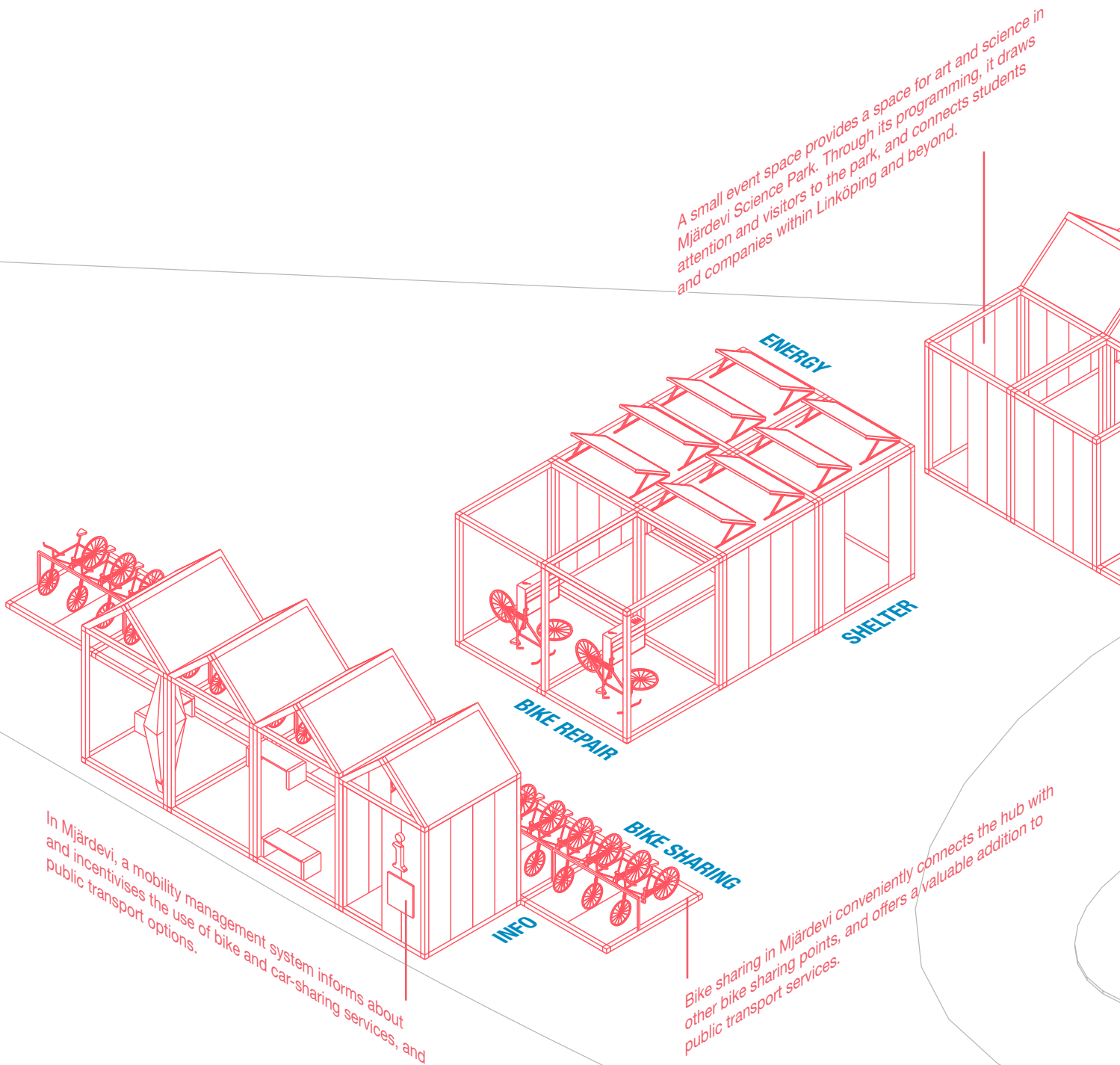
The option for a larger hub is designed to add services and amenities to the public place and is able to cater to a larger number of users. As part of this, bike parking spaces are added. Additionally, large event and exhibition spaces allow for flexible programming and draw in more visitors to the park. It holds the potential to further strengthen the connection to the university through a shared use of spaces. The mobility hub becomes an established destination within the neighbourhood.

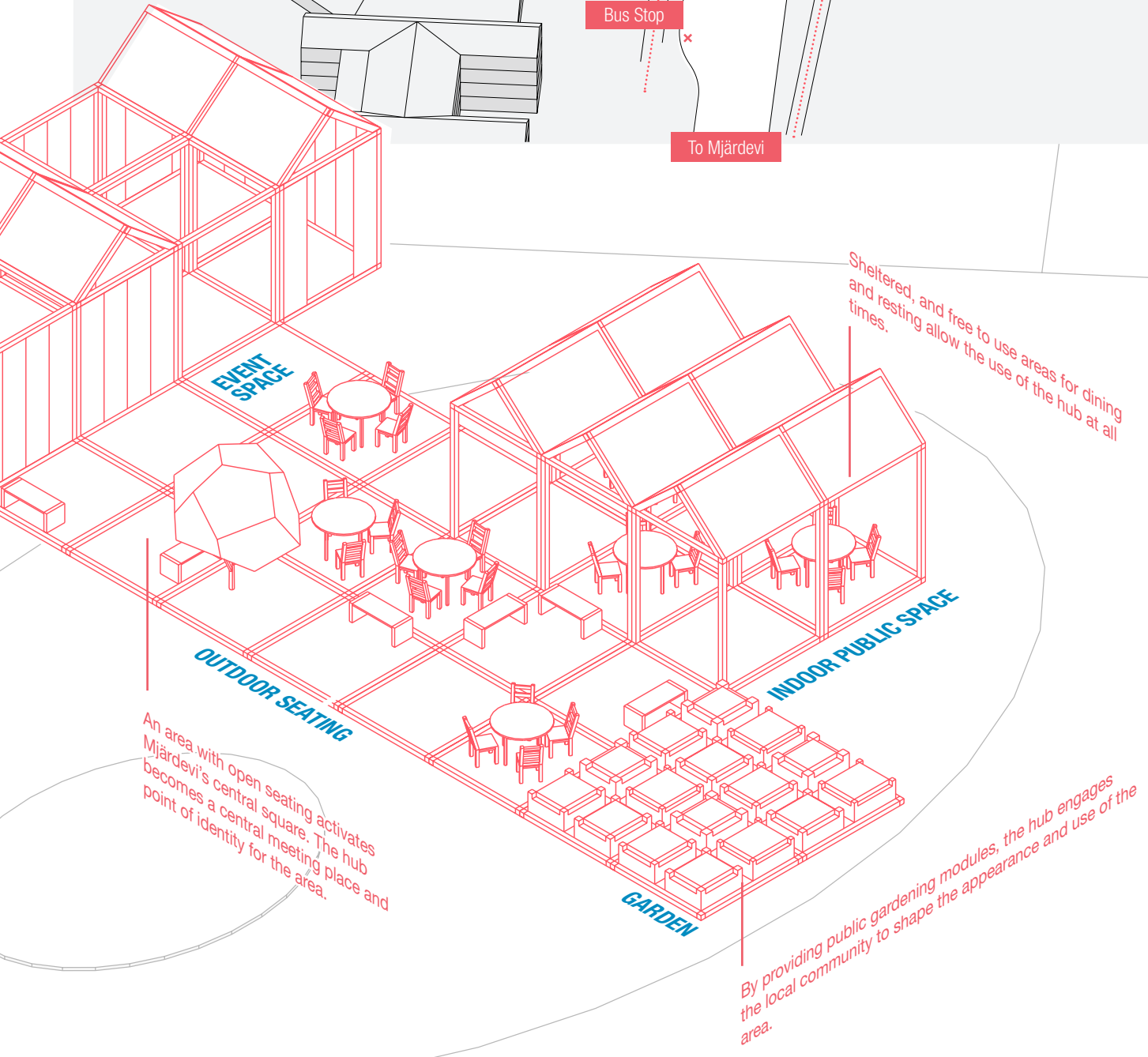
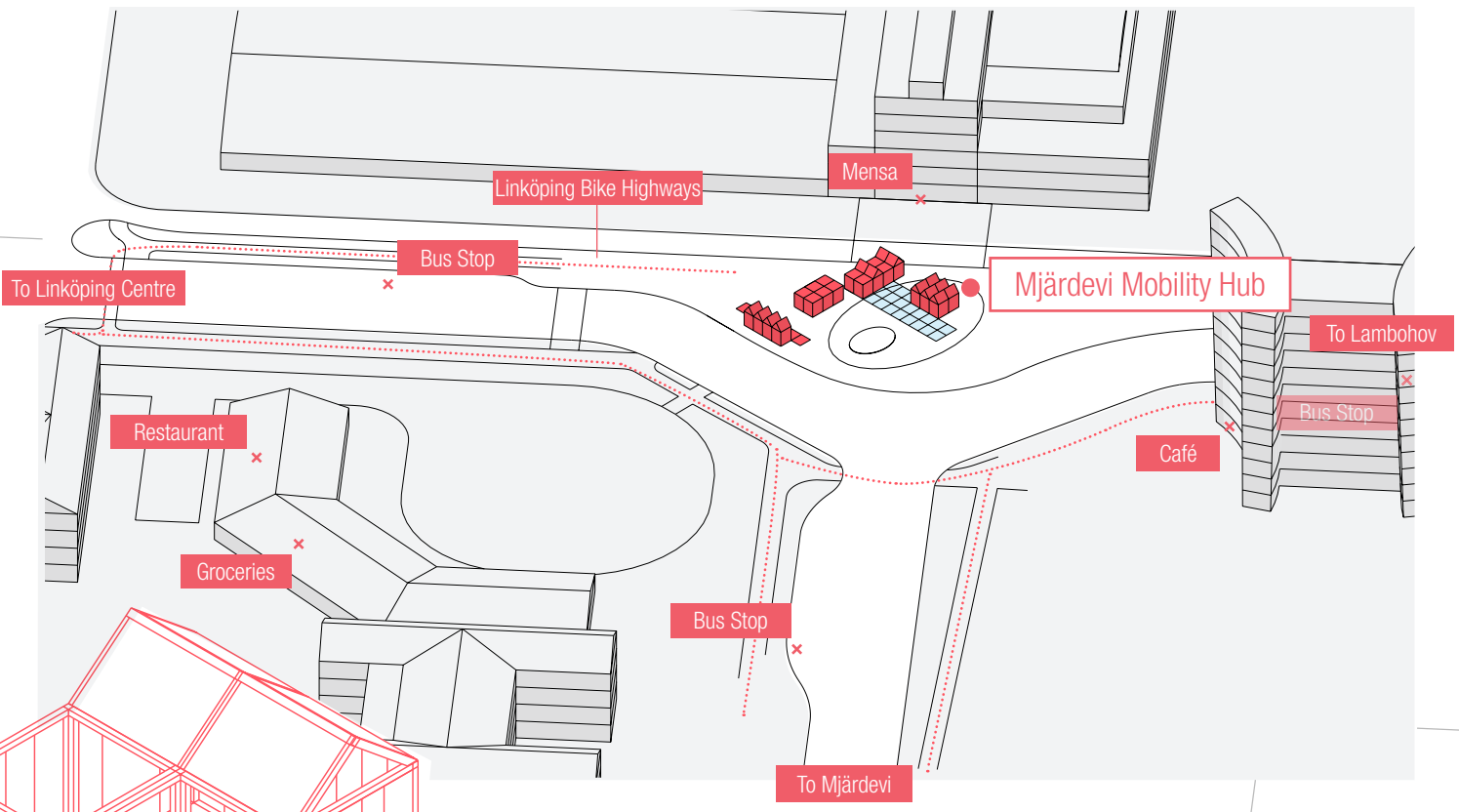
Elements:

- | | |
|---------------------------|---------------------------|
| ● Information | ● Bike sharing |
| ● Waiting/shelter | ●+ Bike parking |
| ● Bike repair | ●+ Car-sharing |
| ○+ Event/exhibition space | ○+ Services (e.g. bakery) |
| ○+ Indoor public space | ○+ Meeting |
| ○+ Garden | ○+ Delivery/pickup |
| ○+ Outdoor seating | ○+ Café/kiosk |
| ○+ Energy | ○+ Food/restaurant |
| ○+ Restroom | ○+ Rain cover |
| ○+ Shopping | |

Case Study Linköping

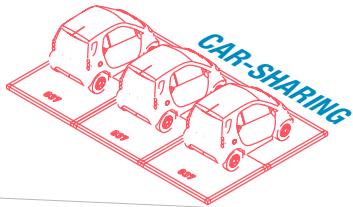
Mjärdevi Mobility Hub - Configuration A



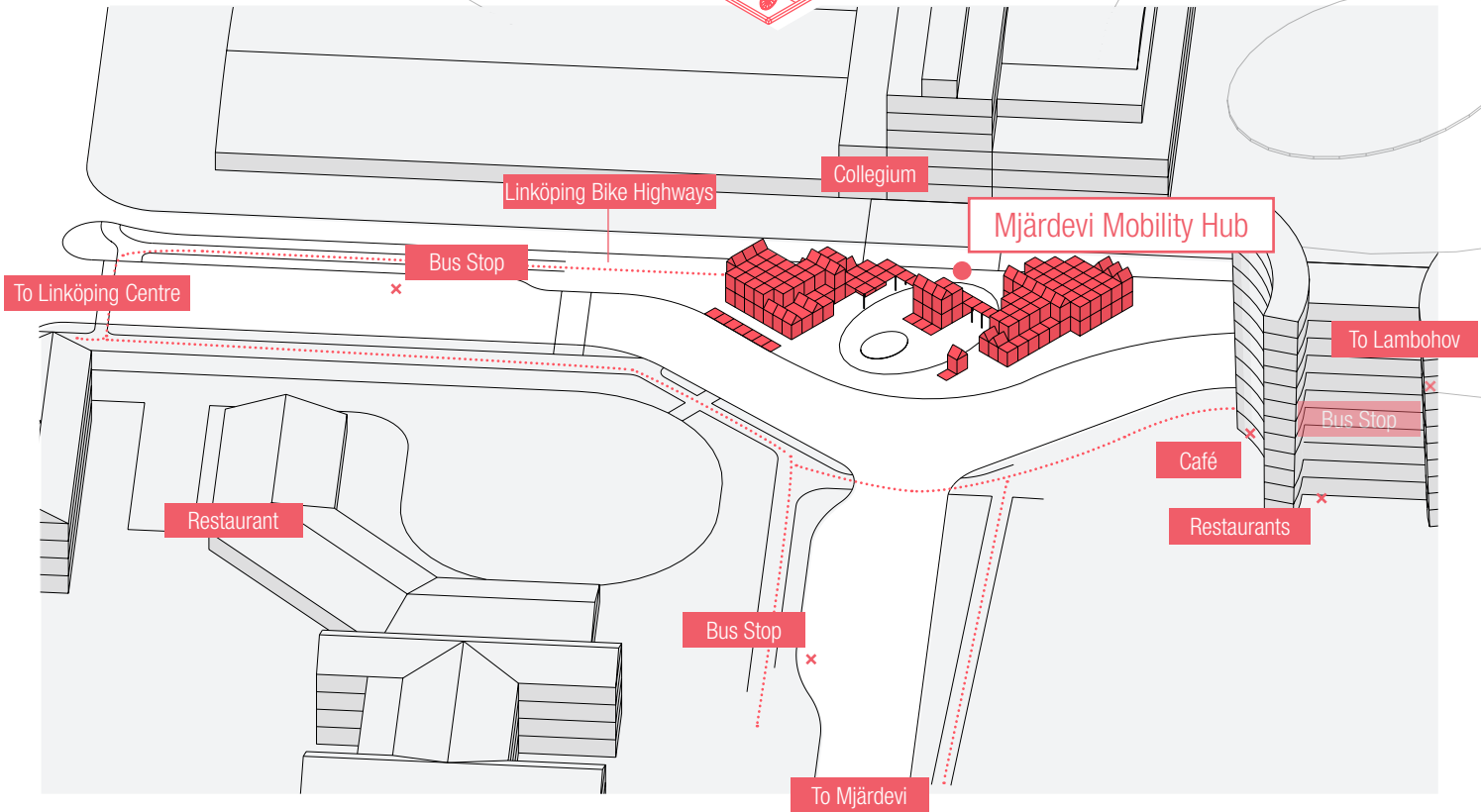
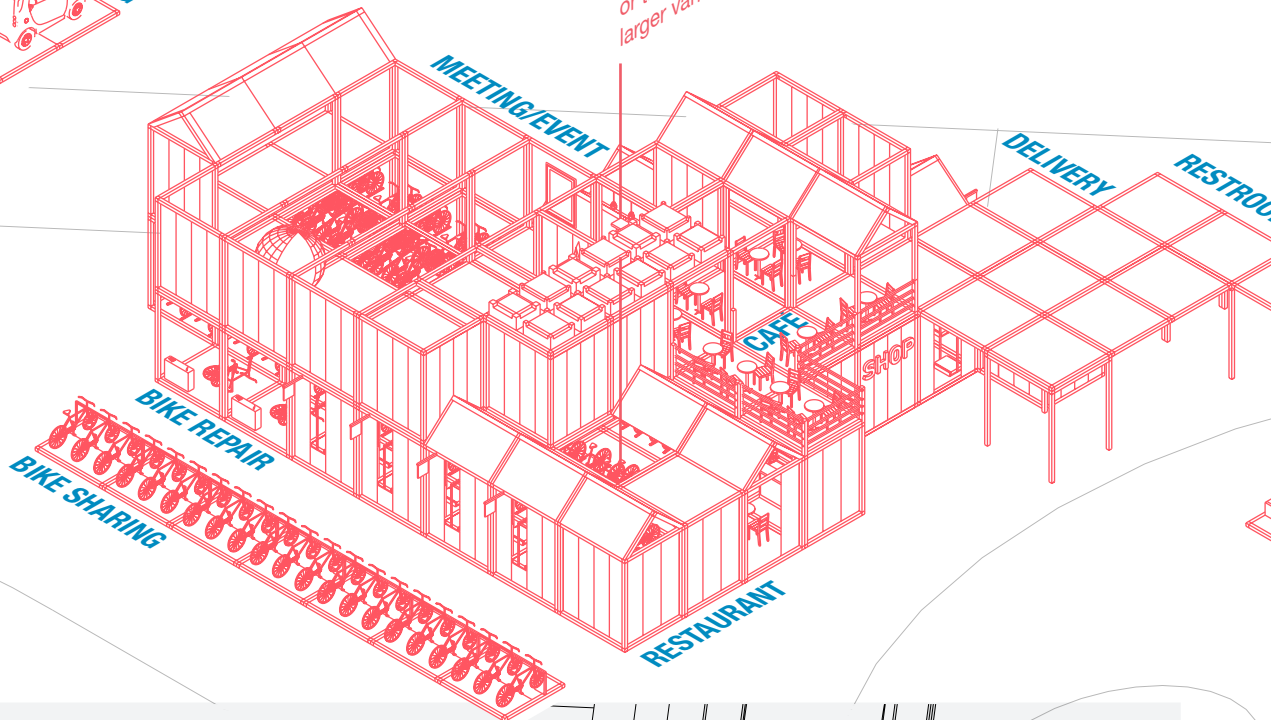


Case Study Linköping

Mjärdevi Mobility Hub - Configuration B

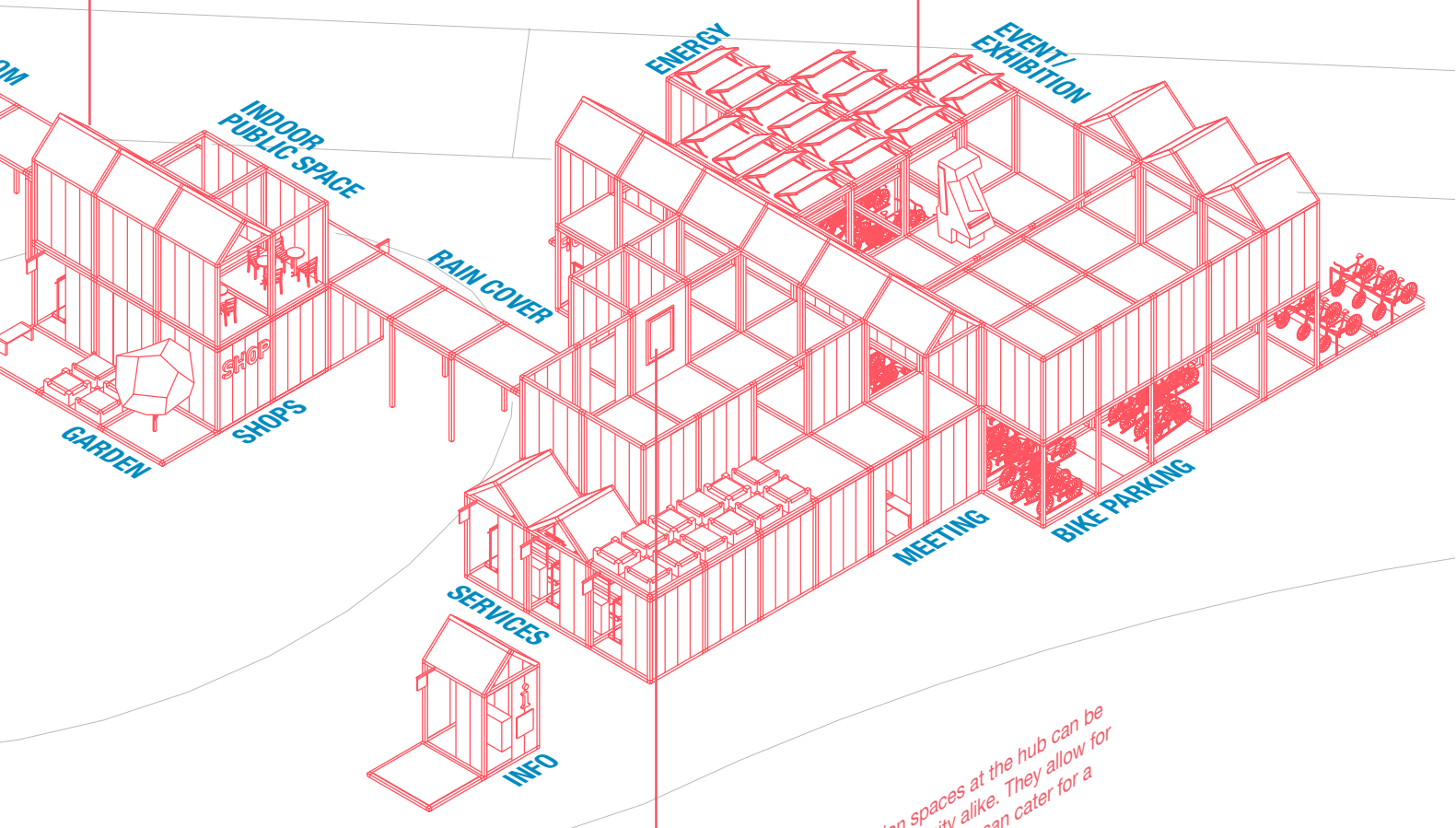


Additional bike parking spaces, along with shops, restaurants and other amenities allow more people to use or transition through the hub, as well as allowing for a larger variety of uses and utilisation of the hub.



Additional restaurant facilities expand the mobility hub as destination for the area. The hub becomes an attractive lunch and dinner option within walking distance to many of the office spaces.

The introduction of energy roofs supports the achievement of Linköping's, and the park's, sustainability goals.



The multiple event and exhibition spaces at the hub can be used by local businesses and university alike. They allow for the programming of larger exhibitions, and can cater for a variety of events and informal meetings.

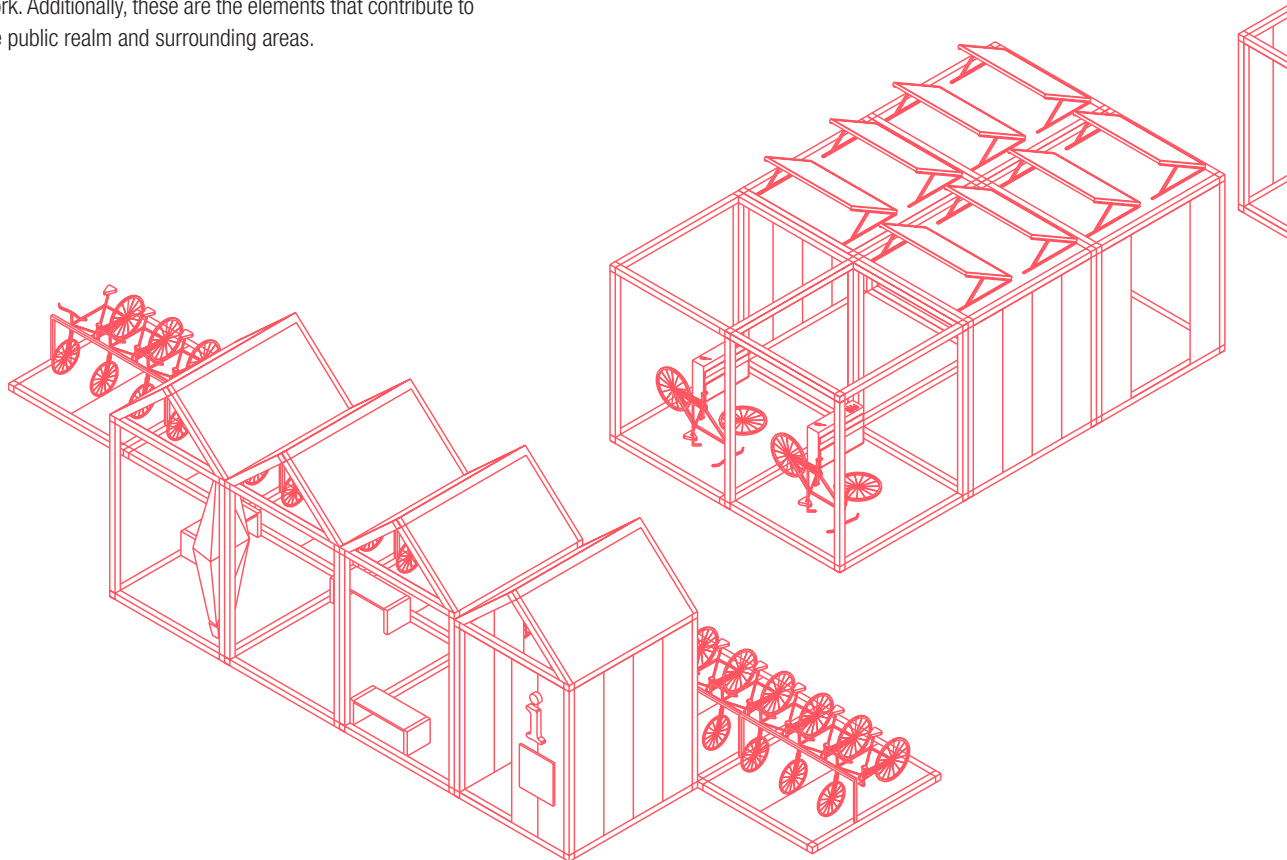
Conclusion

The research project set out to analyse the role of mobility hubs in a transition towards a sustainable transport system. As there cannot be one universal definition of mobility hubs in terms of its physical manifestation, a mobility hub is characterised by its contribution to the sustainable transport transition. Mobility hubs are an integral part of this. They are able to cater to the necessary prerequisites – combining a variety of transport modes, enabling seamless travel experiences, and promoting alternative mode options.

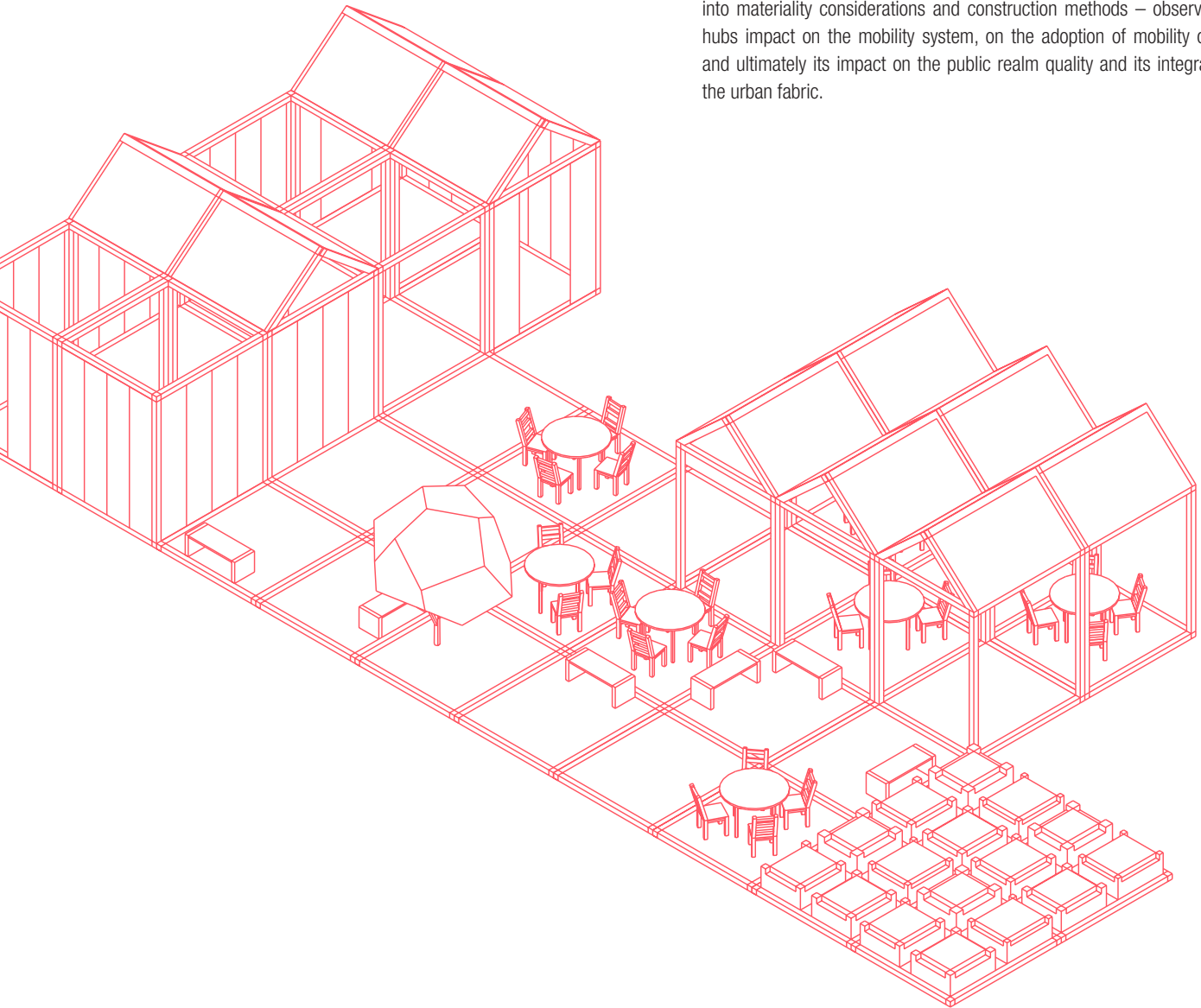
Mobility hubs, however, can be much more than that. A sole focus on transport provision would fall short of their potential. Especially the addition of services and amenities outside of the transport realm can assist, when planned properly, in achieving a shift in mobility behaviour. The service elements, as outlined in the catalogue of elements, address exactly this. They make choosing sustainable transport options easier and more convenient. They provide additional services to the users of the hub and are necessary to make the hub work. Additionally, these are the elements that contribute to the activation of the public realm and surrounding areas.

This focus on promoting and incentivising sustainable mobility, derived as a key goal for mobility hubs, can and should be expanded to the sustainability of the mobility hubs physical manifestation. Construction methods, material use, and keeping the function and value over time are all critical factors that have been explored as part of the developed mobility hub framework.

The proposed mobility hub framework pertains to both – mobility and built environment sustainability as interlinked subjects. We then analysed the applicability of the developed framework in a distinct case – a science park outside the city in Linköping. This case illustrates the adaptability of the framework and its flexibility over time – changing and adapting as and when necessary. The hub can range from small to large and especially when applied in locations with limited existing infrastructure, it can offer a fast and easy to implement alternative to large-scale infrastructure construction projects.



The flexibility over time is probably the defining factor of the framework, as it directly speaks to the fast-changing mobility landscape, while addressing resource and sustainability considerations. We hope to take this thinking further, as we believe that it illustrates a different way to think about our approach to the built environment. We would like to advance this framework towards the implementation of a pilot project. Only then it will be possible to test the theoretical assumptions in a real-life context and dive deeper into materiality considerations and construction methods – observing the hubs impact on the mobility system, on the adoption of mobility options, and ultimately its impact on the public realm quality and its integration in the urban fabric.



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Illustration and Diagram References

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Team

This report is a product of collaboration between the global engineering, design and consulting firm Arup, RISE Research Institutes of Sweden, the municipality Linköping, and the Swedish gas station operator OKQ8 Scandinavia.

RISE Research Institutes of Sweden

RISE Viktoria is a non-profit research institute dedicated to enable sustainable mobility and has become part of RISE, Sweden's innovation partner for business and society, in 2017. It has 20 years background in developing, designing and piloting solutions for different transport areas, many involving advanced ICT. It has broad competencies in customer/user perspective, business model design, and transport policies.

Arup

Arup is an independent firm of designers, planners, engineers, consultants and technical specialists, working across every aspect of today's built environment. Together we help our clients solve their most complex challenges – turning exciting ideas into tangible reality as we strive to find a better way and shape a better world. Arup made its name in the twentieth century as the designer and engineer behind some of the world's most ambitious structures. That creative strength and independence of mind continues to guide us. Today, Arup employs more than 14,000 people, in more than 34 countries – in a culture underpinned by Sir Ove Arup's aims and values.

Linköping kommun

Linköping is located in Southern Sweden, in the Province Östergötlands län, currently home to 112,000 inhabitants. The city has the goal of becoming CO₂-neutral by 2025. Private vehicle use will be significantly reduced, while bike and public transport trips will be fostered. The city will be built denser, make use of new technology and take advantage of the sharing economy. Linköping kommun has a close cooperation with local institutions, among them Linköping Universitet, transport research institute VTI and high-tech companies based in Mjärdevi Science Park.

OKQ8

OKQ8 is one of Sweden's largest fuel companies and we are driven by our commitment to our customers and employees. We are an enabler for people in motion and work proactively with new sustainable solutions. In 2012, OKQ8 AB in Sweden and Q8 Danmark A / S joined forces and formed OKQ8 Scandinavia. OKQ8 has Sweden's largest network of gas stations, 650 stations, half of which are manned service stations. The company's "why" is to be an enabler for people on the move. Its new business innovations section is actively looking for new business opportunities within the areas of future mobility hubs and innovative mobility services for people and vehicles on the move.

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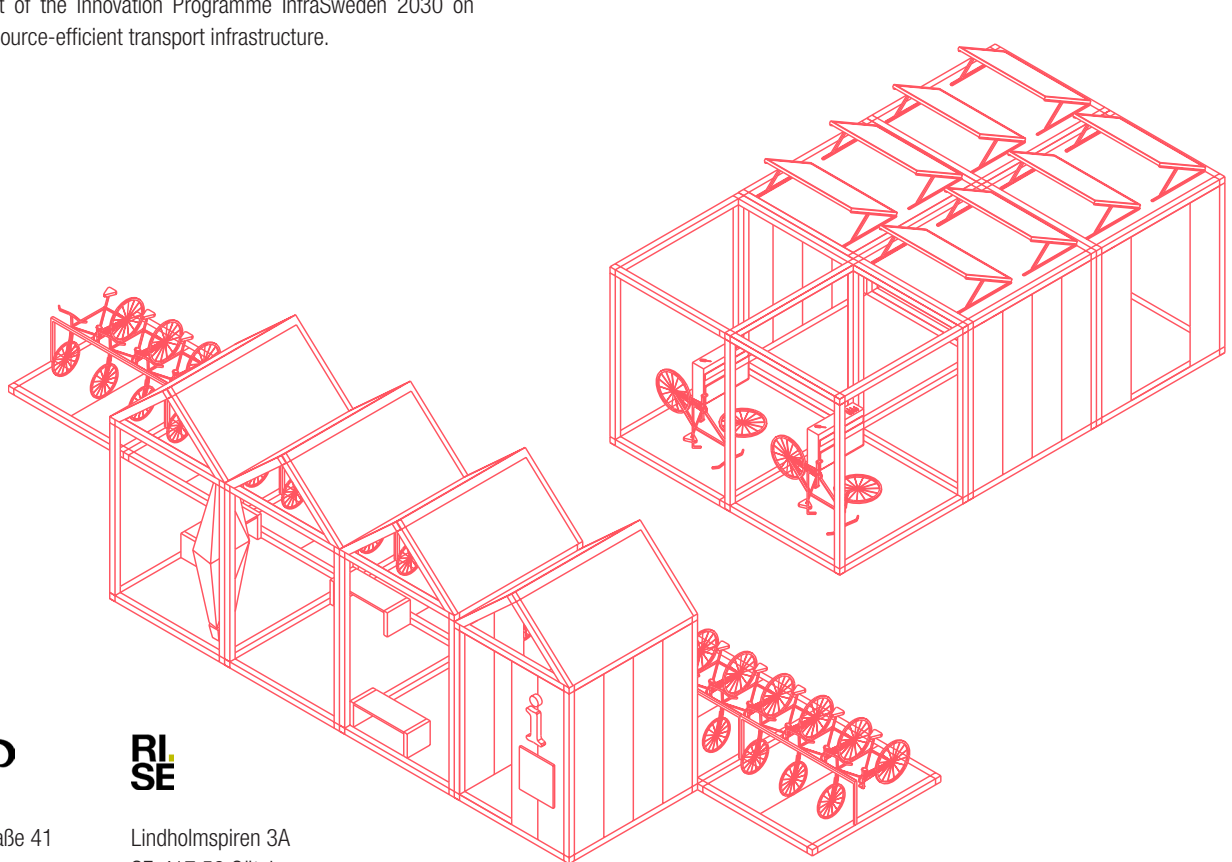
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Mobility plays a vital role in our daily lives and has become one of the most fundamental characteristics of current society. Mobility, or the ability to go from one location to the other, links cultural, economic, social and political aspects of our global society.

The global mobility demand continues to grow, along with the mobility systems' carbon impact. In order to manage future mobility demand and enable a much-needed transition to sustainable, low carbon mobility, it will be crucial to enable seamless transitions from one transport mode to another, requiring organisational alongside physical integration. Beyond providing the modalities necessary to manage a shift to more sustainable transport options, a shift in mobility behaviours needs to happen in order to adopt these. Mobility hubs come in here – they can make alternative options easier, more attractive and more convenient to use. The design, location and specifically the associated services of a mobility hub can influence this.

This report explores the case for mobility hubs as an enabler for a changing mobility pattern. A mobility hub framework and its potential application in a Swedish city is outlined.

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