
TUMCREATE
interactive virtual research lab

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June 2017

TUMCREATE + ARS ELECTRONICA FUTURELAB

About TUMCREATE

TUMCREATE is a research platform for the improvement of Singapore's public transportation, including the deployment of electric and autonomous mobility. Researchers from Technical University Munich and Nanyang Technological University join forces and are funded by Singapore's National Research Foundation as part of the Campus for Research Excellence And Technological Enterprise (CREATE).

TUMCREATE consists of over 100 scientists, researchers and engineers led by professors from the Technical University of Munich (TUM) and Nanyang Technological University (NTU).

TUMCREATE was founded in 2010 to foster research collaboration between Singapore and TUM, following the foundation of TUM Asia in 2002 for providing TUM educational programmes in Singapore. In its first phase (2010 - 2016) the research focussed on electromobility in megacities. In the second phase (2016 - 2021) the research is now focussed on defining the ultimate public transport system for Singapore through a vision involving electric autonomous vehicles as a part of public transport from 2030 onwards.

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Background

TUMCREATE consists of six groups investigating different research domains, all related to certain aspects of mobility (Image 1).

Within Phase 2, TUMCREATE focuses its research activities for the development of a Semi-Rapid Transit (SRT) system as ultimate public transport system for Singapore. The SRT consists of several vehicle modules, intelligent infrastructure, intelligent bus stops, operation and control centre and a full ITS connection. The main research objectives are:

- to study the feasibility of this SRT system in large megacities like Singapore
- to integrate such a new public transport mode into the existing hierarchical public transport system.

Because of the complexity of the SRT system and the variety of research areas within TUMCREATE, it has been necessary to rethink the way interdisciplinary research can be done. A research platform is needed in which researchers from diverse areas – traffic engineers, computer scientists, electrical and mechanical engineers as well as designers – can reach their research goals in an efficient way, learning from each other's, with the possibility of collaboration with external partners. With a such research platform, it will be possible (among others) to:

- run simulations at microscopic and macroscopic levels,
- facilitate the conception and design of stations, vehicles and infrastructure,
- assess the impacts of operations strategies on the system and on travel patterns,
- analyse user behaviours and user perception of news mobility systems, like the SRT.

Beyond the everyday research activities, a platform for demonstration is also necessary. Indeed, TUMCREATE hosts several delegations every year with visitors ranging from project reviewers, university professors, industry partners, government officials, decision makers, funding agencies to students and people without scientific background. Communication channels like White Papers may not be suitable for the entire audience and for meetings with several attendees, therefore, it was necessary to imagine a demonstration platform in which:

- the results can be understood by everyone,
- the results can be lived as a shared experience to maximize the impacts on the audience.

The Interactive Virtual Research Lab is a solution that combines the diverse needs for a research and a demonstration platform.

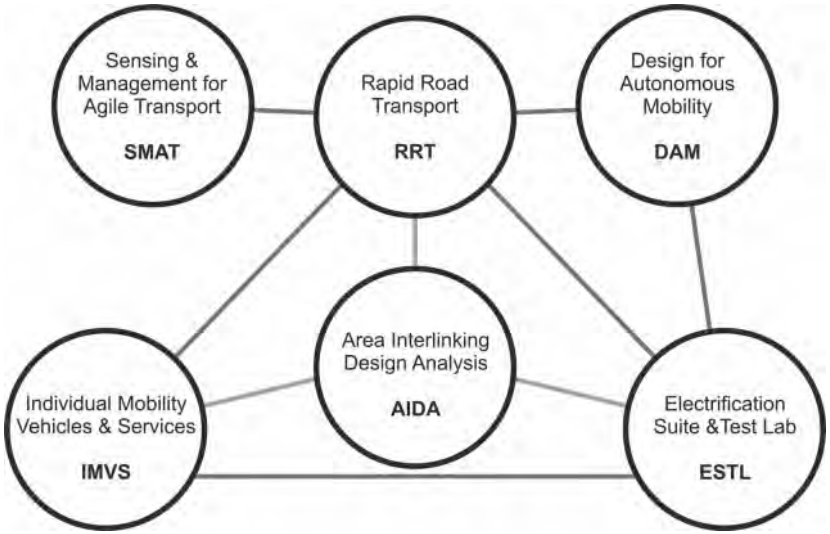


Image 1. Research groups and structure, TUMCREATE

Aim

To develop a unique research and demonstrator platform for urban mobility - which merges the interdisciplinary scientific expertise of TUMCREATE with the available technology for virtual reality.

Motivation

To strengthen the research excellence of TUMCREATE in the field of mobility and to increase its visibility within the scientific community in Singapore and beyond.

- As agreed upon at the 6th May 2016 meeting at TUM, Munich by the TUMCREATE management and PPIs.
- Wish from NRF about common research goals; experience from Phase 1 review.
- Demonstration at the mid-term review (2018 - 2019) and at the ITS world congress (2019)

Image 2. Experiments in virtual reality (VR)

Image 3. Ars Electronica Center, Linz, Austria

ARS ELECTRONICA
FUTURELAB

www.aec.at/futurelab/en/

Ars Electronica Futurelab focuses on the future at the nexus of art, technology and society. Their works are considered as sketches of possible future scenarios in art-based experimental forms.

The work of the Ars Electronica Futurelab is directly linked to the various partners from the business zones of manufacturers, the creative industries, art and from the academic world. Their range of services concentrates on expertise developed throughout the years in fields such as media art, architecture, design, interactive exhibitions, virtual reality and real-time graphics.

Collaboration

Contact to the Ars Electronica Center was first initiated in November 2016 by DAM and AIDA. This relationship has been further strengthened by a short collaborative project that was successfully completed in May 2017.

With expert domain knowledge in latest visualization technology and aligned research interests, Ars Electronica Futurelab forms an ideal entity for collaboration on the interactive virtual lab project and further for extending the boundaries of ongoing mobility research.

Image 4/5. Deep Space 8K at Ars Electronica Center, Linz, Austria

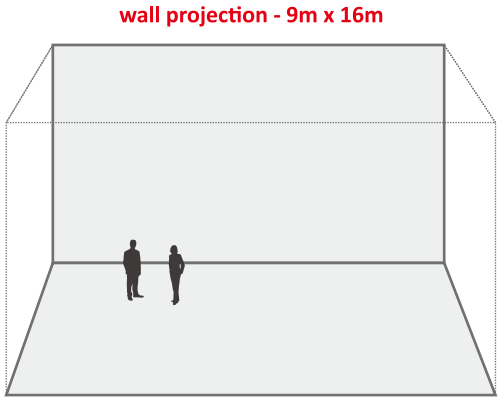


Image 6. Deep Space 8K setup, Linz, Austria

Deep Space 8K

Deep Space 8K, a 16×9 metre wall and 16×9 metre floor built for projection and laser tracking – with stereo 3D projection, 8K resolution and 120Hz frame rate, it takes the experience of virtual reality immersion to the next level.

In this special space you might find yourself transported to the ancient Mayan city of Tikal, scale the Alps, take a flight across the entire known Universe, or travel through the human body in ultra-close-up. The Deep Space 8K is not only a room in which breathtaking pictures and videos in 3D can be shown with unmatched precision, but also a place at which it is possible to refashion the exhibited material.

Image 7. Collective / shared experience within Deep Space 8K

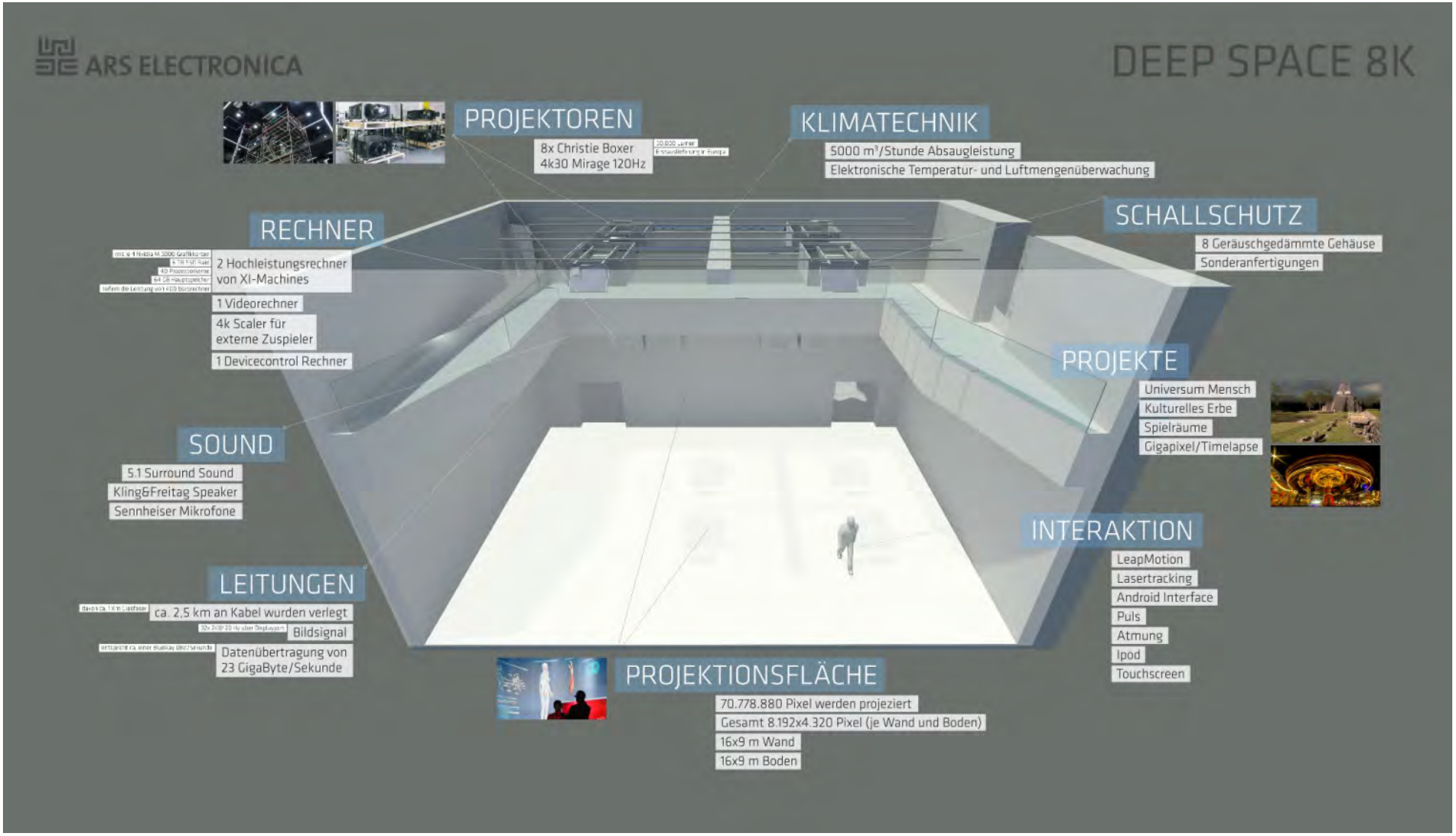


Image 8. Deep Space 8K setup, Linz, Austria

Solution - Interactive Virtual Research Lab

The first version of the Interactive Virtual Research Lab has been developed by DAM and AIDA for supporting the ongoing mobility research at TUMCREATE and for demonstrating the results. This platform is based on a state-of-the-art visualization equipment including virtual reality head mounted displays (HMD) (Oculus Rift) and the Deep Space 8K developed by the Ars Electronica Center in Linz, Austria.

Humans in this virtual immersive and responsive environment can be observed how they interact with a partly real, partly virtual vehicle, and their responses to various AV communication strategies can be easily sensed, tested and verified using the 3D virtual immersive environment. This would not be possible otherwise, unless we make working prototypes with additional sensors and test it in real world situations which are far more time, effort and finance consuming.

This research tool enables an impressive visualization and live experience of vehicle concepts, mobility systems and operation strategies at a city scale which is understandable to scientists, students and people from various backgrounds.

Benefits

For research
the Interactive Virtual Research Lab

- is ideal for data exploration and design review applications
- facilitates the communication between the research groups by visualising directly the research steps within a common platform
- can be used without complete isolation from the real world (in comparison with Head Mounted Display which can be disorienting)
- limits the necessity of real-life experiments with cost-intensive prototypes involving daily traffic of Singapore, pedestrians and passengers. Such prototypes would furthermore require time for construction and validation regarding safety and legal issues
- validates the concepts before actual prototyping. Virtual Reality is already included within the R&D activities of OEMs for scientific and engineering applications.

For demonstration
the Interactive Virtual Research Lab enables

- the visualisation of the entire SRT system and its deployment on a city scale (not possible with physical prototypes)
- an innovative channel to show research results in addition to the traditional White Papers or conference presentations
- an immersive environment that maximizes the impacts on the viewers
- a shared experience with multiple viewers, ideal for small group presentation

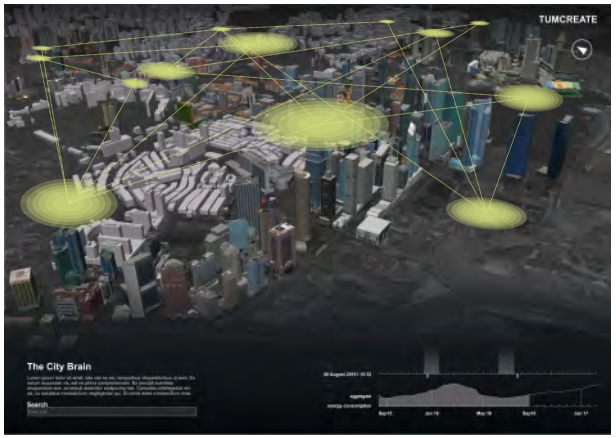
Concept

If a city is viewed from above, it is a world in motion. Trains carry people to and from work; taxis circulate in abstract patterns; trucks deliver goods and carry away garbage; pedestrians walk down city blocks; cyclists zip through traffic. Mobility is the lifeblood of our cities and essential for urban life.
Urban mobility needs to be analysed holistically in order to understand its interactions with infrastructure and people, and its impacts on ecology and society.

Hence it is important to deploy various mobility concepts and strategies in a city scale simulation and analyse its effects at various scales. For eg. various operational strategies for platooning of SRT modules could be deployed in simulation and visualized at a street or human scale where as the effect of such strategies on traffic congestion or on charging infrastructure or station placement could be viewed at a district, regional or city scale. Impact of congestion, terrain or frequent stops on various vehicle sub-systems could be visualized in real-time for effective communication.

City scale

Regional scale



District scale

Street/junction scale

Human scale

Vehicle/component scale

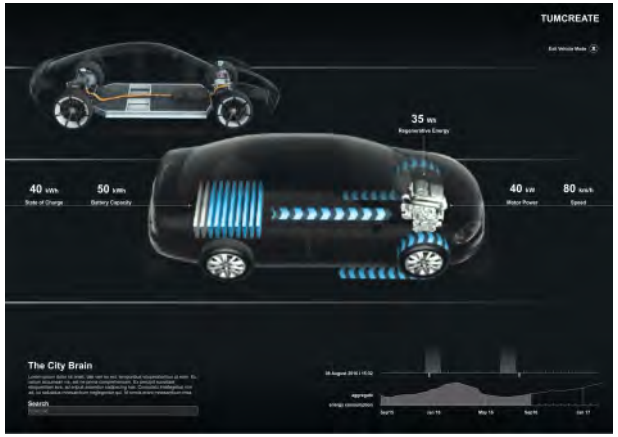


Image 9. Holistic mobility simulation at multiple scales

Interactive Virtual Research Lab - Setup using Deep Space 8K

The setup for the Interactive Virtual Research Lab consists of 3 key components:
a. humans or test subjects who are immersed into the city scale simulation using head mounted displays (HMD)
b. a projection on the wall displaying the first person view of the test subjects (humans) immersed into the simulation
c. a projection on the floor displaying an overview of the city simulation where the humans are interacting

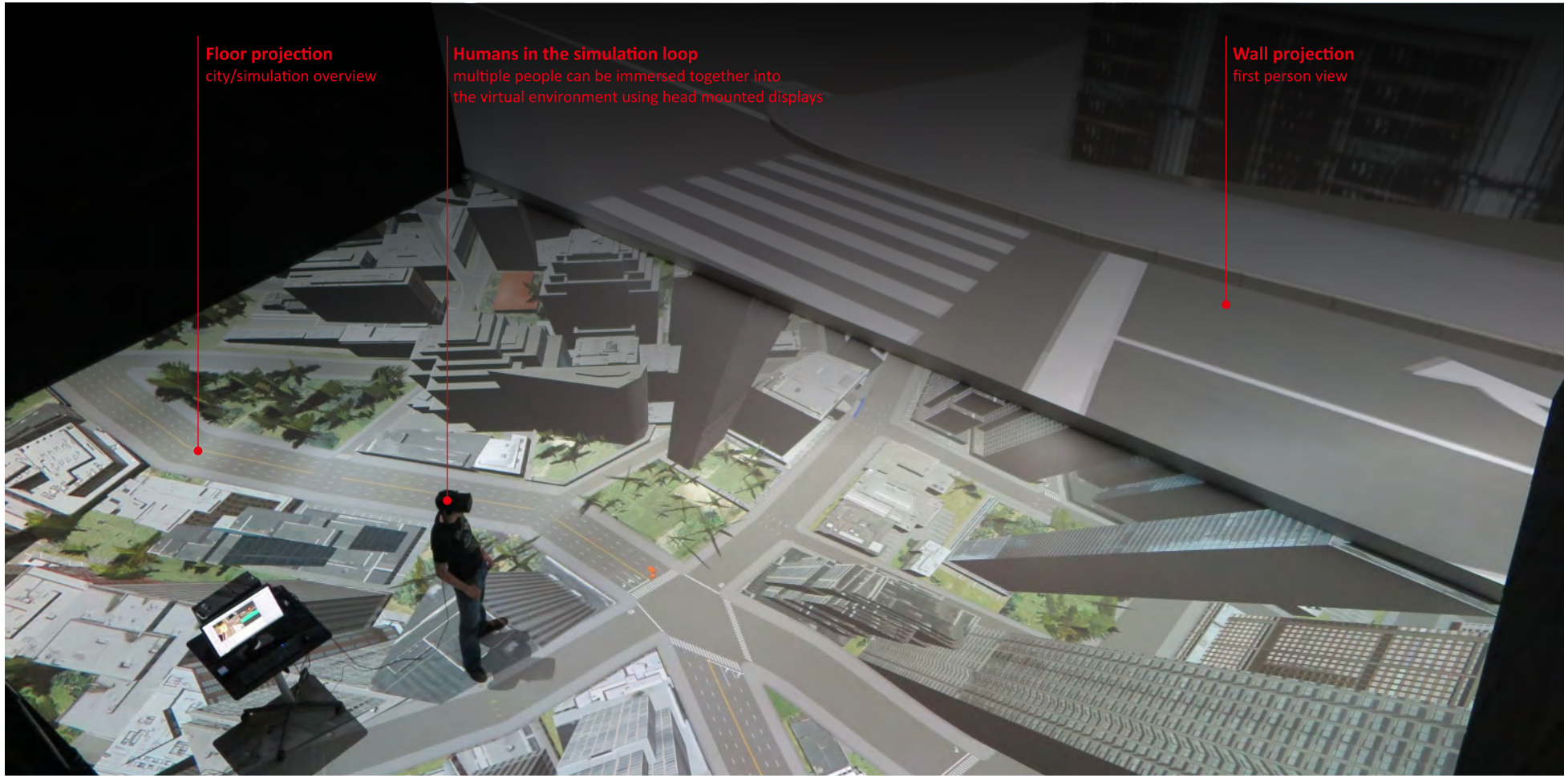


Image 10. TUMCREATE demonstrator setup in deep space

Usecases

Following experiments are foreseen:

- Interaction, between AVs - pedestrians - other traffic participants
- Analysis of dwelling time; boarding and alighting of passengers depending on the stations, platforms and vehicle design
- Investigations on effectiveness of information and guidance systems
- Development of HMI systems at the stations, in and out the vehicle

A platform for

- institutions to visualize and study new mobility concepts and human interaction
- government agencies or research institutes for testing social acceptance of new infrastructure concepts / new information systems / visualization of future transport plans
- collaborative projects for understanding interdependencies over different disciplines

Autonomous Vehicle (AV) Interaction

(immersion + interactive visualization essential)

AV communication strategies could be designed, tested and verified using this platform, which would not be possible otherwise.

Experiencing New Mobility Concepts

(immersion + interactive visualization essential)

New mobility systems and vehicle concepts can be live experienced and social acceptance of new technologies can be assessed.

Research Demonstrations & Data Analysis

(high fidelity visualization essential)

Demonstration of holistic mobility concepts and its impact at a city scale which is understandable to people from various backgrounds.

Demonstration 29.05.2017
Ars Electronica Linz, Austria

Image 11/12 (top). Demonstration in Linz, Austria 29.05.2017
Image 13 (bottom). Demonstration banner, 29.05.2017

Image 14. Interaction with an AV at a crossing, human in the loop simulation

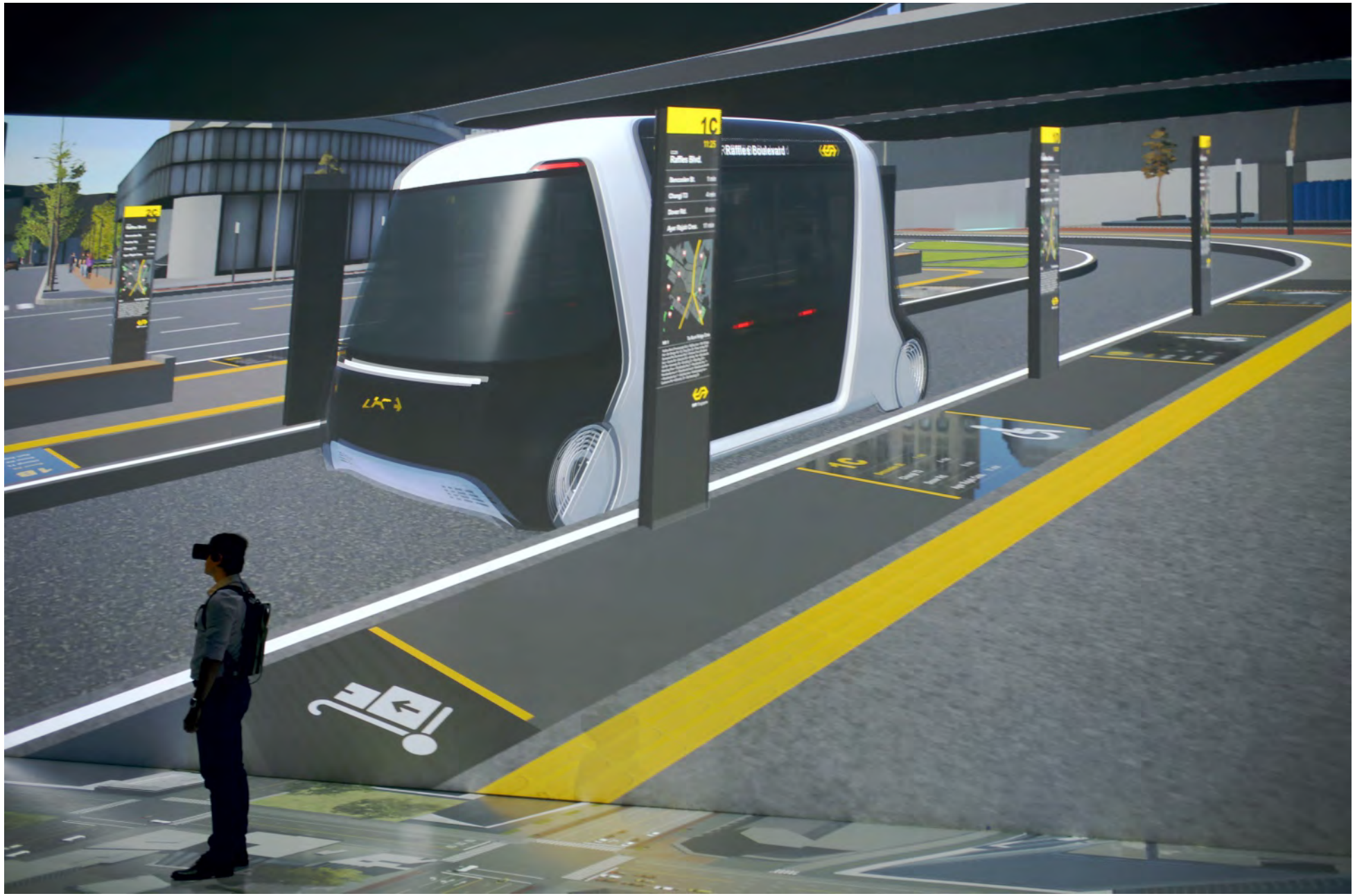


Image 15. Experiencing new mobility concepts, SRT station scenario

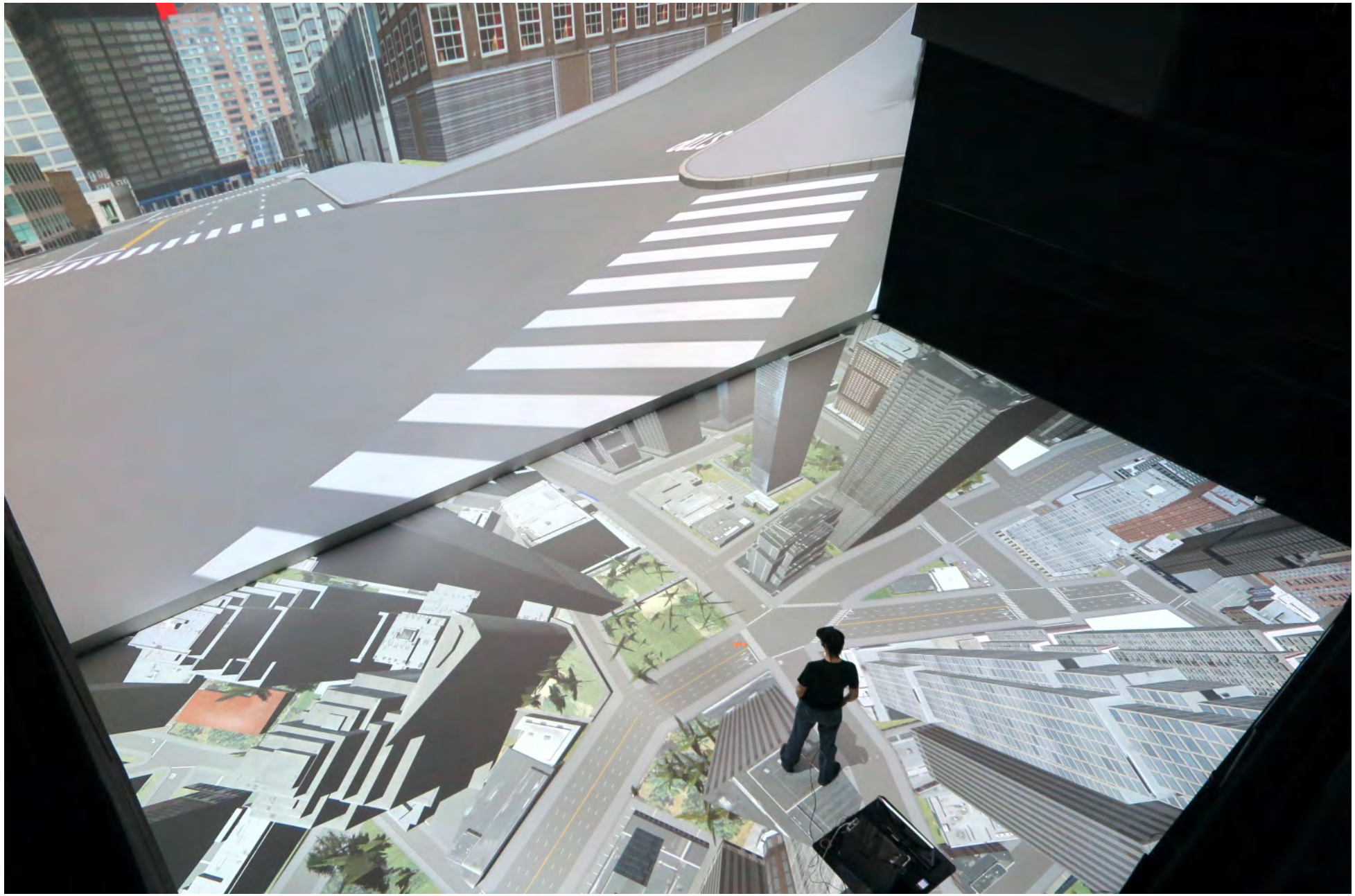


Image 16. Deep space 8K, impressive scale for a convincing research demonstration

Image 17. Interaction with pedestrians in the virtual environment

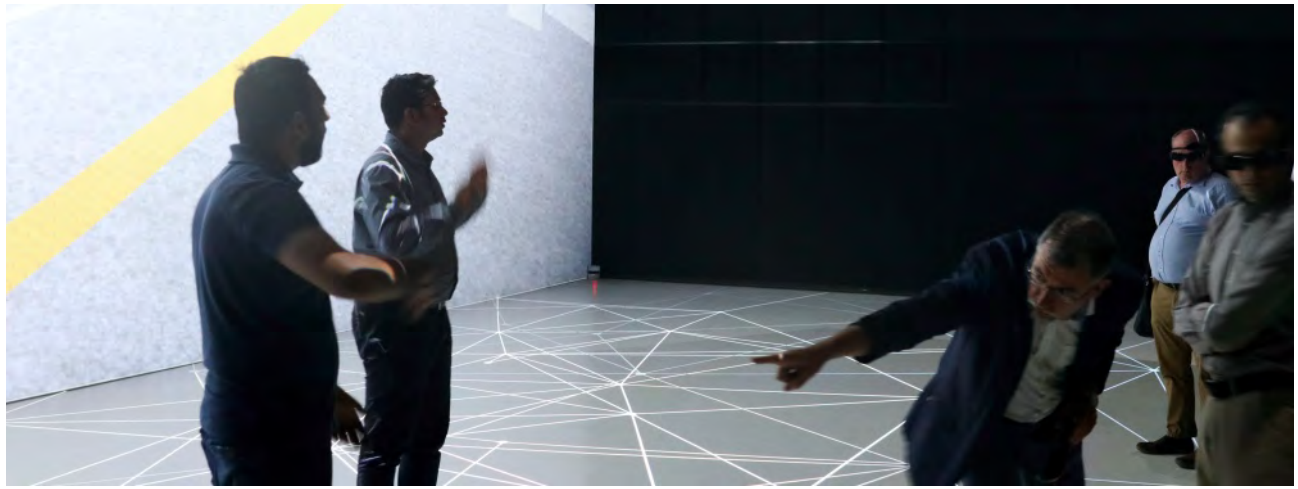
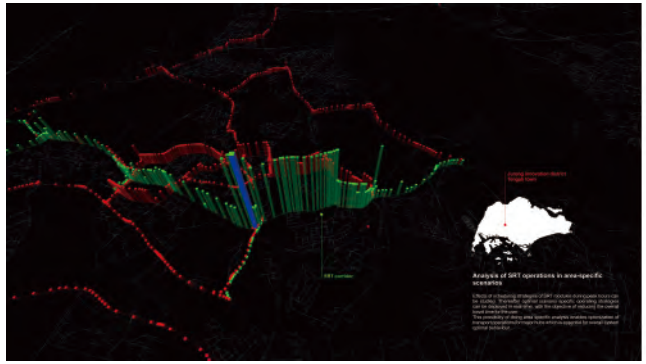


Image 18 (collage). Impressions of the demonstration in Linz

Image 19. Impressions of the demonstration in Linz



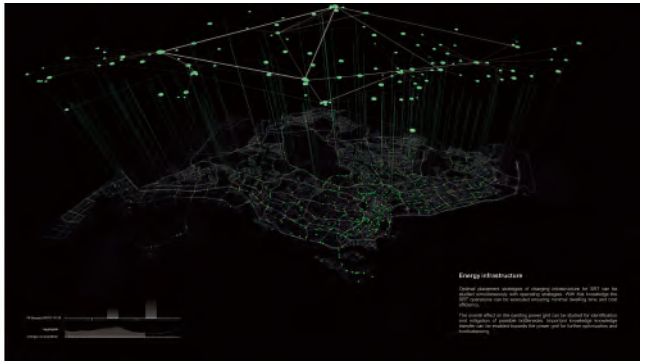


Image 20. Data analysis and presentation of simulation results, impact at Singapore scale

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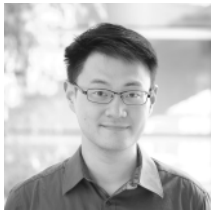
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