Working on better cities with fewer cars

xcarcity

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Author(s): Tian Zwart

Contents

1. Introduction & Updates

The third Design Session for the XCARCITY program took place on November 24th, at *The Happy Flow* in Rotterdam. The consortium was eager to join, indicated by the most participants since the start of XCARCITY. Arjan van Binsbergen (TU Delft) opened the day with an introductory presentation, talking about the objective of XCARCITY and looked back on the previous two Design Sessions. The set-up of this Design Session was also briefly mentioned, with a sneak peek to the two Use Cases: Amsterdam Zuidas & Rotterdam M4H.

To spark creative thinking, Kim Maas (Pon) was invited as an inspirational speaker. She shared a range of examples from Pon's work, illustrating how their initiatives move us to a better world. One example was the E-lympic Mobility Hub, located next to their office, which showcases innovative approaches to sustainable mobility.

Figure 1: Kim Maas presenting to the XCARCITY consortium.

Over the past year, several developments have taken place across the three XCARCITY Use Cases. Paragraph 1.1 focuses on Almere Pampus, Paragraph 1.2 highlights Amsterdam Zuidas, and Paragraph 1.3 introduces the new Use Case: Rotterdam Merwe-Vierhavens (M4H).

1.1. Almere Pampus

Almere Pampus has been involved with XCARCITY from the very beginning, providing an interesting use case. The large scale of the area, and the location and function within the Metropolitan Region of Amsterdam, makes it a very suitable project to learn from. Since this Use Case joined at the start, the knowledge for many aspects of the mobility system with less cars, was still unclear. However, after two years, a detailed report has been written on the results for this to-be-developed area. During Design Session 3, the report was officially handed to the municipality of Almere.

1.2. Amsterdam Zuidas

Amsterdam Zuidas is already involved with XCARCITY for some time and already has some tools available. The redevelopment of this area is already well underway, which provides opportunities to test outcomes fast which makes quick feedback loops possible. A major interest of the municipality is to gain more insights in pedestrian flows, since there are many different functions in the area.

1.3. Rotterdam M4H

The Merwe-Vierhavens (M4H) area is part of the Rotterdam port, which is located on the westside of the city and to the north of the Maas river. The area is approximately as big as the city center, and currently still has port industry. The municipality of Rotterdam, together with the Port Authority, wants to transform M4H into a living-work area. The feel of the port, and the feel of the city within the same area. The first area within M4H that is being transformed, is Merwehaven and will have room for 2,500 homes, a school, a GP, a park, and a supermarket. There will also be 30,000 m^2 for small entrepreneurs.

What makes this development interesting for XCARCITY, is that Rotterdam does not want any parking spaces on street-level and does want to provide shared mobility in mobility hubs. The aim is that inhabitants of M4H do not have to own a private car while still having sufficient accessibility and quality of mobility.

2. Zuidas Interactive Session

The Zuidas Use Case got (re)introduced by Barry Ubbels. After his presentation, the present consortium members got split up in four groups. The first three groups would look at different tools that were developed specifically for the Zuidas, and the fourth group did not look at any tools but used expertise judgement to evaluate different road designs for the Gustav Mahlerlaan.

2.1. Solution Explorer

The Solution Explorer is a tool that analyses multiple solutions in a structured way. The group that looked at this tool valued this structured approach, however, there were also quite some recommendations for improvement. The visualization in the tool, and of the results can be improved. Also, the intuitiveness, transparency, and inclusivity were found to need improvement. The participants in the group want more control over the scenarios, better stakeholder integration. More details on possible improvements of (the use of) the Solution Explorer are listed below:

- Visualization of cross sections (stacked)
- Add requirements, also on inclusivity
- Visualize road use differently
    - Rotate bars
    - Show distribution (incl. median and percentiles)
- Use a radar graph
- Organize KPIs so that good/bad are ordered similarly
- Cluster solutions, then iterate to find better ones
    - Some said that there are too many scenarios
- Paint on the map to indicate the importance of areas
- Maximum and Minimum of indicator values (what are requirements?)

The following indicators were ranked based on importance:

1. Accessibility (per mode)
2. Liveability
3. Air quality
4. Traffic safety
5. Feasibility (incl. amount of work (cost))

Green is not all the same: trees ≠ grass

The resulting outcomes of this tool are not directly trusted by the participants of the group. Mainly because the visualization is too chaotic to find an optimum, and the explainability of the model. They also state that an engineer is needed to interpret the outcomes, and the tool is not unique. Trust in the results will be enhanced when the quality and quantitative interpreting is improved.

The question is raised if this is for short-term interventions, long-term solutions, or both?

The group also suggested useful additions for the Solution Explorer:

- Add claims of public transport, pedestrians, water
- Add parking (for both cars and bikes) as outcome
- Comparison of solution to the current situation
- Include all roads as variables, or at least consider the consequences
- The selection of one solution within a range
- Visualise what is done by the model
- Select realistic scenarios to start with
    - Current set-up has random non-feasible solutions
- Consider scoring
- Use reinforcement learning
- Consider objectives of stakeholders as a starting point
    - For example, PT operator would want reliable service, and enough space
    - Other stakeholders have different objectives
- New indicators:
    - Vehicle Loss Hours (VLH) biases towards car users
    - Order of axis

This group full of participants with different expertise proposed many improvements and additions to make the Solution Explorer better to understand and more useful in practice. The group does see the potential and would use it again. The idea of integrating this in a serious game has also been proposed.

2.2. Predictive Digital Twin

Using the newly developed Capacity Regulator Module, the group explored multiple pre-calculated what-if design scenarios. There was a lot of interest in the results using this tool. It was especially useful to see the capacity of links (roads) and intersections. It was also helpful to find critical areas (e.g. hospitals), including the visualizations of these bottlenecks. There were also some concerns noted. These concerns were mainly focused on the choice of indicators used for evaluation, and the different aggregation levels. Some considerations are proposed:

- Indicators like Vehicle Loss Hours (VLH) or delay need to be changed
    - Or, calculated alongside other prescriptive indicators
- KPIs need to be assessed carefully
    - External effects were greatly seen when changing car space to green/bike
- Identification of negatively affected areas

The following indicators were considered important to be explored:

- Noise levels due to cars
- Safety indicator including:
    - Risk factors
    - Reliability
    - Overall convenience
- No more VLH (old school!)
    - Replace by, for example, travel time per population group
- Accessibility or Reachability, also with respect to population groups
- Accessibility of jobs
    - Use a threshold value of *X* minutes
- External effects outside of Zuidas? Larger scale system effects?

The group was enthusiastic about the tool, and its usefulness was clear. Several additions were proposed to develop the tool further:

- Modal shift effects due to change in road space allocation
    - Adaptive behaviour
    - Disaggregation effects, for both population groups and areas
- Study impact of capacity changes between different modalities
- Social context/influence
- Intersection-level capacity modelling

2.3. Pedestrian Model

This group explored the possibilities of the Pedestrian Model. Besides suggestions for this tool, there are several suggestions for the design of the Zuidas area regarding pedestrian friendliness:

- Assign green spaces along the sidewalks
- Develop strategic pedestrian crossings to limit pedestrian delays
    - Including traffic light timings
- Wider sidewalks with less barriers
- Better entrance locations for public transport services
- Space for shared mobility should not be taken from pedestrian space
- Inclusivity for disabled / less-mobile people

Besides the design of the Zuidas area, multiple additions have been suggested:

- Crowdedness in time and space
    - When is the threshold capacity reached
- Delays at intersections for pedestrians
- Travel times for pedestrians
- Safety, or perceived safety
    - Light, visibility
    - Intersection crossings
    - Indication of unsafe locations
- Accessibility for different groups (e.g. disabled people)
- Types of pedestrian flows (heterogeneity) and their distribution in time and space
- An addition could be an (interactive) map to show walking times in a certain area

This group also paid attention to sensors. Firstly, the locations of sensors was discussed. The recommendations were that these are placed along busy roads and close to hotspots (e.g. university, hospital, station). Below the discussed applications are listed, alongside challenges regarding their implementation.

Applications	**Challenges**
Capturing real time traffic flow	Privacy
Capturing speed	Cost
Safety	Time
Air quality	Security

2.4. Expert Judgement

This group focused on three alternative designs of the Gustav Mahlerlaan, which is located to the south of the train station Amsterdam Zuid. The first design (D1) made the Mahlerlaan a cycle street, where cyclists and cars share the same lanes. The second design (D2) had separate cycling lanes on both sides of the car lanes. The third design (D3) had a separate two-way cycle path on the north side of the car lanes. No tools were used, but expert judgements provided the input for a discussion. This discussion was based on three indicators: health, accessibility, and quality of public space.

Before the focus was put on these three indicators, the reasoning behind the full area design was elaborated on to create context for the experts. The focus was then shifted to the Gustav Mahlerlaan, and its three alternative designs.

Health
D1: less safe, because of sharing space with cars/trucks (especially with high intensity)
D1: most space for green

D2: loading/unloading spaces have to cross the cycling lanes on both sides

D3: most space for safety
D3: much space for green

General suggestions:

- Create buffer between car and bike (for D2 and D3)
    - Can be art or greenery
- Loading/unloading at specific time slots
    - To prevent unsafe conflicts with cyclists

Accessibility
D1: most space for (less-mobile) pedestrians

D3: one side has less space

General suggestions:

- Problem with interaction between loading/unloading spaces and bikes
- Crossing with Gustav Mahlerplein needs attention
- Alignment shift for bike lanes can create ‘pitlanes’ for loading/unloading

Quality of public space
D1: most space for non-mobility functions: green, blue, terraces

D3: alternative design (with ‘pitlanes’) -> more space for non-mobility functions

General suggestions:

- Nudge pedestrians and cyclists by creating ‘nice’ spaces (high quality)
- Work with multi-level infrastructure

The expert judgement group mainly focused on D3, and possible adjustments to this design. Not using models gave the experts more freedom to think of creative solutions. However, the need for data was also evident to strengthen or clear up certain decisions in the designs. Current intensity data and 3D visualizations would have helped the experts, but there were still recommendations made by this group:

- Intersections are main points of interest
    - On both ends of these alternatives, but also with Gustav Mahlerplein
- Look at the number of loading/unloading spots
- Clear prioritization of the different functions
- Support choices with flow data, and connections with surrounding area

3. M4H Interactive Session

The Rotterdam Merwe-Vierhavens Use Case got introduced by Vincent Joanknecht of the municipality of Rotterdam. Together with his colleagues he answered multiple questions from the consortium about the development plan for the M4H area. Some of the questions could not be answered, since many decisions have not yet been made. This offered a good starting point for the Interactive Session for 4 groups with the focus on Last Mile, Inclusivity, Adaptability, and Hub Innovation.

3.1. Last Mile

The Last Mile group split up into two groups to discuss the challenge of Last Mile transport from, towards, and within M4H. Their results are documented separately. See Figure 1 for the personas used in this group, and the research question that was addressed.

Figure 2: Group 1 focused on Last Mile transportation in the M4H area.

Group A

This group first focused on how the different personas would travel, and what their specific needs are. For Maya, who works irregular shifts, a shared car can be beneficial because sometimes she might be able to take public transport (PT) while other times she works at night, and no PT is available. If she has a private car + bike, she likely wants to be able to park these in one of the mobility parking hubs. This is mainly in the case when she does not work near M4H and cannot cycle to work. For The Colins Family, there is also need for a car when traveling to family outside of the city. However, these are needed at specific times (likely the weekend). Regarding PT, they would like to be close to a stop. For Helen, who works within the M4H area, it would be best to have a (second) bike at a station so she can get to her work quicker. Being at the workplace within 45 minutes was mentioned. The last mile for Jacob, who has a back injury and cannot carry heavy groceries among other things, the solution is to allow the

delivery of groceries, so he does not have to carry them himself. The same holds for other deliveries. For Edward, who does not own a smartphone, a bus with a regular timetable works for him since he cannot order one easily. PT options with a maximum of 1 transfer are preferred. Another option is Valys, but this must be ordered online for less mobile people.

Some other general considerations were costs, exploitability, accessibility for different groups (including other than beforementioned personas), and social safety.

The solutions and strategies that this group propose are:

- Put the cycling bridge more to the north
- Provide a shuttle service
    - Short routes
    - Also, to/through Schiedam + train station
    - During the night -> on-demand or extend the timetable
- Create enough bicycle parking at Marconiplein metro station
- Extend / move the tram service
- For surrounding neighbourhoods, the following should be introduced / adjusted
    - Parking policies
    - (Shared) mobility hubs
    - Cycling infrastructure
- Check current road and PT capacities

Finally, the group used the available maps which they found useful. For next steps, data about current traffic flows, the (socio-economic) profile of future M4H inhabitants, and the mobility profile of first inhabitants / inhabitants of similar areas could be useful. Mainly for running models and simulations for land use and modal split.

Group B

The second group focusing on this topic, mentioned the following KPIs: Travel time, Cost, Waiting time, Distance to stop, Safety, Air quality, Occupancy rate of the PT.

Design considerations, including the perspectives of the personas, are:

- On-demand (autonomous) bus
    - Peak hour: also scheduled timetable
- Bridges that support Autonomous Vehicles (AVs) and Bikes
- Upgraded bike parking at Marconiplein
- Link PT-network to mobility hubs, including payment system
- Think of space for (larger) families in mobility options

This group recommends macro and micro simulations, specifically for **1)** Demand for hubs, and **2)** Demand for Public Transport.

3.2. Inclusivity

This group focused on the inclusivity of the mobility system within M4H. Again, personas were used to be able to approach the question from different perspectives. See Figure 2 for an overview of the personas and the main research question of this group.

Figure 3: Group 2 focused on inclusivity of the mobility system in the M4H area.

For this topic, the group also started looking at the different personas. For The Johnson Family, the challenge of a children seat within a shared car was mentioned. These could possibly be offered in certain locker boxes. Traveling with small children would go more smoothly with a (shared) car, or short distances to amenities like childcare or schools. Good and safe cycling infrastructure could also help promote his as an alternative. For Margaret, 400 meters feel like a long distance to walk to a mobility hub. Making this shorter would make sense. The difficulty of working with digital devices makes the use of apps or other useful tools difficult, think of renting a shared car. For Mark, who works irregular shifts in the port of Rotterdam, public transportation is not an option. He has to use private transport, and a network of mobility hubs where there is a chance that he cannot park his (shared) car in the nearest hub might be a big issue. For Micheal & Anna, mainly the costs of parking or the rent of shared modes can be an issue. It was also mentioned that in Rotterdam low-income households also have a higher chance of not being able to cycle. For the Youthers, not many difficulties were identified. They "will find their spot", but this can also be created and taken into consideration for urban design. Also to be able to prevent nuisance. This persona might have received too little attention.

An overall conclusion this group drew was that the inclusivity for one persona not directly caused exclusivity for the other personas.

An important conclusion this group stated is that creating an inclusive mobility system cannot be considered without considering urban design. And combining inclusivity with the urban design, social cohesion is also a topic worth looking at. This is considered in the proposed solutions and strategies:

- Create places where people (from different socio-demographic groups) can meet.
    - Entrances of mobility hubs
    - Benches along walking routes – also for less-mobile people to rest
- On-Demand mobilities – consider night shifts
- Sufficient water crossings to minimize travel time/distance
    - Mainly focusing on active modes
- Think of the adaptability of the mobility hubs
    - Costs are a challenge here
- Strategy for long-term: if (young) families start living here now, how will the M4H demographics look in 20/30/40 years?
- Public cycling lessons (Free)
    - Organised by community?
- Safe cycling/walking routes to schools, amenities, surrounding neighbourhoods
- Create social safety – public spaces (social control), no dead ends
- Van/carpooling for harbour workers – company transport?
- Elderly homes close by the mobility hubs to minimise distance
- Hubs need to fulfil a social role within the neighbourhood
- Identify (unique) needs for shared cars (e.g. Children seats)

Since one point kept coming back in this group's discussion, a more extensive elaboration on a network of multiple mobility hubs vs having one hub for each vehicle is given. Concerns are that when someone goes to a hub by bike in the morning (think of an early morning shift), to get their (shared) car and travel to and from work, that this person might not have space in the same hub as where they parked their bike that morning. They would have to park their (shared) car in a different hub, walk to the hub where their bike is parked (which is likely more than 500 meters away), and then cycle home. This network might **exclude** certain users of the network of hubs.

Several instruments are proposed for the Digital Twin:

- Model access of people to (different types of) amenities
- The impact of the locations of water crossings / connections to surrounding NBHs
- Consequences of different systems for mobility hubs *(see previous paragraph)*
- Long-term planning – housing families now, but what happens in 20/30/40 years

3.3. Adaptability

For the adaptability of the mobility system in/around M4H, this group aimed to discuss design approaches and policy tactics. However, this group encountered a challenge regarding this question, thinking it was a bit early in the design process to focus on policymaking due to *a lot of unknowns*. In Figure 3, the main research question is stated.

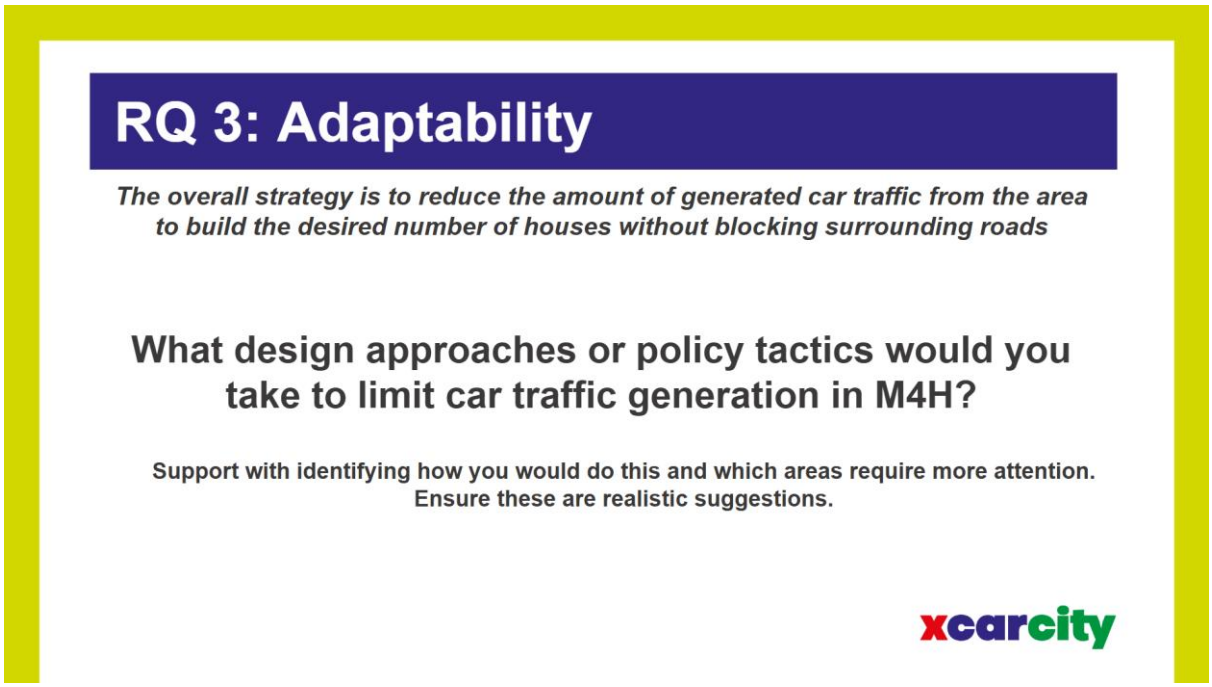

Figure 4: Group 3 focused on the adaptability in the M4H area.

Instead of focusing on the policy tactics, they focused on the design approaches in the current plans. The discussion focused on amenity locations, public transport, active mode routes, and freight transport.

- Amenity locations
  The idea of the municipality is to rely on amenities in the surrounding NBHs, but to get there is difficult. People have to cross a dike or a busy road, and the distance is quite long. Especially for the more remote areas in M4H.
- Public transport
  Rotterdam wants to focus on good public transportation. However, the group would expect that there is metro-oriented development (*TOD*), which does not look present in the current plans. Additionally, regarding PT, will an (automated) shuttle service provide sufficient quality and capacity for the last mile in M4H?
- Active mode routes
  There are nice “shortcuts” for cyclists and pedestrians using bridges, but these do not seem to connect logically to the surrounding areas, or the city centre.
- Freight transport
  Since this is also a Makers district, are the needs for transportation of this sector also considered in road design. Additionally, to get to Marconiplein, a road used by freight transport needs to be crossed which is not ideal for accessibility.

This group offered the following design suggestions:

- Great emphasis on Marconiplein
    - Transit-Oriented Development, high residential densities
    - Cyclist and pedestrian oriented, also to get to city centre?
- More attention is needed for the transportation needs of the Makers industry
    - Dedicated infrastructure, or water transport?
    - Also, the employees in this industry, do they have parking spaces in hubs?
- Attention on how the population composition can change over time
    - Shift in transport needs?
    - Is there demand after housing crises is resolved?
- Create good and logical routes to surrounding NBHs
    - For amenities, or provide them within M4H / close to Marconiplein
    - Social cohesion – do not create an "island" within the city
- To realise a large modal share for shared mobility, you need an extensive supply
    - Not 10s of vehicles, but 100s
- Remote parking could work, but consider:
    - Acceptable walking distances, which planners seem to overestimate
    - Pressure on surrounding NBHs
- Create good connections to train station Schiedam Centrum
- A good analysis on how an (automated) pod/shuttle would work in M4H

An important question that was risen was if the design of this neighbourhood focuses on **1)** Long-term needs in addition to short-term needs, and **2)** The need for freight transport.

Things or data that would be good to have: land use map, visuals from street level or VR/XR, (expected) need for freight transport by Makers

Several instruments/models are proposed for the DT:

- The effect on mode choice of:
    - Attractiveness/comfort of bike and pedestrian routes, spatial quality
    - Shared mobility
    - Location of parking hubs, remote parking
    - New modes (e.g. cable cars, water bound transport etc)
    - Makers district / industry
    - **And does this change in the long-term?**
- Needs for Makers (freight transportation, employee parking)
- Potential of shared mobility
- Better prediction of pedestrian and bicycle flows

Considering spatial quality, social safety (incl. nighttime), comfort

3.4. Hub Innovation

The mobility hubs in M4H were given a closer look by this group, given that these locations could also offer other functions. Additionally, the M4H area consists of several subareas which contain their own mix of functions: housing, offices, amenities, and industry. Figure 4 shows how the challenge was presented to the group.

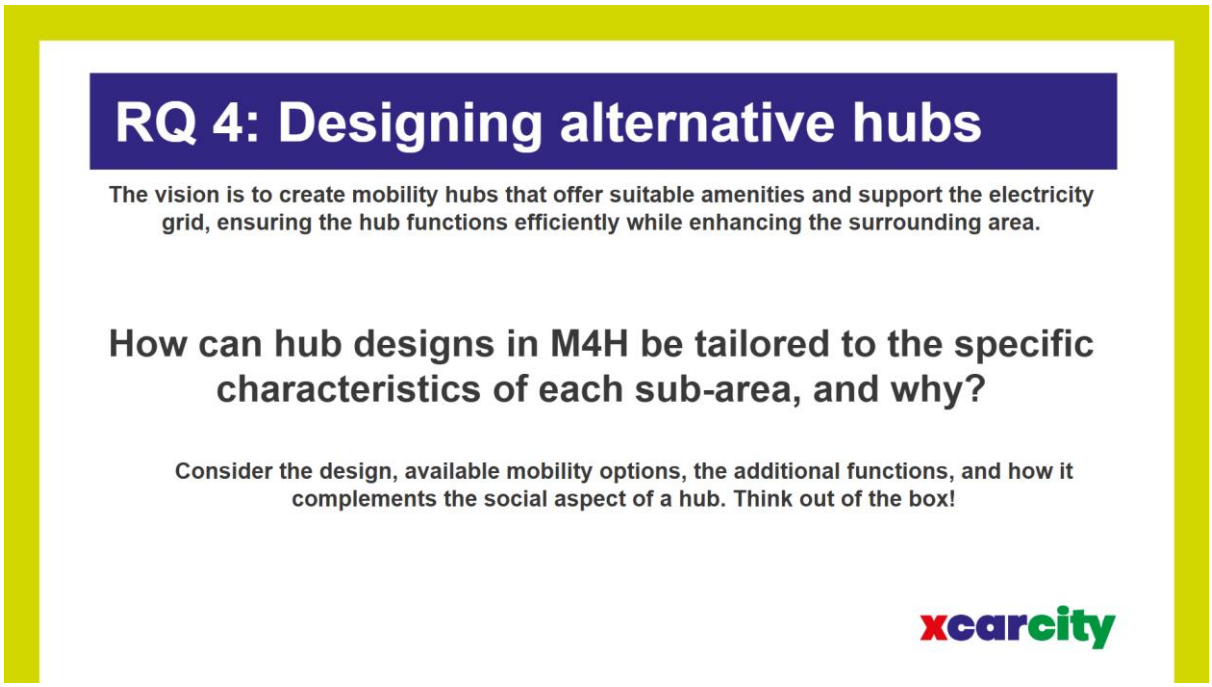

Figure 5: Group 4 focused on the mobility hubs in the different areas of M4H.

The following design considerations are offered by this group:

- Combine hubs with other amenities (e.g. supermarkets), for attractiveness
- Hubs should provide enough visibility for shared modalities
    - Ground/Lowest floor dedicated to shared modes to lower bar
- The following factors are important:
    - Accessibility
    - Coverage
    - Visibility
    - Inclusiveness
    - Simplicity
- Hubs likely create some traffic in their areas, consider this in location choice
- Mode choice is not that elastic towards costs
    - Some people would still use a car, even if it is significantly more expensive
- Subsidies companies / industry for offering shared mobility services to employees
    - Leasing bikes
    - Shared mobility credits (just like OV-business?)
- Provide on-demand services for elderly / less-mobile people

Important take-away from this group is the consideration that if you want shared mobility to be attractive, that these modalities must be visible, easily accessible and inclusive. Creating other functions in and around hubs can play an important role, just like companies can play a big role.

This group would have found it useful to have the following data: land use and their characteristics, empty spaces, charging infrastructure, historical demand, type of people/households in M4H, concept of business model.

The following instruments / models for the Digital Twin are proposed:

- Mode choice
    - Shared mobility included
- Trip purpose / O-D prediction
- Car Ownership
- Housing choices
- Employment choices
- Heterogeneity in population behaviour (socio-demographic groups)
- Optimize the multimodal function

4. Way forward

XCARCITY is progressing steadily, with three Design Sessions completed and numerous other activities organized and upcoming. Following the presentation of the final report for the Almere Pampus Use Case, full attention now shifts to the Amsterdam Zuidas and Rotterdam Merwe-Vierhavens areas.

The upcoming cycle will concentrate on integrating various research outputs and models into a unified Federation of Digital Twins for both Use Cases. This work will be carried out in close collaboration with the respective municipalities, ensuring an iterative process that delivers tools that are useful in their planning and decision-making and remains aligned with what is technically and operationally feasible. The outcomes of this Design Session, which are summarised in Chapter 2 and Chapter 3, will form the basis for the work done in 2026.

Work Package 6

There will be a big role for Work Package 6 this year. Two postdocs will be working on the Digital Twins for the XCARCITY Use Cases: Amsterdam Zuidas and Rotterdam Merwe-Vierhavens. The goal is to answer the following questions in this next cycle:

Zuidas

- How can digital twins capture and assess multi-sensory user experiences (e.g., movement, sight, sound, smell)?
- How can pedestrian travel demand and flows be predicted using limited information about the built environment?

Merwe-Vierhavens

- How can behavioural demand models be integrated into the Digital Twin to better represent how people plan daily activities and adapt their mobility choices?
- How can the Digital Twin be used to test and evaluate new mobility services (e.g., on-demand mobility and hubs), including operational performance aspects such as fleet size, capacity, and location?

Work Package 7

Work Package 7 focuses on connecting the needs of municipalities and other stakeholders to the tools being developed within the project. An important part of this work is maintaining a clear link with Work Package 6, where gathered knowledge and insights are brought together.

- Can we connect current design challenges to the tool development in Work Package 6?
- What stakeholder links are necessary for the research progress?
- What are the goals for the next Design Session?

Work package 7 will also play a role in organising and using Post-Design Sessions as a source of new knowledge and improved collaboration.

If you have any additions, suggestions, or questions regarding this document, please contact:

Tian Zwart – t.zwart@tudelft.nl