



UNIVERSITÀ DEGLI STUDI DI NAPOLI  
FEDERICO II

itee<sup>PhD</sup>  
information technology  
electrical engineering



# Manfredi Napolitano

## Digital Twin for Smart Cities: Mobility DT

Tutor: Nicola Mazzocca

Cycle: XXXIX

Year: Second

# Candidate's information

- MSc degree: Computer Engineering
- DIETI Research group/laboratory: SECLAB
- PhD start date: December 29<sup>th</sup> 2023
- Scholarship type: PNRR - DM 118/2023

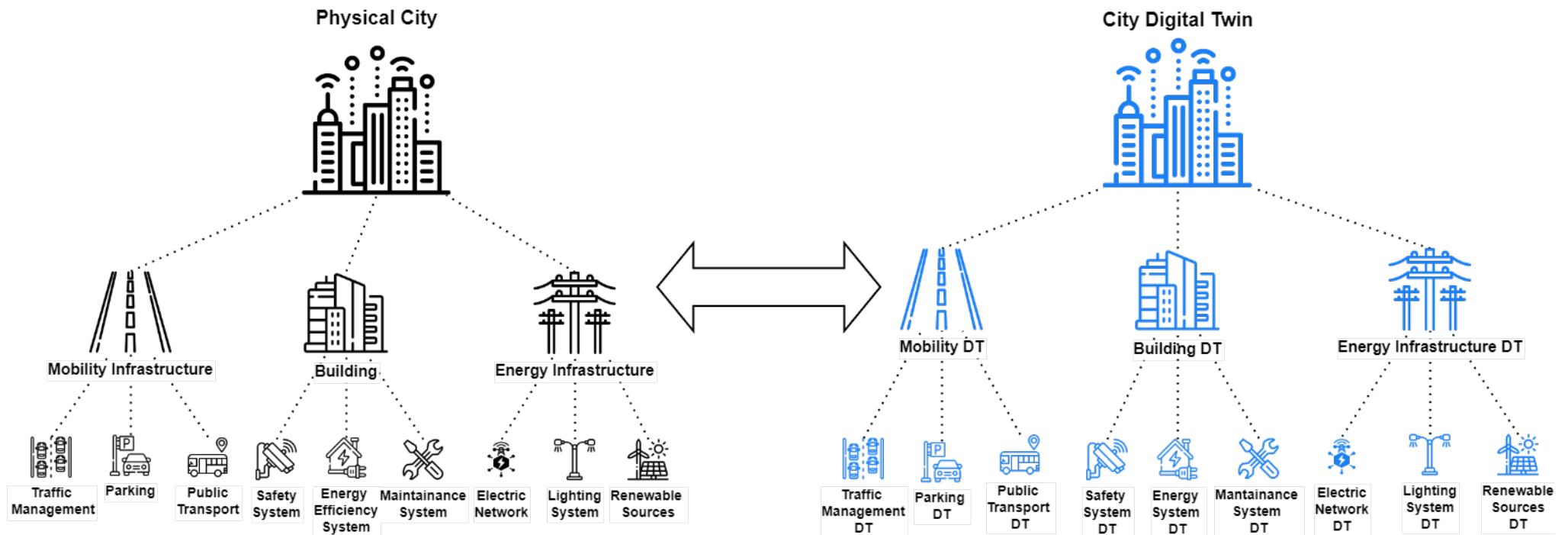
# Summary of study activities

- PhD courses:
  - How to boost your PhD
  - 20<sup>th</sup> TAROT Summer School on Software Testing, Verification and Validation

|                                 | Courses | Seminars | Research | Tutorship |
|---------------------------------|---------|----------|----------|-----------|
| Total                           | 10      | 2        | 47       | 0         |
| Expected (2 <sup>nd</sup> year) | 10-20   | 5-10     | 30-45    | 0-1.6     |

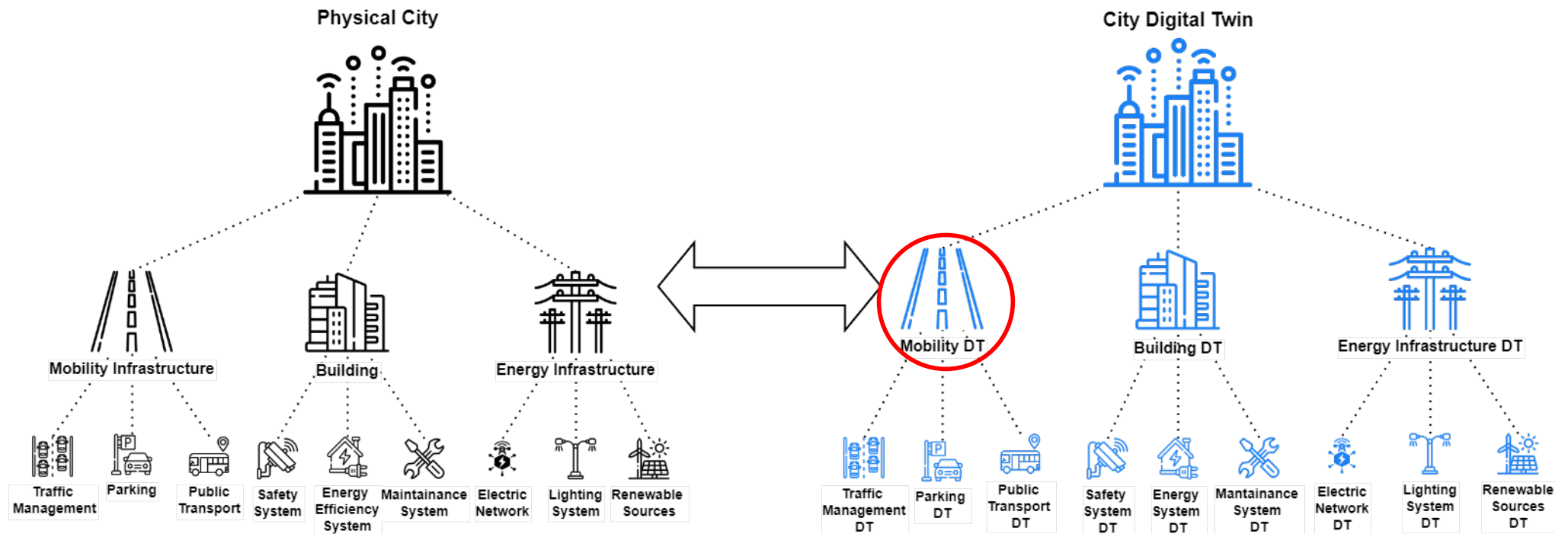
# Research Context

- My research field is about the Digital Twin for the Smart Cities domain: deepening Digital Twin for Mobility



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# Research results

- **FlowTwin**, a methodology and software framework for developing Mobility Digital Twin for Traffic Flow monitoring.
- Github Repository for the case study available here: <https://github.com/Manfr-edi/BoMoDT>

# Research products

|      |                                                                                                                                                                                                                                         |
|------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [P1] | M. Napolitano, A. Somma, A. De Benedictis, N. Mazzocca<br><i>FlowTwin: A Digital Twin for Traffic Monitoring,</i><br><b>IEEE Open Journal of Intelligent Transportation System (OJ-ITS),</b><br><i>Published on November 26, 2025</i>   |
| [P2] | M. Napolitano<br><i>A Reinforcement Learning Approach for Urban Traffic Management with Digital Twins,</i><br><b>41st ACM/SIGAPP Symposium On Applied Computing – Student Research Competition,</b><br><i>Accepted, to be presented</i> |

# Research activity: Overview (1/3)

- **Problem**

Urban traffic monitoring systems strain to represent traffic dynamics, limiting effectiveness of MoDT solution.

- City-wide traffic monitoring relies mainly on macroscopic data (flow, speed, density), which, taken alone, cannot capture more complex traffic dynamics.
- Existing tools struggle to accurately reproduce real traffic conditions and therefore ensure consistency with the environment in which twinning takes place.
- Digital Twins require deeper modeling and continuous data integration to bridge the gap between measured and simulated flows

# Research activity: Overview (2/3)

- **Objective**

The goals of my activities are:

- **Analyze** the current state of Mobility Digital Twin solutions, with a focus on traffic monitoring approaches.
- **Investigate** how to model complex traffic dynamics starting with a multi-scale perspective and through real data.
- **Design and develop** a MoDT framework specifically aimed at large-scale, behaviorally realistic traffic flow modeling.

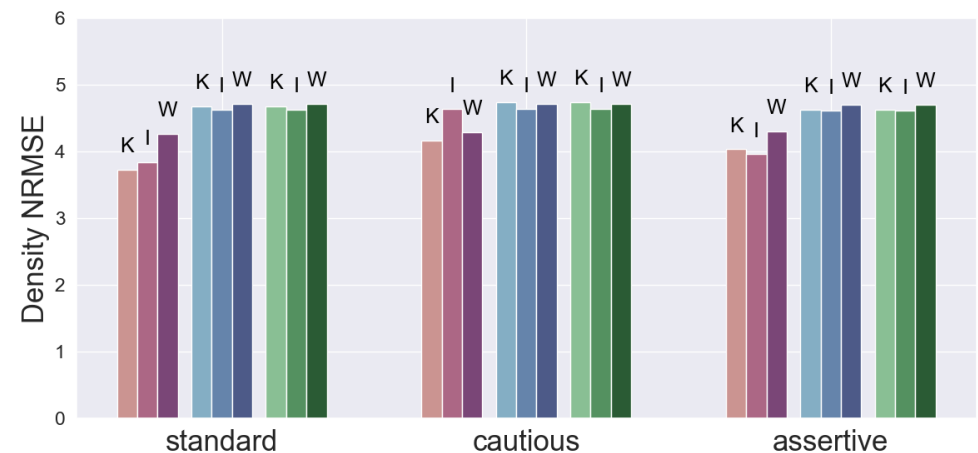
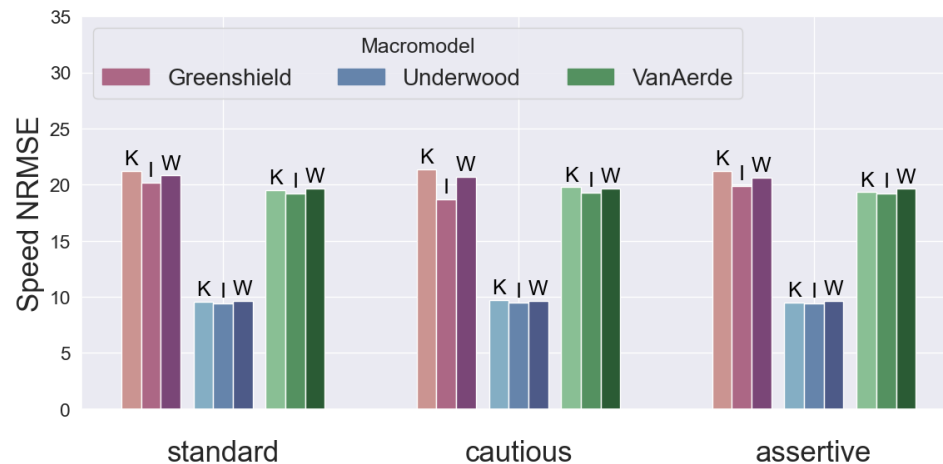
# Research activity: Overview (3/3)

- **Methodology**

- **Microscopic modeling & calibration:** adoption of microscopic models, calibrated through a combined procedure (involving both macro/microscopic models) using real traffic data and simulation outputs.
- **Two-phase methodology:** definition of an *offline* phase for calibration and validation, and an *online* phase enabling reactive, continuously updated traffic monitoring.
- **FlowTwin framework design:** realization of a modular MoDT architecture that operationalizes the methodology and can interact with real urban infrastructures.

# Research activity: Calibration Process

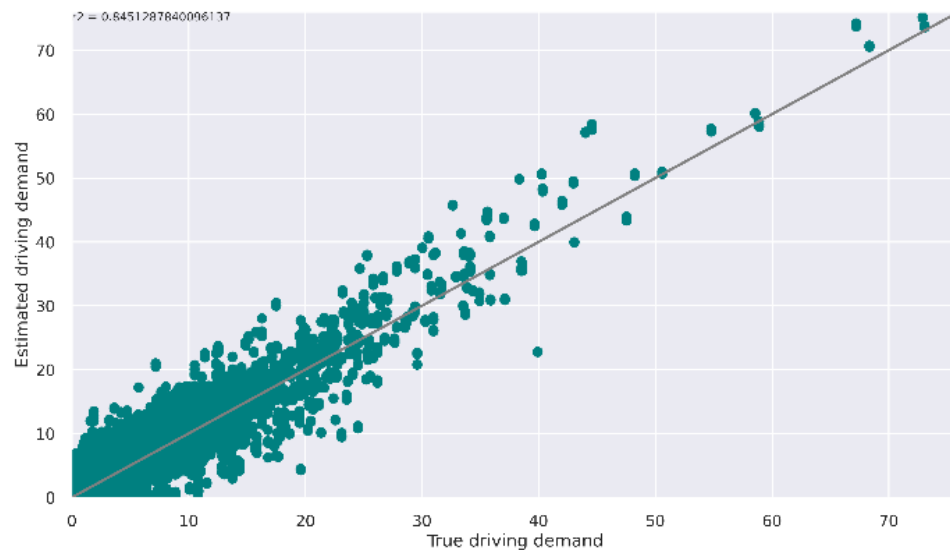
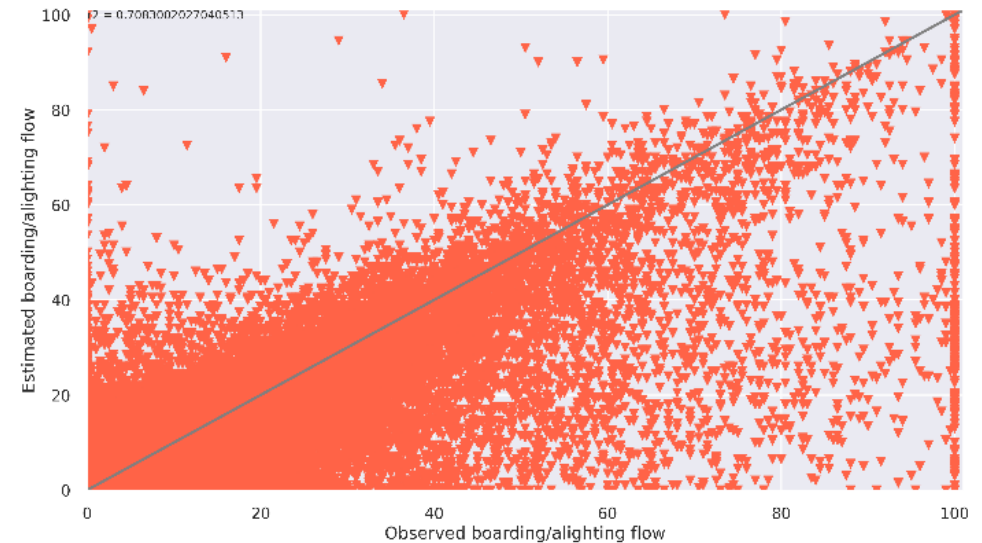
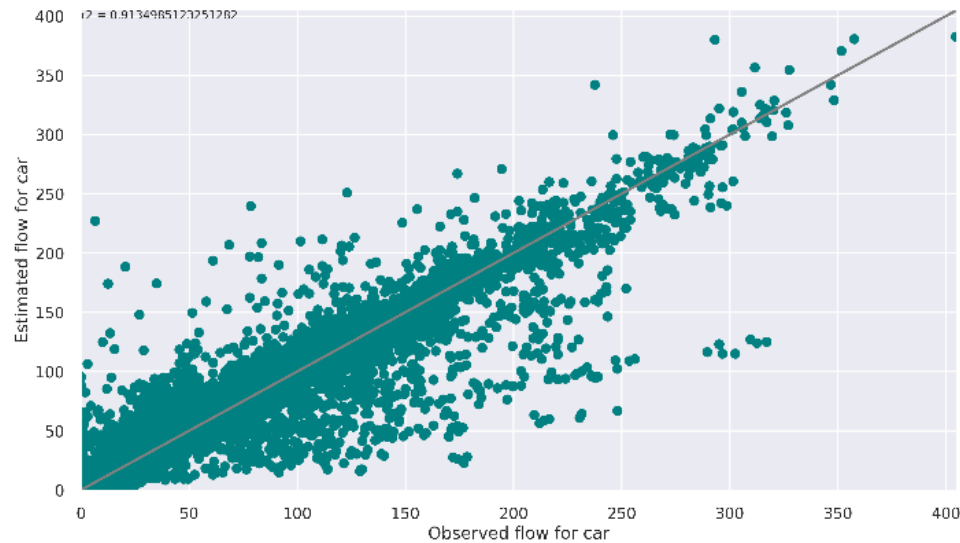
Comparison between the microscopic models examined in the calibration process: Krauss (K), IDM (I), Wiedemann-99 (W) in accordance with the estimates derived from the three macroscopic models evaluated.



# Research activity: Hitachi Rail collaboration

- Six-month (May-November) research activity carried out at Hitachi Rail S.p.A., in collaboration with Carnegie Mellon University (CMU):
- **Study of MAC-POSTS** (CMU): analysis of the tool architecture and its extension toward multimodal Origin-Destination estimation (MMDODE).
- **Sensitivity analysis of MMDODE**: development of a structured sensitivity analysis to assess model robustness, parameter influence, operational limits, and realistic applicability of MMDODE workflows.

# Research activity: Hitachi Rail collaboration



# Progress and Future Goals

- Planned 6-months period (mid-January → mid-July) at TUM in Munich.
- Next activity will focus on the integration Autonomous Vehicles (AVs) into the MoDT framework.
- Expected Thesis Title: “Data-Driven Mobility Digital Twins for Urban Traffic Modeling and Monitoring”