Working on better cities with fewer cars

Report: Outcome Report on the XCARCITY–DMI Ecosystem Synergy Workshop

Date: 21 Apr 2025

Author(s): Bart van Arem, TU Delft

Jie Gao, TU Delft

Carla Robb, TNO

Jingjun Li, TU Delft

Contents

1. Motivation for the Workshop

The XCARCITY and DMI synergy workshop, held on Thursday, 10 April 2025, at Het Vakwerkhuis Delft, was organised to explore and identify potential synergies between the XCARCITY research programme and the DMI Ecosystem.

The DMI ecosystem is a national public-private ecosystem aimed at building sustainable and liveable cities together with governments, companies, and knowledge institutions. One of its accelerators the adoption of digital twins in different domains in the Netherlands, such as urban mobility systems. In parallel, XCARCITY focuses on integrating diverse models and methods into a digital twin federation that supports strategic and operational decision-making for cities with reduced private vehicle dependencies.

As both initiatives share a strong focus on sustainable urban environments through digital twin technology, our workshop served as a platform to explore synergies between ongoing research and other national and international digital twin efforts. We also sought to understand how stakeholders at different layers—policy, research, implementation—can collaborate more efficiently, and identify future opportunities for innovation. Amsterdam Zuidas was selected as a specific use case, serving as a practical reference point to review ongoing digital twin developments and identify opportunities for joint actions.

2. Participation

The workshop hosted over 30 participants across the various sectors, including academic institutions, government agencies, research organisations, and industry partners.

The following organisations were present on the day:

- AMS Institute
- CROW
- Gemeente Amsterdam
- Gemeente Almere
- Geonovum
- Goudappel
- Ministry of Infrastructure and Water Management
- Map TM
- Technolution
- TNO
- TU Deft

3. Insights from Separate Presentations

3.1. Opening Statement

The workshop opened with an introduction by Bart van Arem emphasising the need for innovative, digitally driven solutions to address growing urban challenges such as accessibility and sustainability. The joint effort between the XCARCITY programme and the DMI ecosystem was presented as an opportunity to leverage complementary expertise and resources.

3.2. XCARCITY Introduction

Bart van Arem introduced the XCARCITY programme, highlighting its aim to understand the transformation of urban mobility through digital twin federations. Emphasis was placed on the shift from traditional mobility paradigms towards flexible, service-oriented, and data-driven solutions, aiming for sustainable, inclusive accessibility in increasingly dense urban areas.

3.3. DMI Introduction

Roy Boertien outlined the DMI Ecosystem's purpose, focusing on creating favourable conditions for digital twin scalability and adoption (in public-private cooperation). Key activities include setting unified standards for data exchange and practical demonstrators designed to validate and encourage widespread digital twin use in urban mobility management.

3.4. XCARCITY Digital Twin Federation

Jingjun Li presented XCARCITY's Digital Twin Federation concept, detailing its functionalities for real-time management and strategic urban planning. Core components include data integration, advanced modelling capabilities, interactive visualisation tools and human-in-the-loop control, aimed at effectively supporting sustainable urban mobility decisions.

3.5. DMI Digital Twin Overview

Gineke van Putten introduced Geonovum's National Digital Twin reference architecture, framing it as an interoperable "Digital Twin as a Service". She stressed the importance of open standards that connect data, models and visualisations. Testbeds and field labs already demonstrate how these modular building blocks can be reused nationally and shared across Europe.

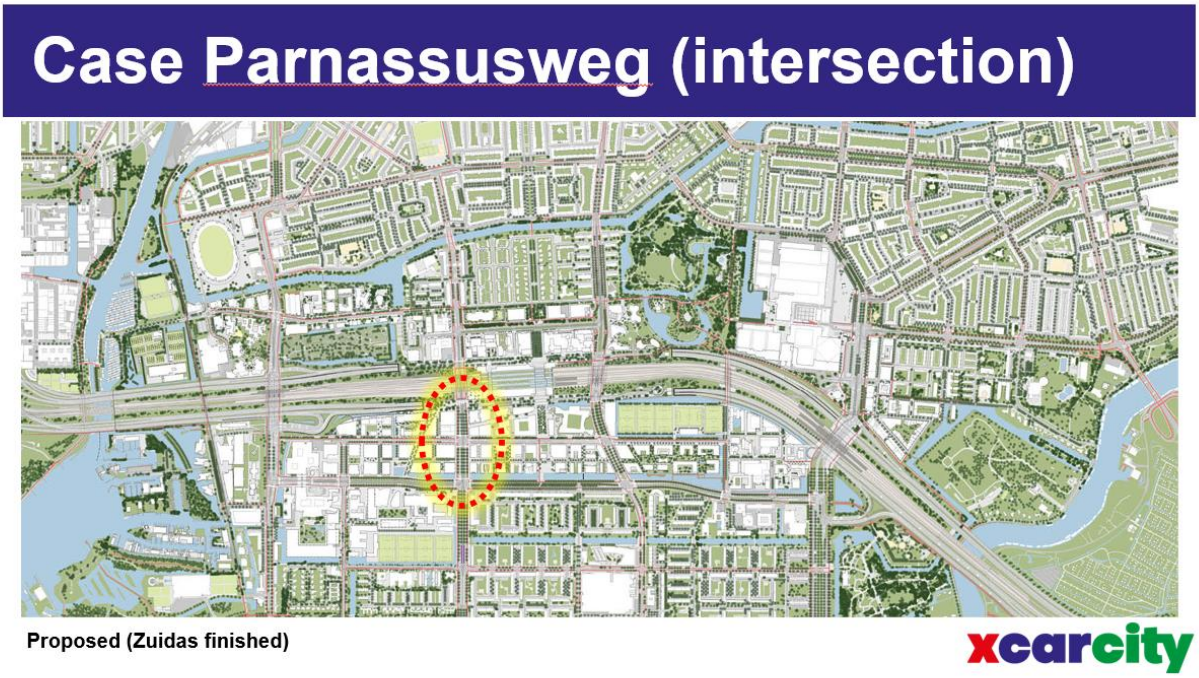
3.6. Car-low Development and Regulation

The session was hosted by Michiel van Dongen, Jyotsna Singh and Sean van der Lee. They addressed regulatory frameworks, strategies, and success factors for car-low city development, showcasing international examples like Copenhagen's cycling superhighways and Barcelona's superblocks. Emphasis was on balancing push (restrictions) and pull (alternatives) strategies, integrated transport planning, and developing measurable KPIs for assessing policy effectiveness.

3.7. Interactive Session

In the afternoon interactive session, Barry Ubbels first introduced the Amsterdam Zuidas redevelopment project, highlighting challenges related to transitioning from a traditionally car-centric area to a more pedestrian-friendly, multimodal urban space. The presentation stressed the importance of digital twins for informed spatial planning and behavioural changes among stakeholders. Currently, Zuidas relies on tools such as 2D mapping and a traditional transport model (VMA). There is a stressing need for new visualisation tools (3D) that support in spatial planning choices (how to divide space between staying and moving). Special attention should be paid for walking as large pedestrian flows in Zuidas are expected after construction.

Then, Bart van Arem summarised insights from surveys during participant registration, noting widespread familiarity with digital twin technologies among participants. He introduced the interactive workshop goals: identifying how digital twins can concretely inform intervention decisions, with special attention to integrating data, models, and visualisation tools effectively.



Finally, in the interactive session, participants were divided into four groups, each tasked with exploring how digital twins could concretely support policy goals at different spatial and decision-making scales. Specifically, participants were asked to look at (1) How can a digital twin help to understand the contribution of the interventions on policy goals; and (2) What are the components of the digital twin in terms of data, models and visualisation?.

Three groups focused on specific intersections within the Amsterdam Zuidas case:

- At the **Micro Level**, Zuidas is eager to explore the interaction between modalities such as public transport, bicycles, pedestrians and cars. How do we evaluate the flows of pedestrians to support the design decisions in the area?
- At the **intermediate level**, Zuidas is aiming to reduce the impact of cars (including traffic flows and better spatial quality). How do we support Zuidas with insight for strategic decisions based in space and time?
- At the **Macro level**, Zuidas is interested in the behaviour change of citizen. How do we shift behaviour to more sustainable modes of transport and what policy interventions could we include to support this.
- The fourth group took an **integrative perspective**, examining how digital twins could effectively aggregate insights from all three intersections into a cohesive planning strategy.

4. Main findings

The XCARCITY–DMI Ecosystem Synergy Workshop successfully identified several areas of common interest and synergy potential between both initiatives. The key outcomes are summarised as follows:

1. **Shared Vision on Digital Twins for Urban Mobility:** Participants reached a consensus on the development and use of digital twins for urban mobility, highlighting four essential components:
    - **Data and Data Acquisition:** Establishing robust methods for gathering accurate and relevant urban mobility data.
    - **Modelling and Analytics:** Enhancing analytical capabilities to better model urban scenarios and mobility behaviours.
    - **Visualisation and Imagination:** Using advanced visualisation tools to better understand and communicate complex urban dynamics.
    - **Interactive Human-in-the-loop:** Ensuring user-centric design and facilitating stakeholder involvement throughout the decision-making process.
2. **Complementary Approaches:** A clear delineation of complementary roles emerged:
    - The **DMI Ecosystem** primarily aims to create favourable conditions for the efficient scaling and broader adoption of digital twins. This includes the development of unified data standards, facilitating seamless data exchange, and setting up demonstrators to showcase practical applicability.
    - The **XCARCITY Project** contributes foundational knowledge on digital twin components and develops tailored demonstrators that translate research insights into real-world applications. It focuses on fundamental research into the building blocks of digital twins, providing the scientific basis needed to design and evaluate innovative mobility solutions in urban environments.
3. **Common Demonstration Areas:** There was notable alignment regarding demonstration locations, with Almere, Amsterdam, and Rotterdam identified as mutually beneficial cities for piloting and validating digital twin solutions.
4. **Commonality of Partners:** The workshop highlighted significant overlaps among key stakeholders and partner organisations involved in both ecosystems, including:
    - Ministry of Infrastructure and Water Management (IenW)

   - TU Delft
   - TNO
   - City of Amsterdam
   - AMS Institute
   - City of Almere
   - MapTM
   - Fietsersbond
   - BAM Infra
   - Technolution

   This shared network provides a strong foundation for collaborative initiatives and joint projects.

5. **Digital Twins for Sustainable Accessibility:** Participants proposed specific use-case suggestions illustrating how digital twins could support decision-making for sustainable accessibility in the Amsterdam Zuidas area. Digital twin could effectively demonstrate the impacts of various infrastructure and policy options, enabling stakeholders to visualise and evaluate their implications comprehensively.

5. Future steps

The workshop identified substantial opportunities for deeper collaboration between the DMI Ecosystem and the XCARCITY Programme. Specifically:

- **Structured Collaboration Framework:** To build on the synergies identified during the workshop, the development of a concrete collaboration framework or joint action plan is recommended. This would enable more systematic knowledge exchange, coordination of ongoing efforts, and alignment of goals across both initiatives.
- **Joint Demonstration Projects:** Immediate opportunities were identified to jointly pursue demonstrator projects in Amsterdam Zuidas and Almere, where ongoing activities can readily benefit from collaboration. Furthermore, substantial long-term collaboration potential exists for the Merwe4haven area in Rotterdam, which is currently in its planning phase.

6. Pictures During the Workshop

Figure 1 Group Picture

Figure 2 Opening Session by Bart van Arem & Roy Boertien

Figure 3 Result Demonstration of the Pre-Workshop Survey

Figure 4 Discussion during the Interactive Session

7. Appendices

Appendix 1: Results from the Zuidas Interactive Session

7.1. Group 1: Intersection 1 Microlevel

Interaction between modalities PT/Bike/Pedestrians/cars and interfering flow of pedestrians – insights for design decision in the public realm

Summary of the discussion:

Components of the digital twin: The digital twin ingests infrastructure and mobility-device sensor data (e.g. check-in/PT data), origin–destination and received data, and synthetic scenario datasets, plus traffic-flow measurements, which feed into a predictive modelling framework that links data and model layers.

Policy-goal contributions: An interactive visualisation model lets stakeholders compare the social, financial and environmental impacts of different interventions, select and analyse specific KPI subsets, and integrate multi-sector data for a holistic evaluation of policy measures**.**

Translation of the Results from the discussion:

Digital Twin Components
• Infrastructure in the area • Check-in/out Public Transport → Mobility Driven • O-R-D • Synthetic/senarto area • Traffic flow data • Pedestrian model • Data ←→ Model
Digital Twin support with understanding the contribution of the interventions on policy goals
1. **Visualisation** helps to understand the difference between the impact of different model/s limits, the bottom line, social, environments 2. Select **subset of measures** (compare, analyse, understanding) 3. **Integration** of different sectors

7.2. Group 2: Intersection 2 Intermediate Level

Impact of reducing cars (traffic flows and spatial qualities) and insight for strategic decisions (in space and time)

Summary of the discussion:

Components of the digital twin: By modelling traffic-management interventions in real time, visualising multimodal flows (pedestrians, cyclists, vehicles), running scenario-evaluations (e.g. car-free vs. car-access, liveability trade-offs), animating time-lapse impacts and integrating stakeholder feedback to quantify each measure's effect on policy objectives.

Policy-goal contributions: It combines a vehicular traffic model, pedestrian & cycling agent-based modules, amenity/service-area and spatial-quality layers with 3D physical infrastructure, target-group profiles, traffic-flow and noise datasets, and delivers both numerical dashboards for decision-makers and immersive (e.g. VR) experiences for broader stakeholder participation.

Translation of the Results from the discussion:

Digital Twin Components	
• Traffic management interventions in models • Real-Time Code • Making flows transparent • Scenario evaluation: • Car-free • Car Accommodation • Liveability ++ • Time lapse modelling Stakeholder consultants	
Digital Twin support with understanding the contribution of the interventions on policy goals	
Model	**Data**
• Traffic model • Pedestrian and cycling (ABM) • Amenities and servicing area • Spatial quality	• Model 3D • Target group profiles • Traffic management • VR

7.3. Group 3: Macro Level

Impact of set of interventions of behaviour changes and insights for policy making

Summary of the discussion:

Components of the digital twin: It combines an activity-based, multi-modal individual behaviour model (walking, cycling, PT) calibrated with pedestrian counts, PT exit flows, energy and population-growth projections, plus intersection-delay and signal-control engines, all delivered through interactive 3D or dashboard visualisations for strategic planning and stakeholder engagement.

Policy-goal contributions: The digital twin simulates traffic-management interventions and dynamic road space reallocations in real time—making pedestrian, cycle and vehicle flows visible—supports "what-if" and time-lapse scenario evaluations (e.g. car-free vs. car-access, off-peak logistics), captures experiential factors and stakeholder feedback, and enables immersive trials (e.g. bike highways) to quantify each measure's impact on safety, liveability and network performance.

Translation of the Results from the discussion:

Digital Twin Components
1. Activity based – to understand peoples intensity 2. Pedestrian/energy data 3. Pedestrian visualisation 4. Dealy of intersection s 5. Train data/PT data 6. Monitor all exist of train stations 7. Population growth – projection 8. Real tine data 9. Influence green time and typical data strategic planning 10. Logistics – supply – no ca – how? (off peak and dynamic road allocation) 11. XR – feedback Future immersive 12. Bike highway – visualisation – future
Digital Twin support with understanding the contribution of the interventions on policy goals
1. People walking: Students, workers: We need to know people and then design the change behaviour 2. Mobility hub: Hard to change the mode – mobility hub can help 3. Company bike 4. Solar panel – underground (energy and mobility 5. Model the energy – hard to get data 6. Battery stating in buildings – Interaction of different models 7. Mobility/Public transport/Person/Simulations lacking but important 8. Multi modal of individuals – data to calibrate the model (Q2)

7.4. Group 4: All Intersections

Consolidate approach across 3 intersections

Summary of the discussion:

Components of the digital twin: It integrates an organised suite of computational models (traffic assignment, climate-adaptation and crowd-management), multi-level 3D and dashboard visualisations tailored to decision-makers, pedestrian/cyclist flow and experiential modules, ambition-level data layers on outcomes and adaptation needs, plus predictive engines for forecasting mobility and behavioural change.

Policy-goal contributions: It provides a clear reference of the current road network and public-transport links, lets you compare scenarios (e.g. upgrading three parallel roads vs. enhancing PT connections), quantifies modal-shift potential for target groups (students, commuters), and supports co-creative “brainstorm and test” workshops to refine and validate intervention proposals.

Translation of the Results from the discussion:

Digital Twin Components
• Visualisation for communication and improved decision making • Visualisations • Orchestration of models • Modeller for climate adaptation • Pedestrian models
Digital Twin support with understanding the contribution of the interventions on policy goals • Modal shift from vehicle to public transport • Reference situation, current situation and proposals

Scanned images of the results

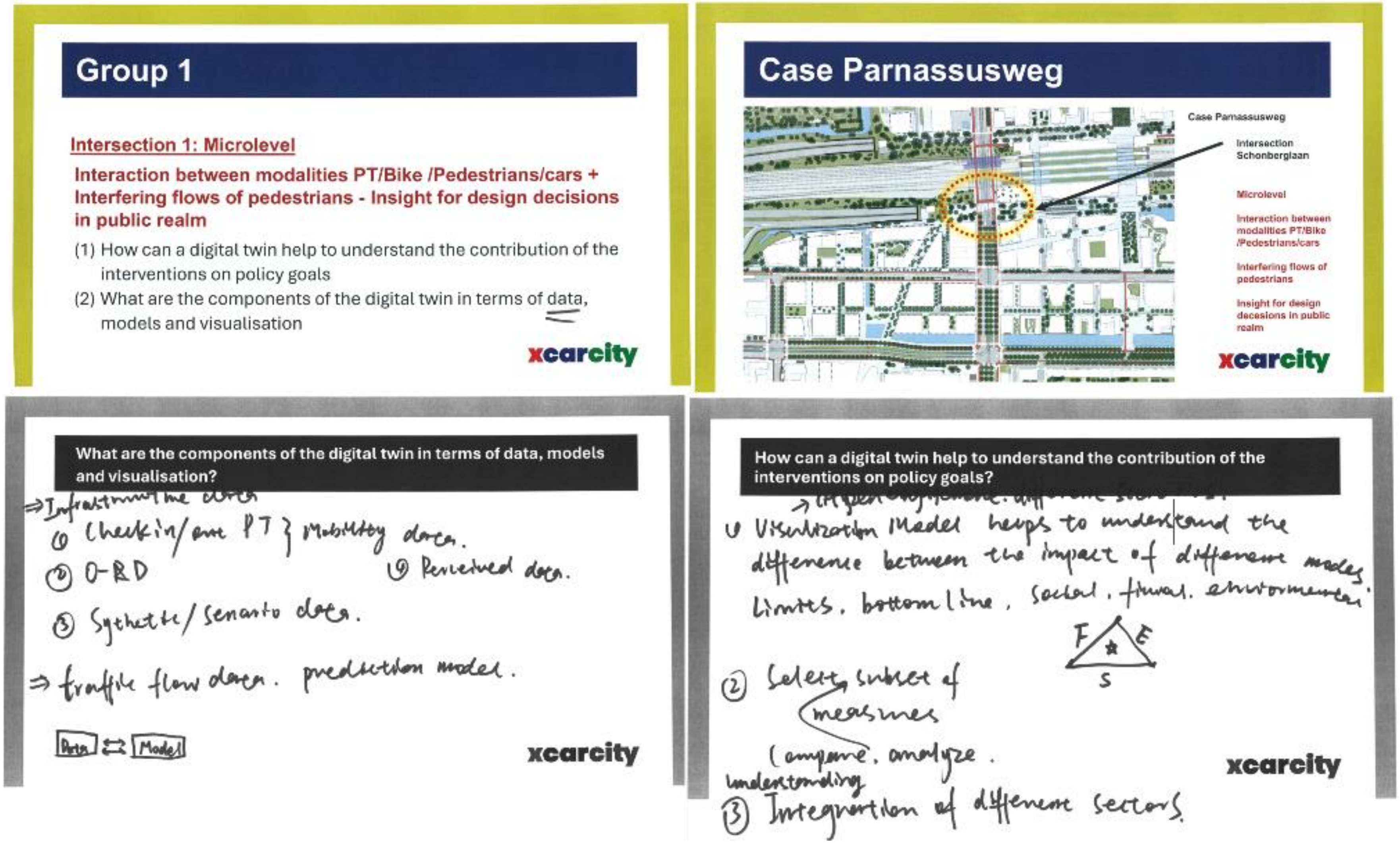


Figure 5: Scan of Group 1 results

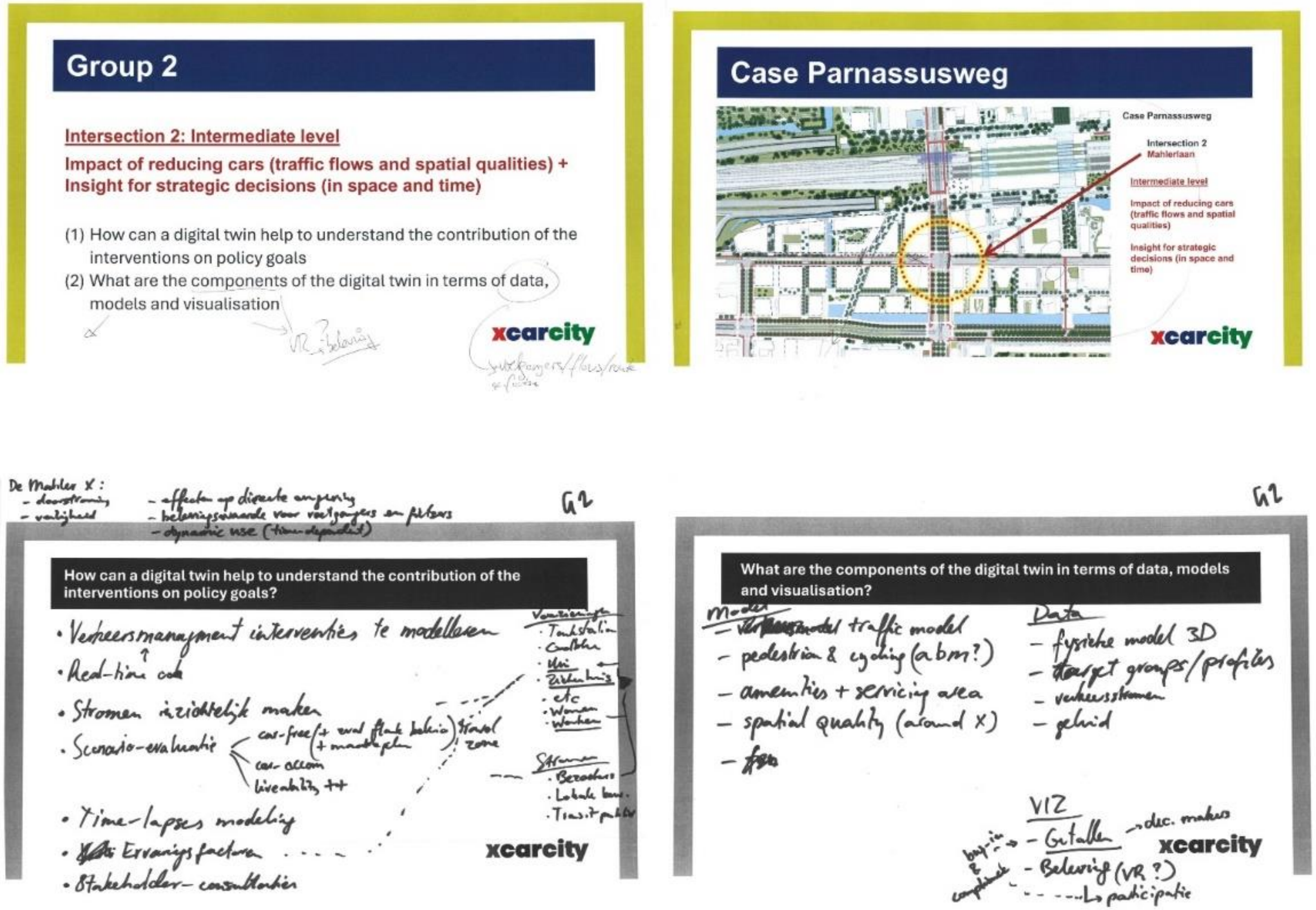


Figure 6: Scan of Group 2 results

Group 3

Intersection 3: Macro level

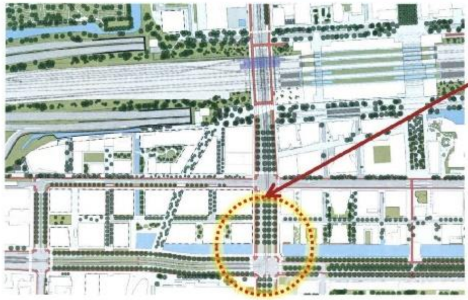
Impact of set of interventions of behavioral changes + Insight for policymaking

(1) How can a digital twin help to understand the contribution of the interventions on policy goals

(2) What are the components of the digital twin in terms of data, models and visualisation

xcarcity

Case Parnassusweg



xcarcity

What are the components of the digital twin in terms of data, models and visualisation?

1). Activity-based model understanding ppl's intension.

2). D: Pedestrian / energy data

3). pedestrian visualisation.

4). delay of intersection.

5). real-time data: ? influence green time.

+ typical data: strategic planning.

6). Train data / PT data.

monitor all exit. 4 train station,

7) ~~cyclist~~ population growth → projection

xcarcity

Inter

8) logistics. → supply → no-car → How?

off-peak

dynamic roadspace allocation.

9). ~~How we use the spaces?~~

XR → feed back → Future

Immersive n

Inter

10) Bike highway. → visulisation / future → let ppl try

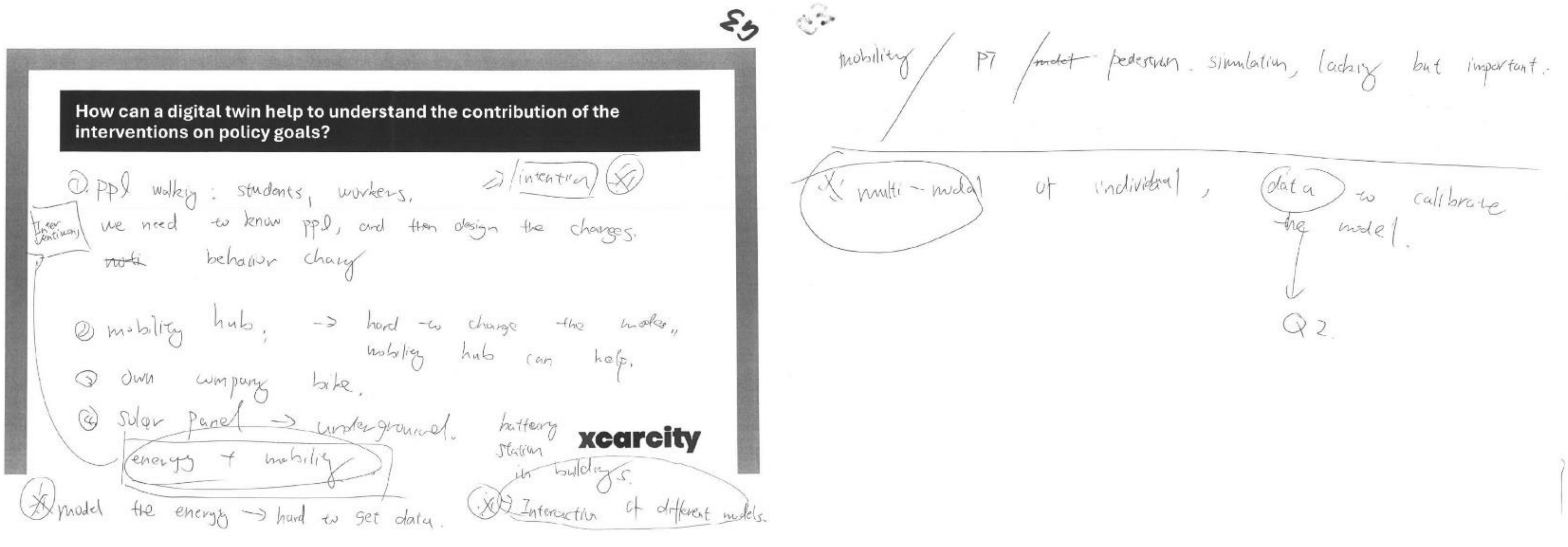


Figure 7: Scan of Group 3 results

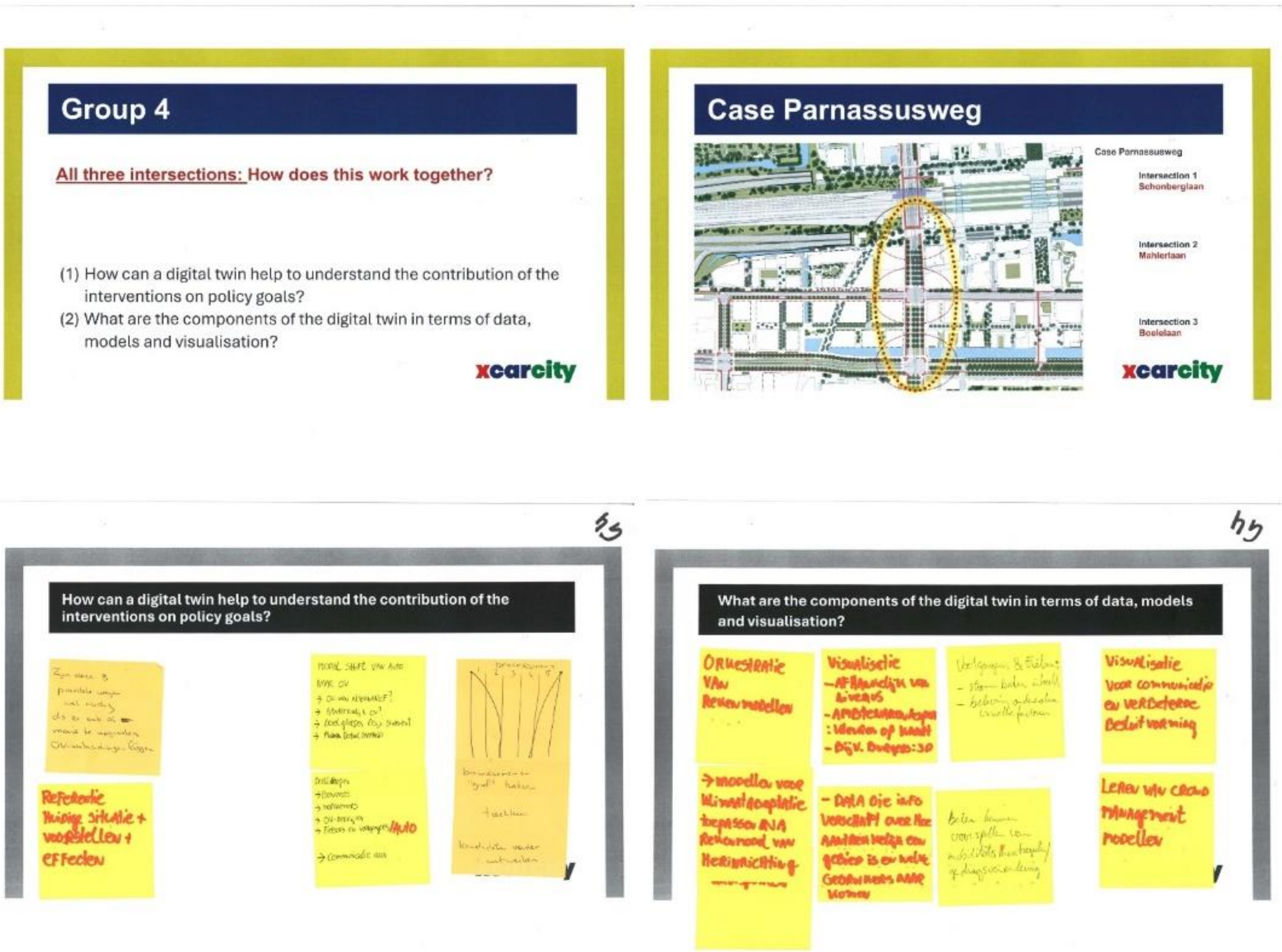


Figure 8: Scan of Group 4 results

Appendix 2: Slides from the Presentation

Attached as separate PDF