Application Case – Urban Traffic Forecasting

Case Study 1: Macroscopic Forecasting
Data Sources & Processing
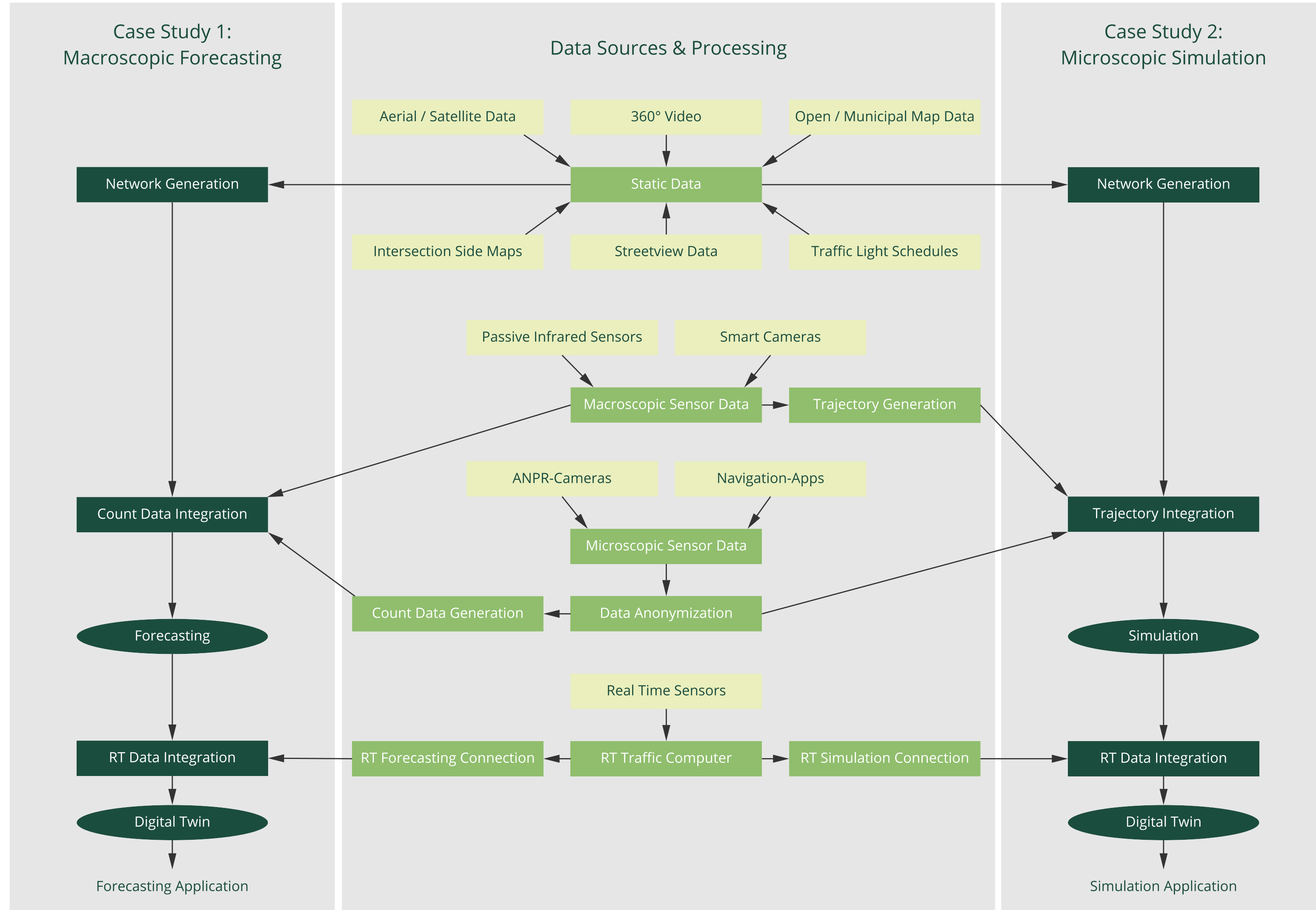### Case Study 2: Microscopic Simulation

Fig. 1: Macroscopic Forecasting and Microscopic Simulation

Macroscopic and Microscopic

On using anonymized data for traffic forecasting

Traffic simulation and forecasting can be done on a microscopic or macroscopic level. Microscopic simulation can be based on anonymized trajectory data retrieved from floating sensors and modelling actual traffic flows through a city on an individual level. Macroscopic forecasting can be based on anonym count data from fixed sensors allowing for real-time traffic prediction given a real-time sensor network.

Case Study 1: Macroscopic Forecasting
- Predict traffic situation for optimal commuting times
- Multiscale multistep prediction for long prediction window and increased performance with Graph Neural Networks to allow for forecasting with various sensors and modalities
- Road Network agnostic traffic forecasting

Case Study 2: Microscopic Simulation
- Traffic Simulation for traffic light optimization
- Integration of static and dynamic data into traffic simulation software SUMO
- Detailed knowledge on road network, traffic light schedules is required and can be modelled

Foundation Models and Multi-step, Multi-scale Traffic Flow Time Series Forecasting
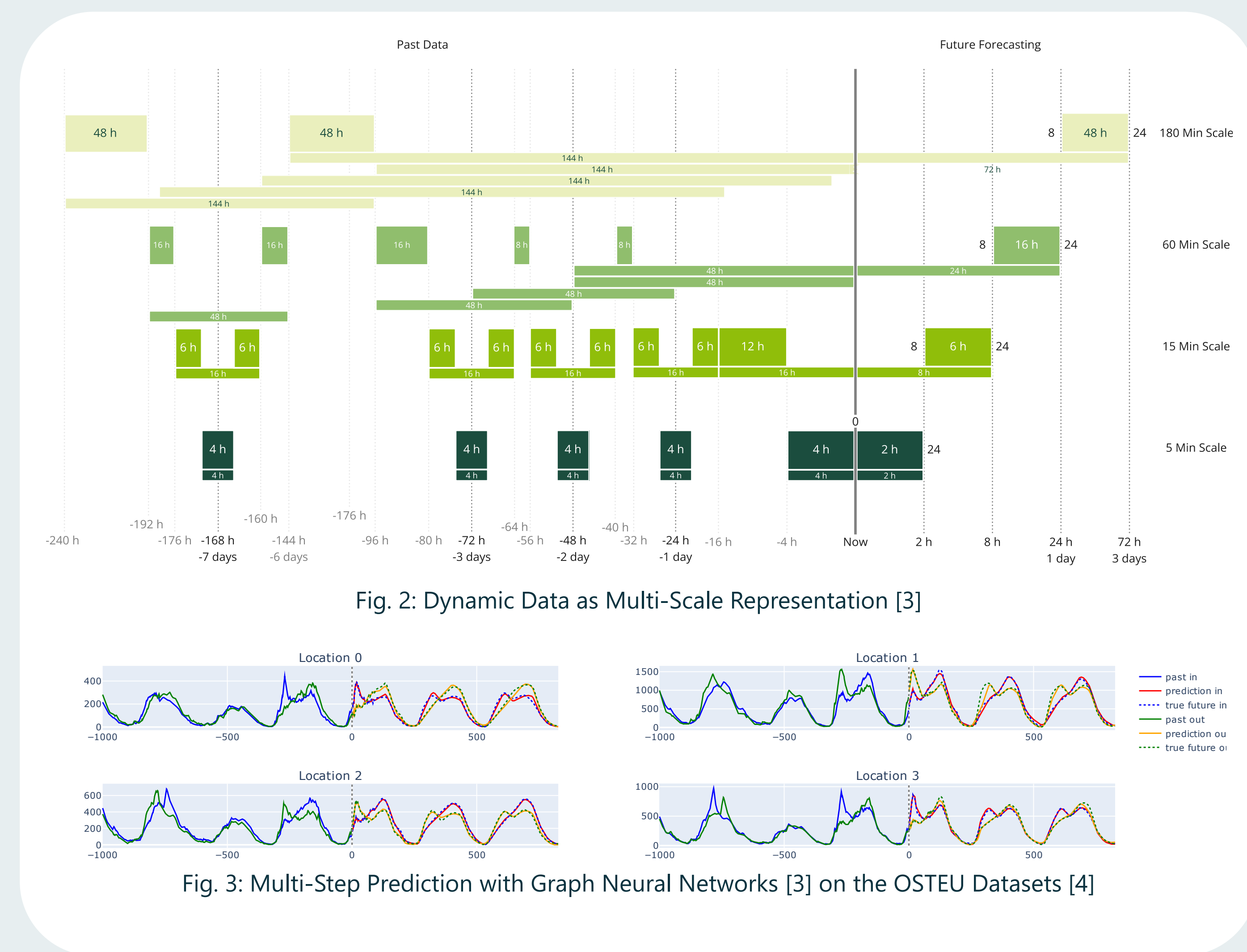
Foundation Models
- Large-scale AI models Trained on massive datasets
- Self-supervised learning
- Adaptable to multiple downstream tasks
- Multimodal

Urban Foundation Models (UFM)
- Designed to understand, analyze, and predict complex urban environments
- Pre-trained on diverse urban data sources
- Enable smart city applications such as traffic management, urban planning
- Integrate multimodal data (e.g., satellite imagery, sensor data, maps, social data)

Malicious Use: Urban Foundation Models [2]
- **Fake content injection:** Manipulating POI ratings / Fake POI recommendations, e.g. recommending one's own business.
- **Traffic system manipulation:** (Sensor) Spoofing traffic management systems to disrupt emergency vehicles, e.g. increase response time of police to bank robbery by traffic jam simulation.
- **Adversarial cyber-attacks:** Data poisoning of traffic forecasting models
- **Public opinion manipulation:** Generating AI-driven disinformation campaigns using open-weight UFMs by making use of learned demographic and regional information.
- **Biological/chemical weaponization:** Using open-weight UFMs to optimize attack locations (air quality models)

Fig. 2: Dynamic Data as Multi-Scale Representation [3]

Fig. 3: Multi-Step Prediction with Graph Neural Networks [3] on the OSTEU Datasets [4]
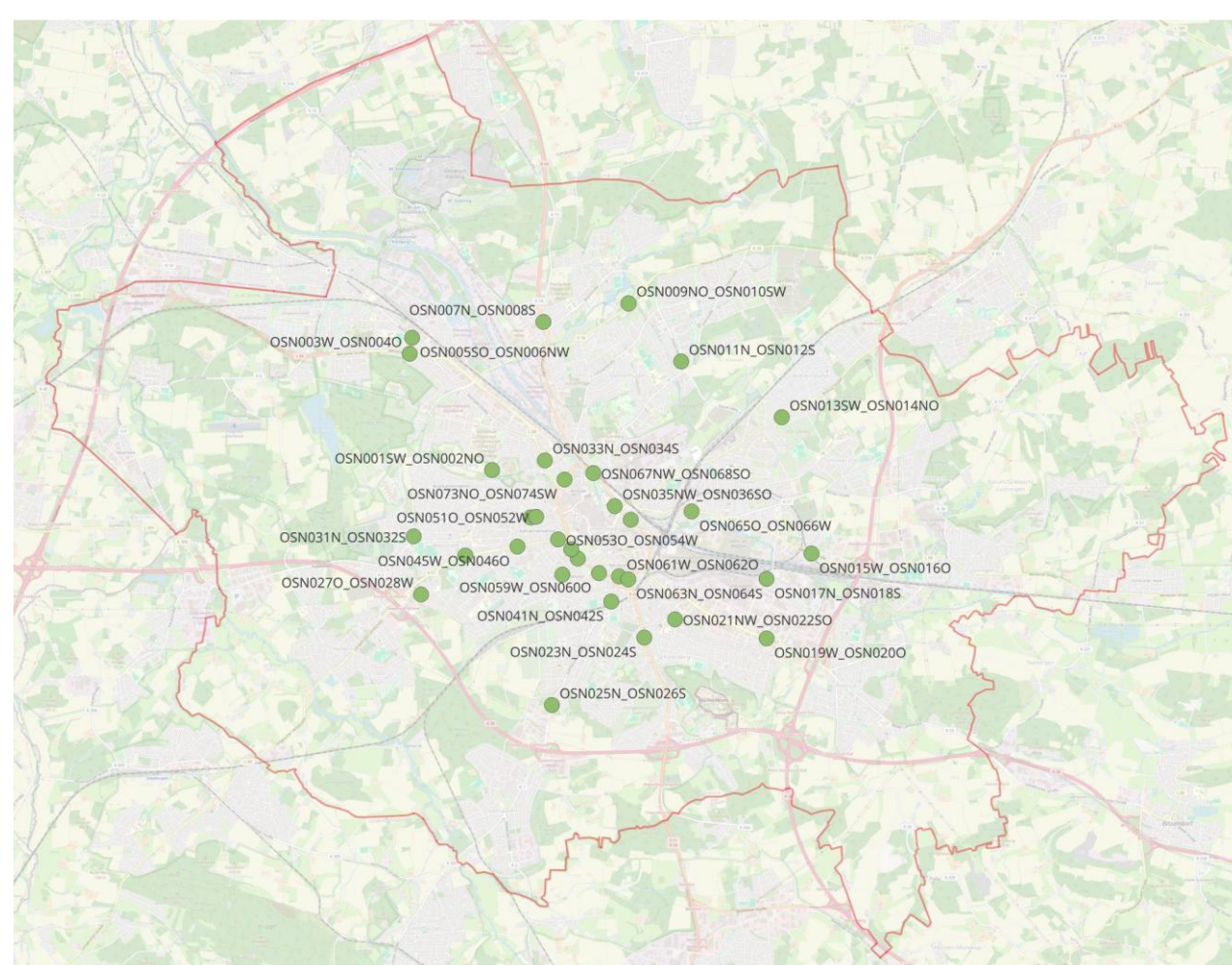
Results and Outlook

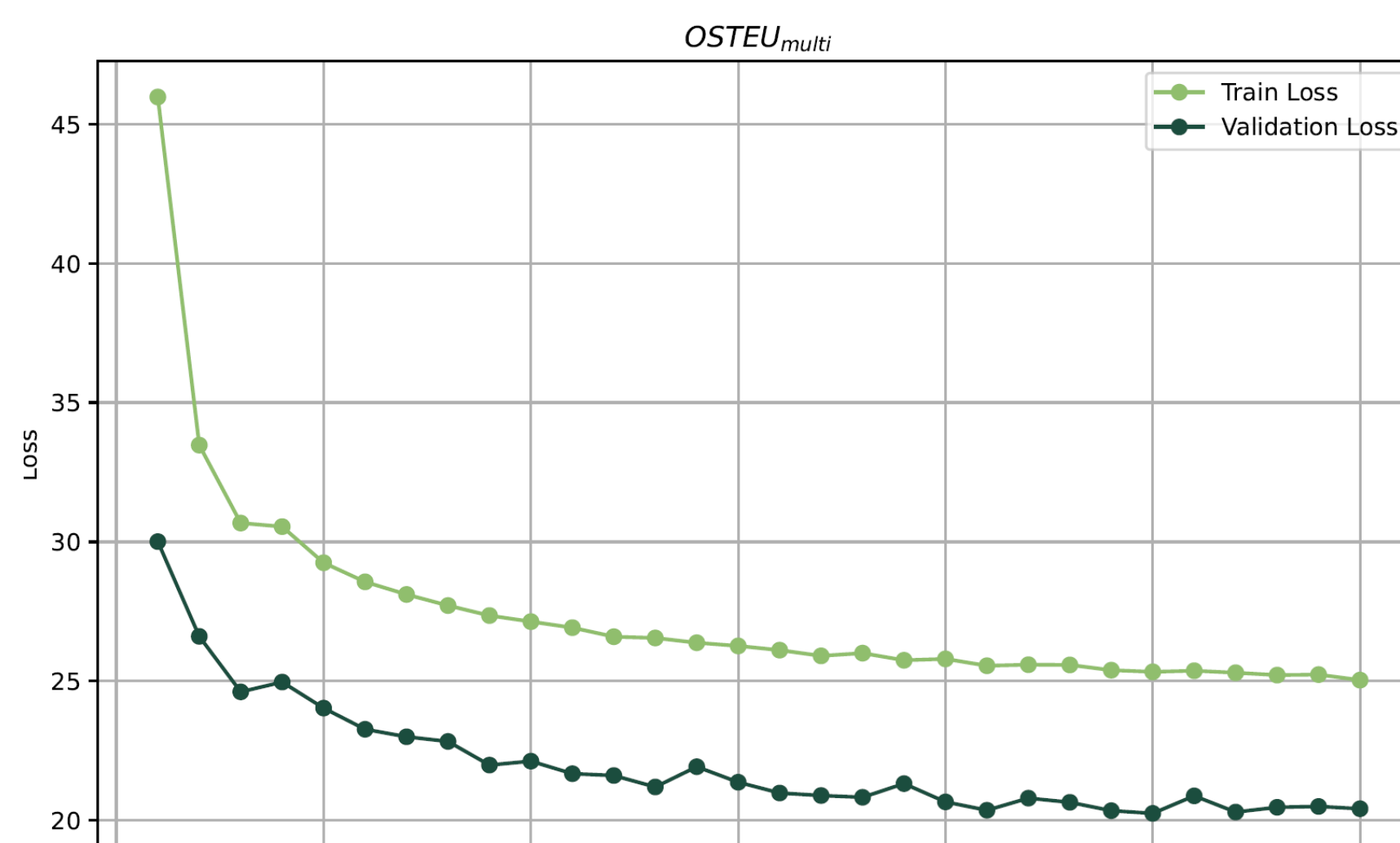Fig. 4: Positions of the Traffic Eye Universals (TEU) Sensors [1]

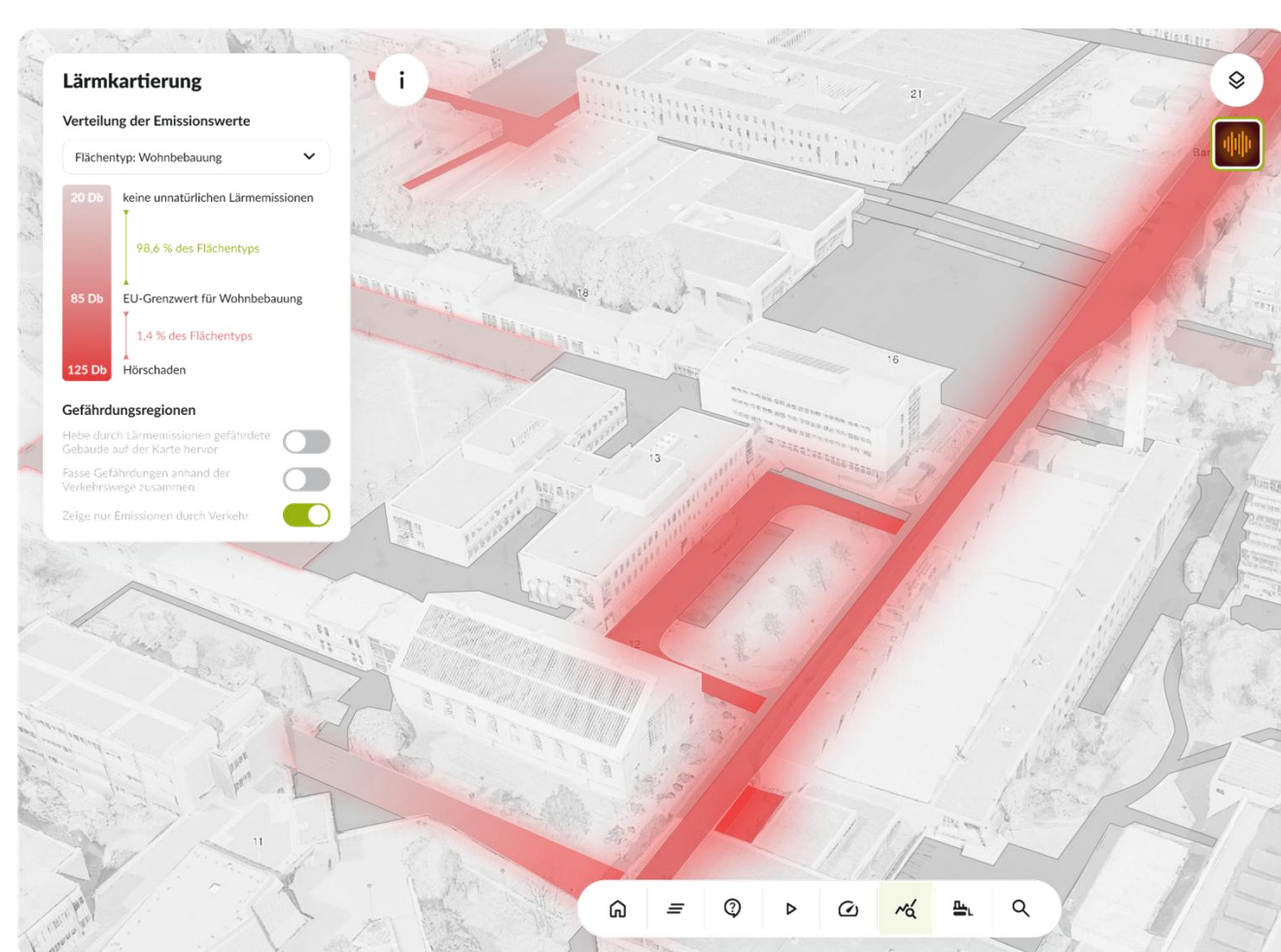Fig. 5: Multi-Step Forecasting [1] on the OSTEU Datasets [4]

Fig. 6: Ideas on Visualization for Digital Twins: Emissions Map by M. Arling, E. Brinker, J. Gärtner, and C. Schleiwies. Student Project, 2024.
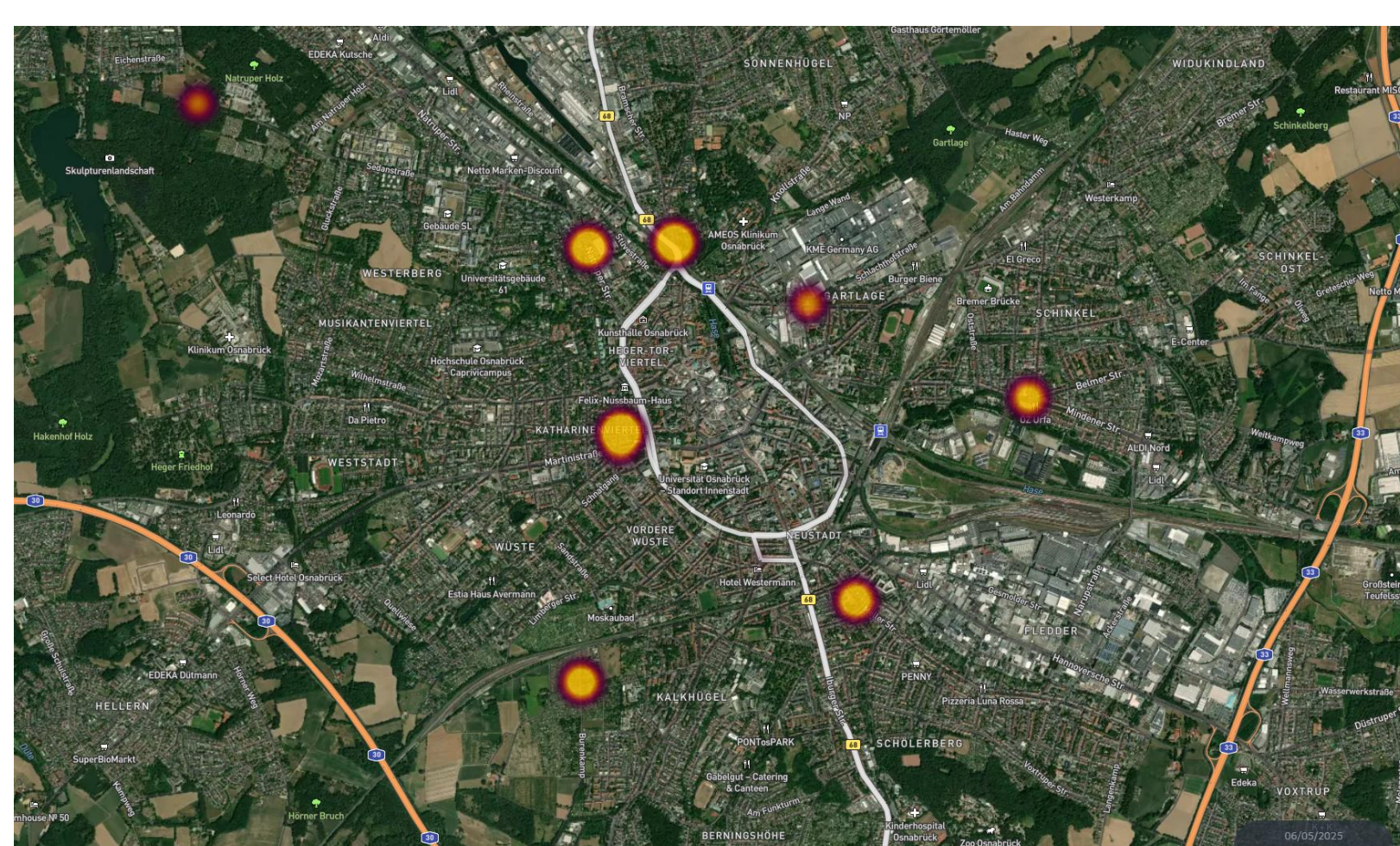

Fig. 7: Live Heatmap Visualization of live data in May 2025

Contributions and Data Sets

[1] Schaffland, A. & Schöning, J. (2025). **Urban Traffic Forecasting, Urban Data Platforms and Urban Foundations Models**. In 2025 7th Experiment@ International Conference (exp. at'25). IEEE.

[2] Schaffland, A., Schaarschmidt, M., Adleh, F. & Schöning, J. (2025). **Urban Foundation Models and Artificial Intelligence Safety**. In 2025 IEEE 9th Forum on Research and Technologies for Society and Industry Innovation (RTSI). IEEE.

[3] Schaffland, A. & Schöning, J. (202x). **Multi-step, Multi-scale Traffic Flow Time Series Forecasting.** Submitted to IEEE Access (under review).

[4] Stadt Osnabrück (2025). **Verkehrszählungsdatensatz Osnabrück** 22-23. ID: 903287344194932736. In "mobilithek.info" - Mobilitätsdaten von Bussen, Bahnen, Taxis und ähnlichen Verkehrsmitteln. BMDV.

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