

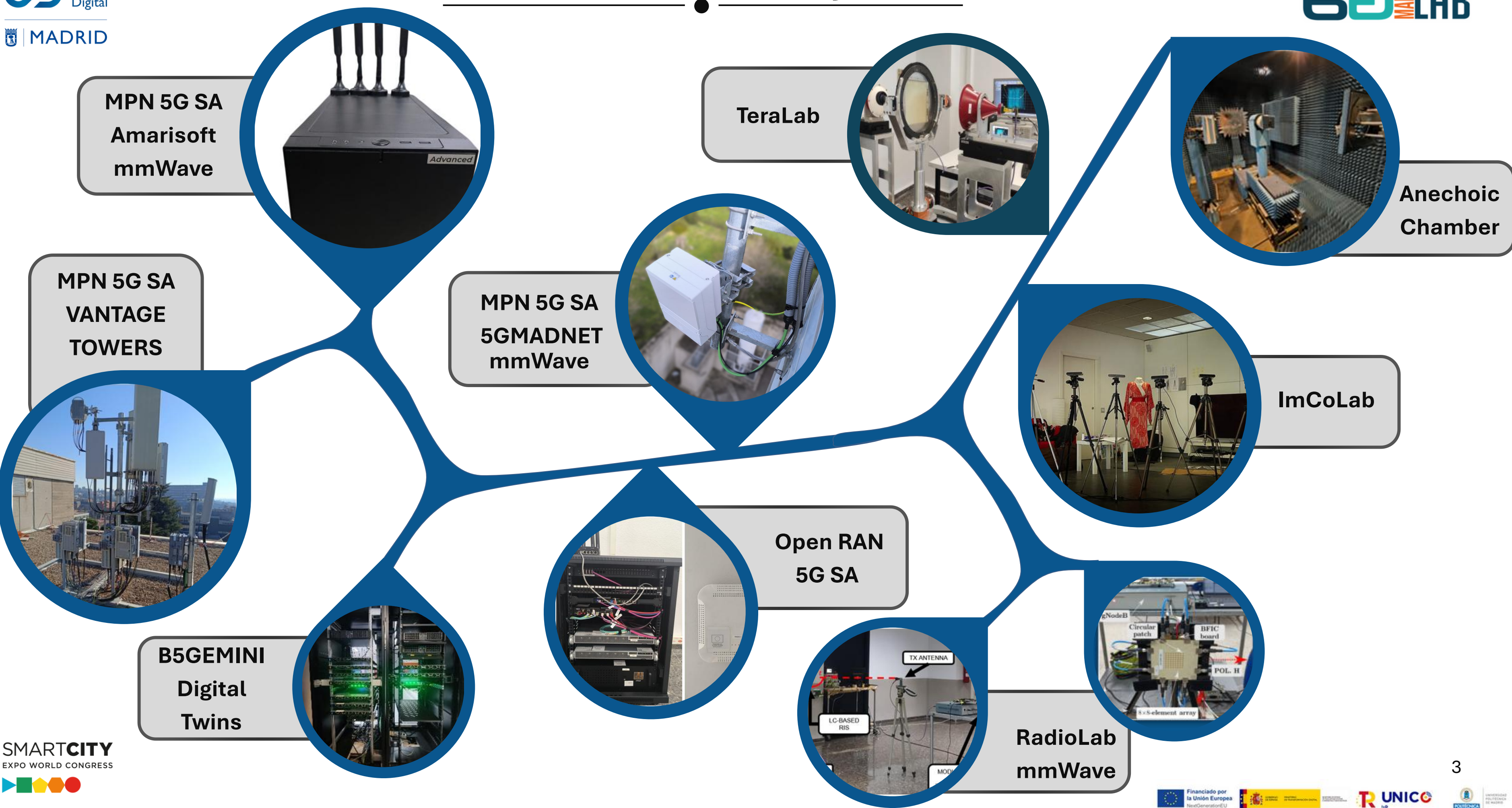


City Intelligence Laboratory (City Council–University Collaboration): LAB5G

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Full Professor
Technical University of Madrid

01. UPM-ETSIT 5G/6G ECOSYSTEM





Design and Validation of Advanced Networks

RIS Surfaces | Massive MIMO |
Beamforming | Phased Arrays

Measurement and Validation of Technologies

EMF-RF | Characterization of
Active/Passive Antennas

Network Simulation and Virtualization with Digital Twins

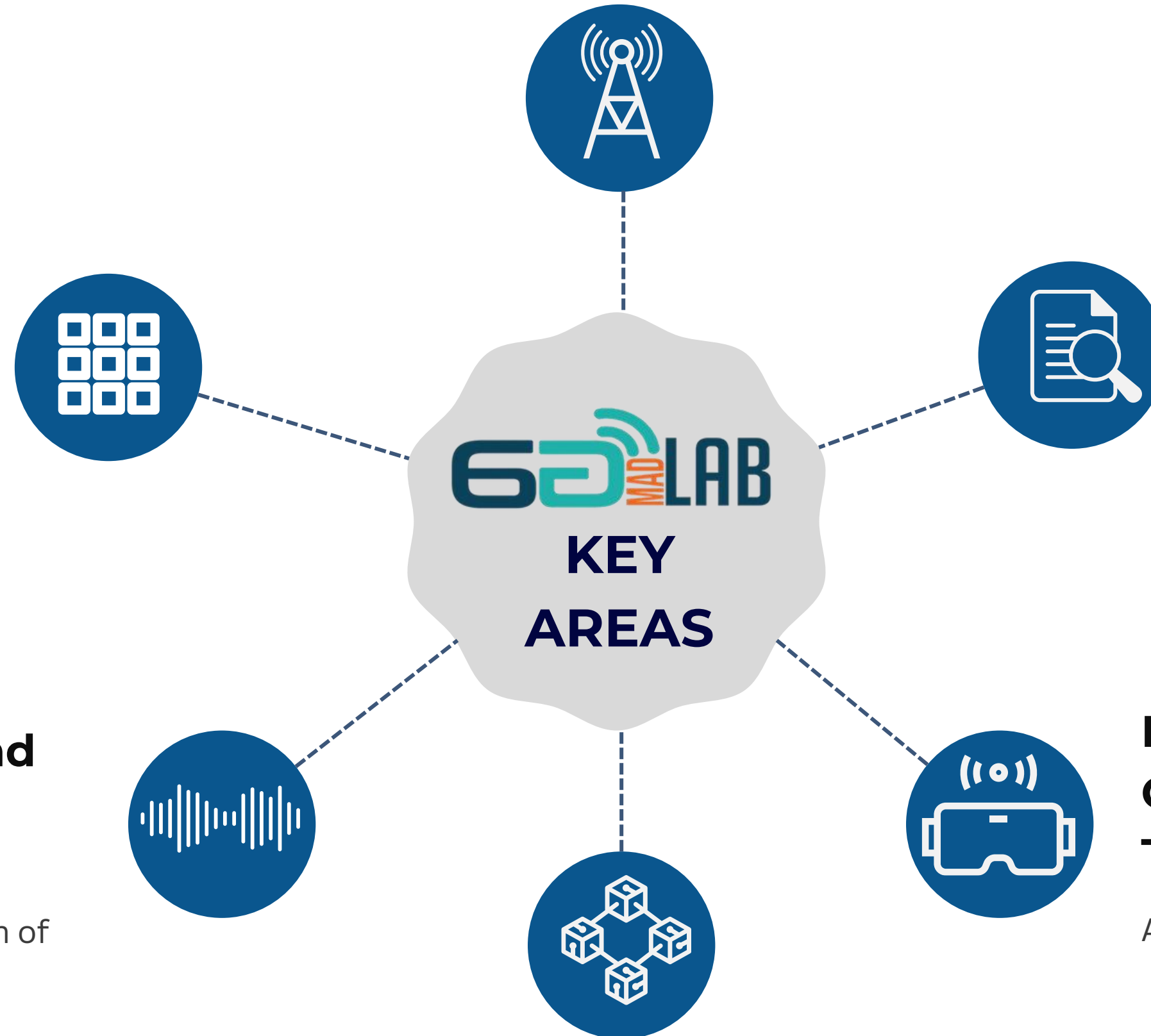
OpenStack | Kubernetes | SDN/NFV | Emulation and Predictive Analysis

Research and Innovation Support

Collaboration in Projects | R&D&i

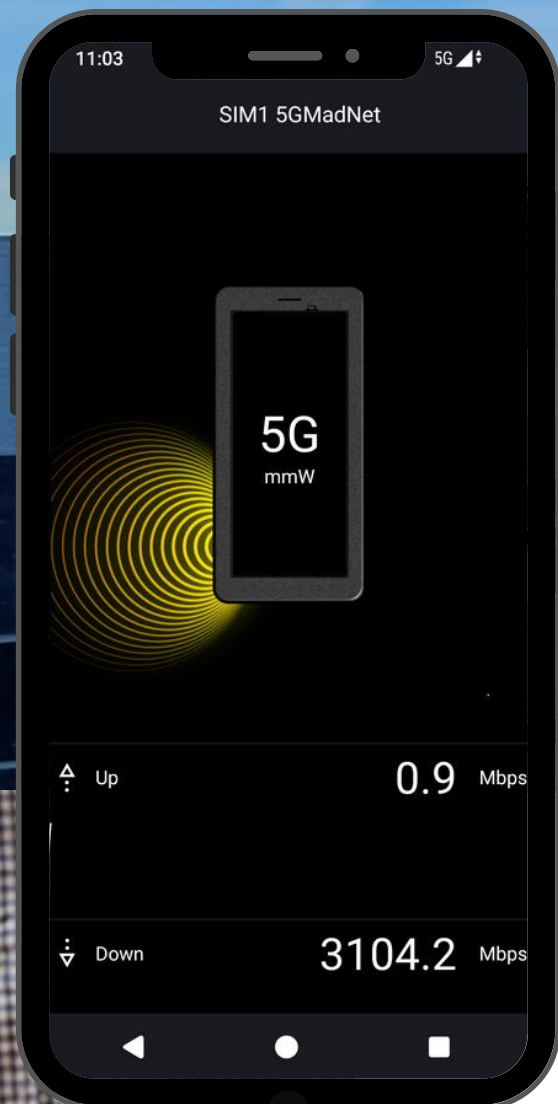
Development and Optimization of Technological Solutions

AR/VR | IA | MEC

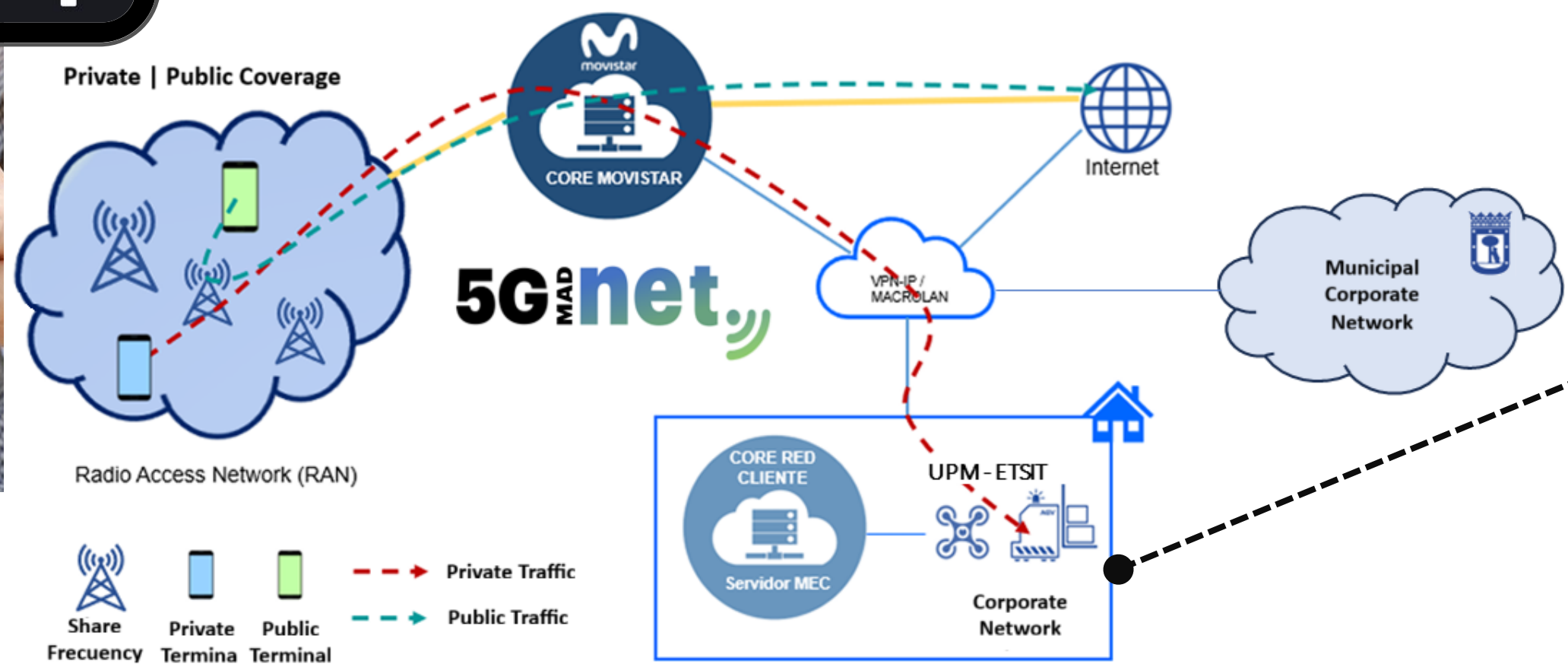


02. 5G SA MPN 5GMADnet





Network Architecture



Key capabilities

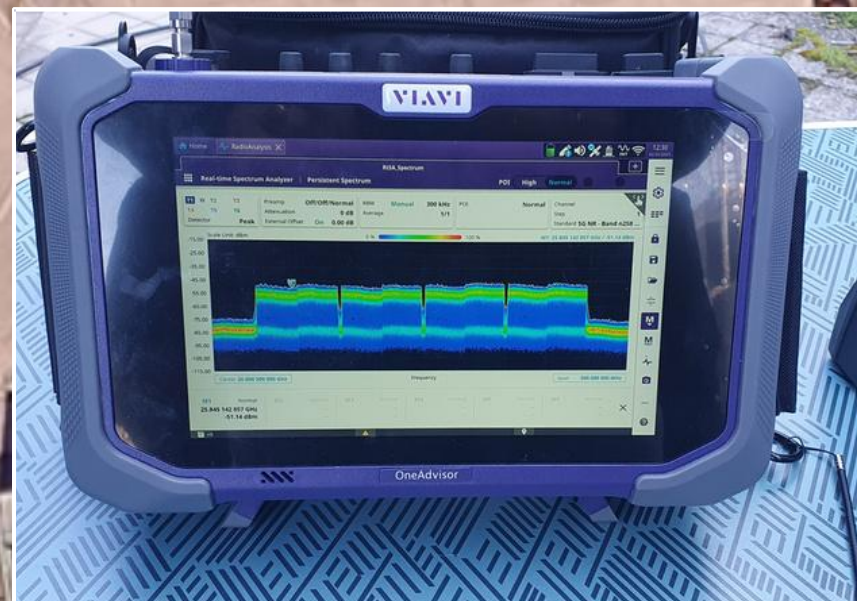
First 5G SA Private Network in Spain operating in the 26 GHz frequency band.

- Transmission Frequencies:

- a) 3.5 GHz (n78) | BW: 100 MHz

- b) 26 GHz (n258) | BW: 400 MHz

- Minimum guarantee of 20% radio resource in the 3.5 GHz band when spectrum and coverage are shared with the public network.
- 100% guaranteed radio resources for the millimeter-wave band.
- RTT latency below 10 ms.
- Guaranteed ability to modify the TDD configuration to favor Uplink in the millimeter-wave band.
- Downlink speeds up to 3 Gbps at the physical layer in the millimeter-wave band



03. USE CASE: 5G MOBILITY IN MMWAVE BANDS



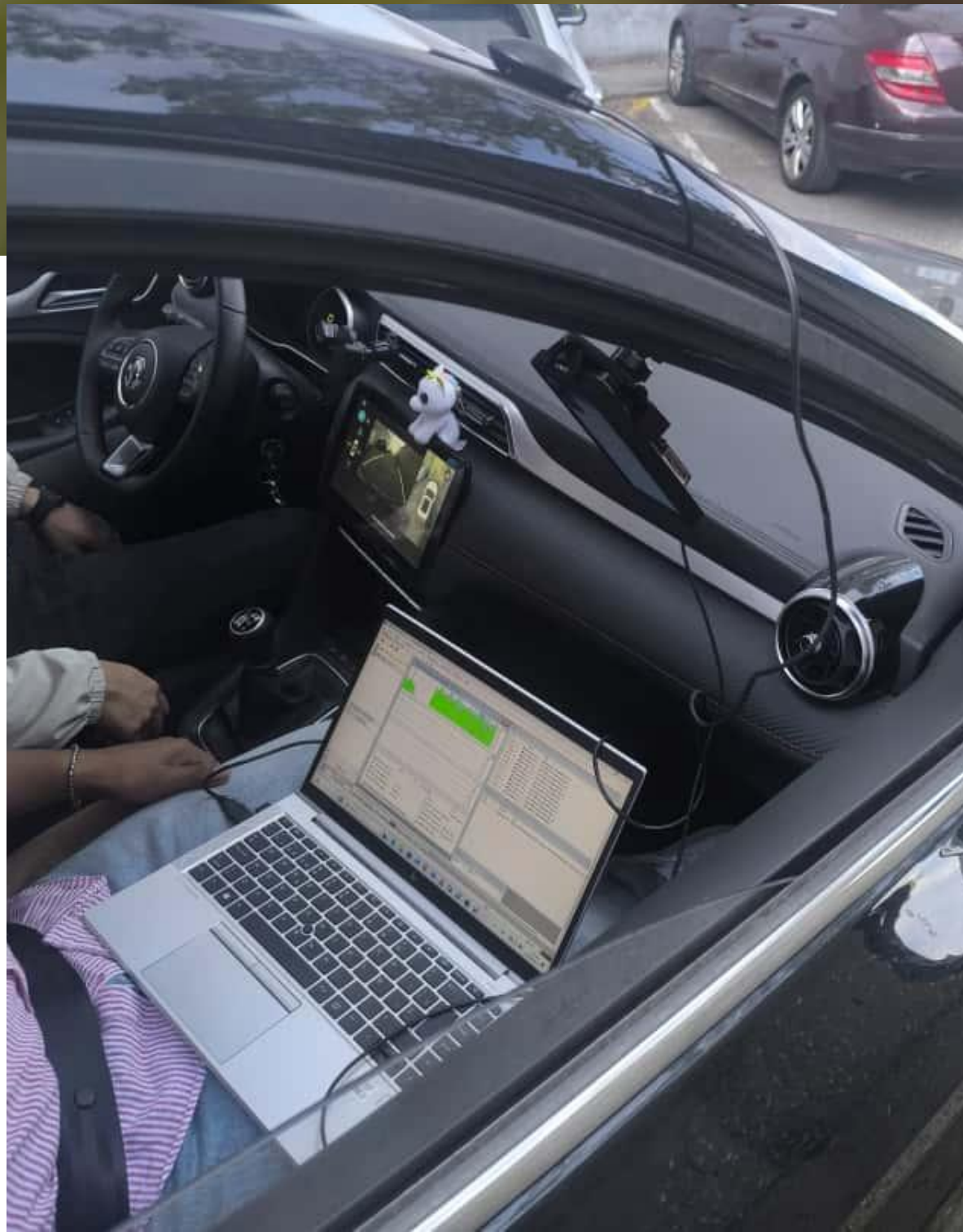
USE CASE: 5G MOBILITY IN MMWAVE BANDS

Test Setup

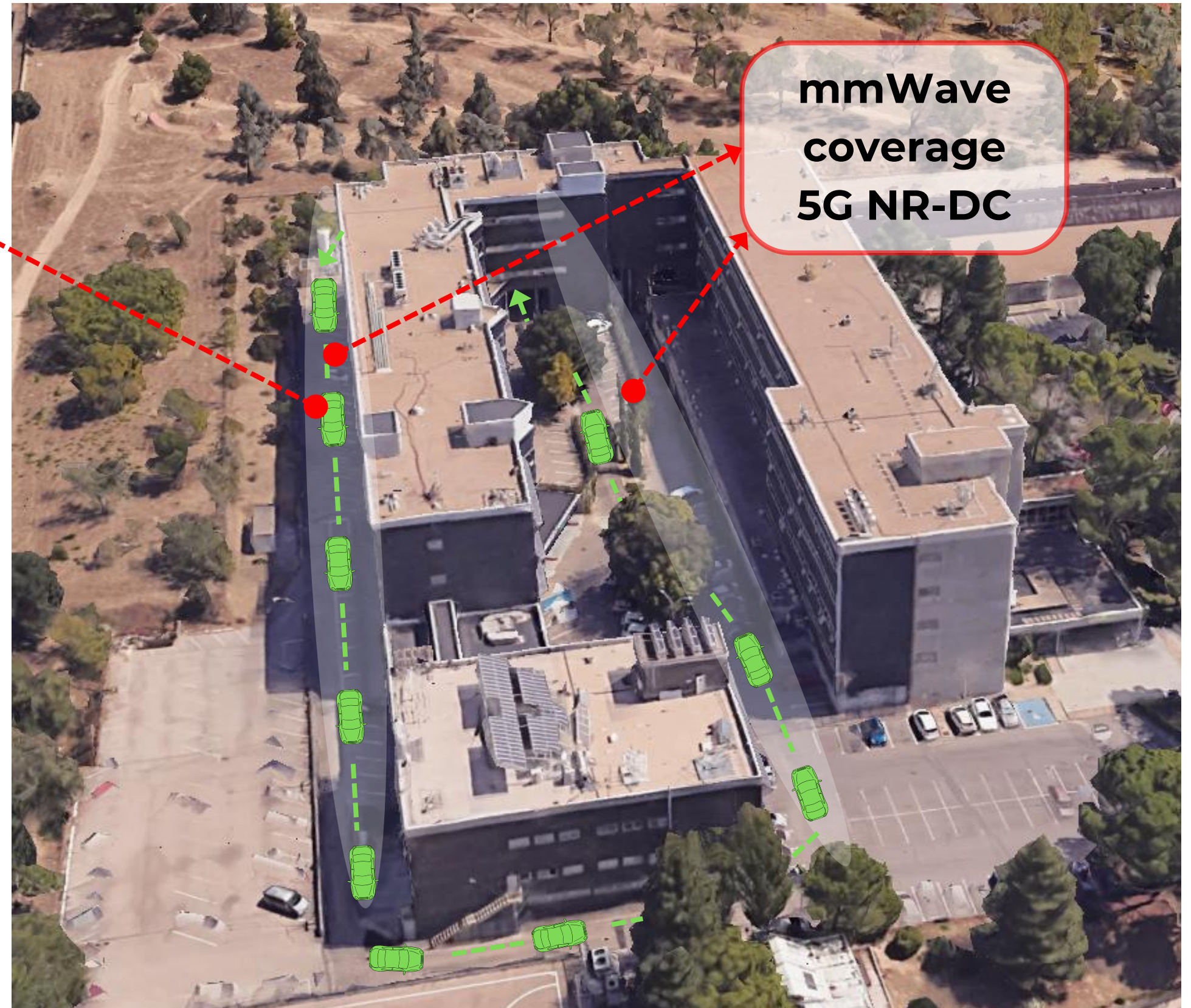
- 5G SA Dual Connectivity (NR-DC)
 - n78 100Mhz + n258 400Mhz.
- UE Sony PDT-FP1
 - 5G Qualcomm MTP X70 UE
- Traffic
 - UDP full buffer Download.
- Max driving speed ~30 km/h
- Drive route ~400 m.
- Peakrate
 - HB: DL 3 Gbps ; UL 350Mbps
- Latency
 - 10 to 20 ms
- Professional Drive Test Tool
 - TEMS Investigation



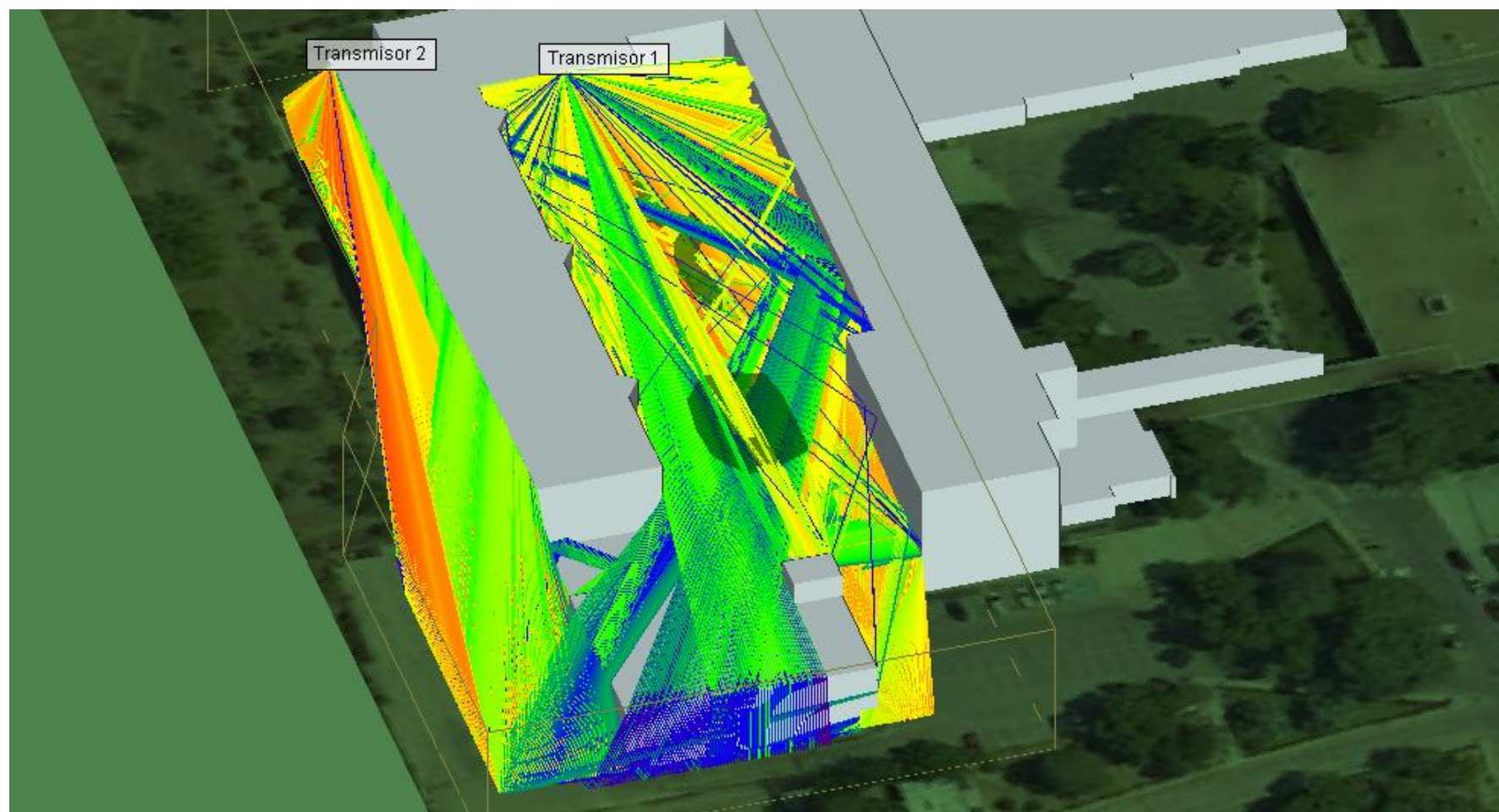
USE CASE: 5G MOBILITY IN MMWAVE BANDS



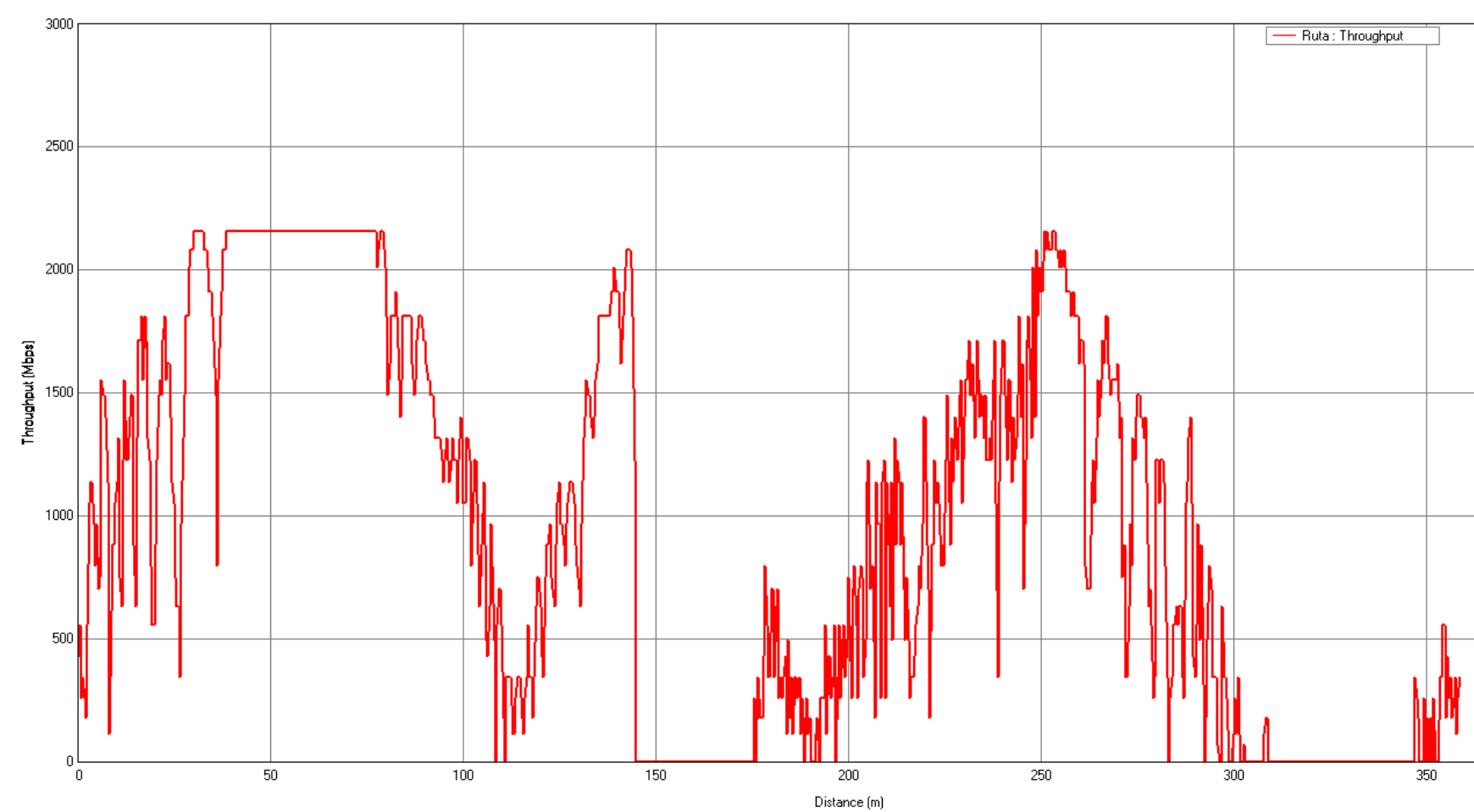
Trials conducted over the 5G SA private network 5GMADnet at the ETSIT-UPM campus. Results showed speeds above 2.5 Gbps and stable connectivity in motion, validating the potential of mmWave technology for mobility scenarios.



SIMULATED PERFORMANCE RESULTS OF THE 5G MMWAVE MOBILITY SCENARIO

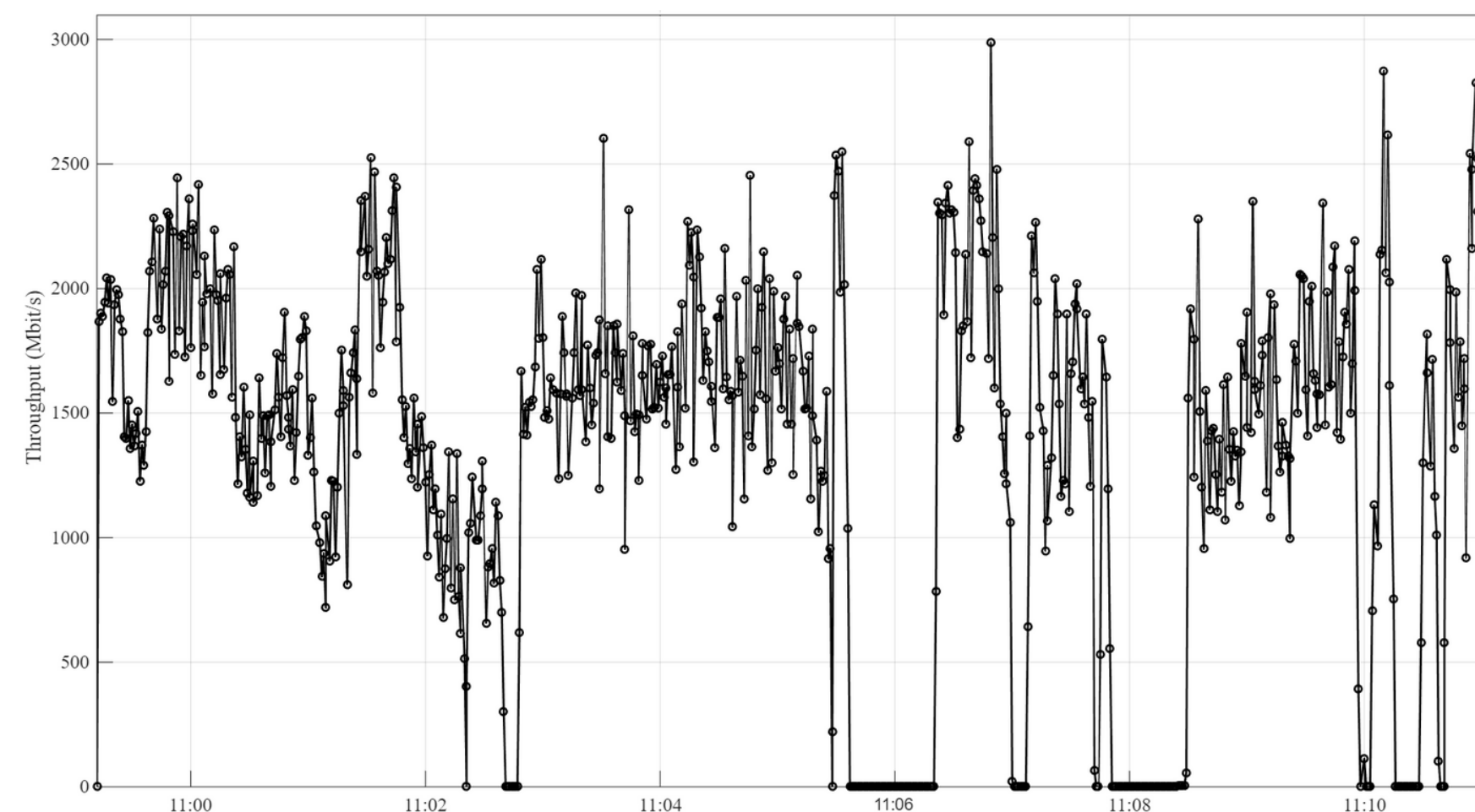


Ray-tracing simulation of the 26 GHz coverage performed with *Wireless InSite* showing signal propagation and reflections from both transmitters over the test area.



Simulated throughput profile along the vehicle route, derived from the ray-tracing results. The curve reflects variations due to LoS/NLoS transitions and antenna geometry within the mobility scenario.

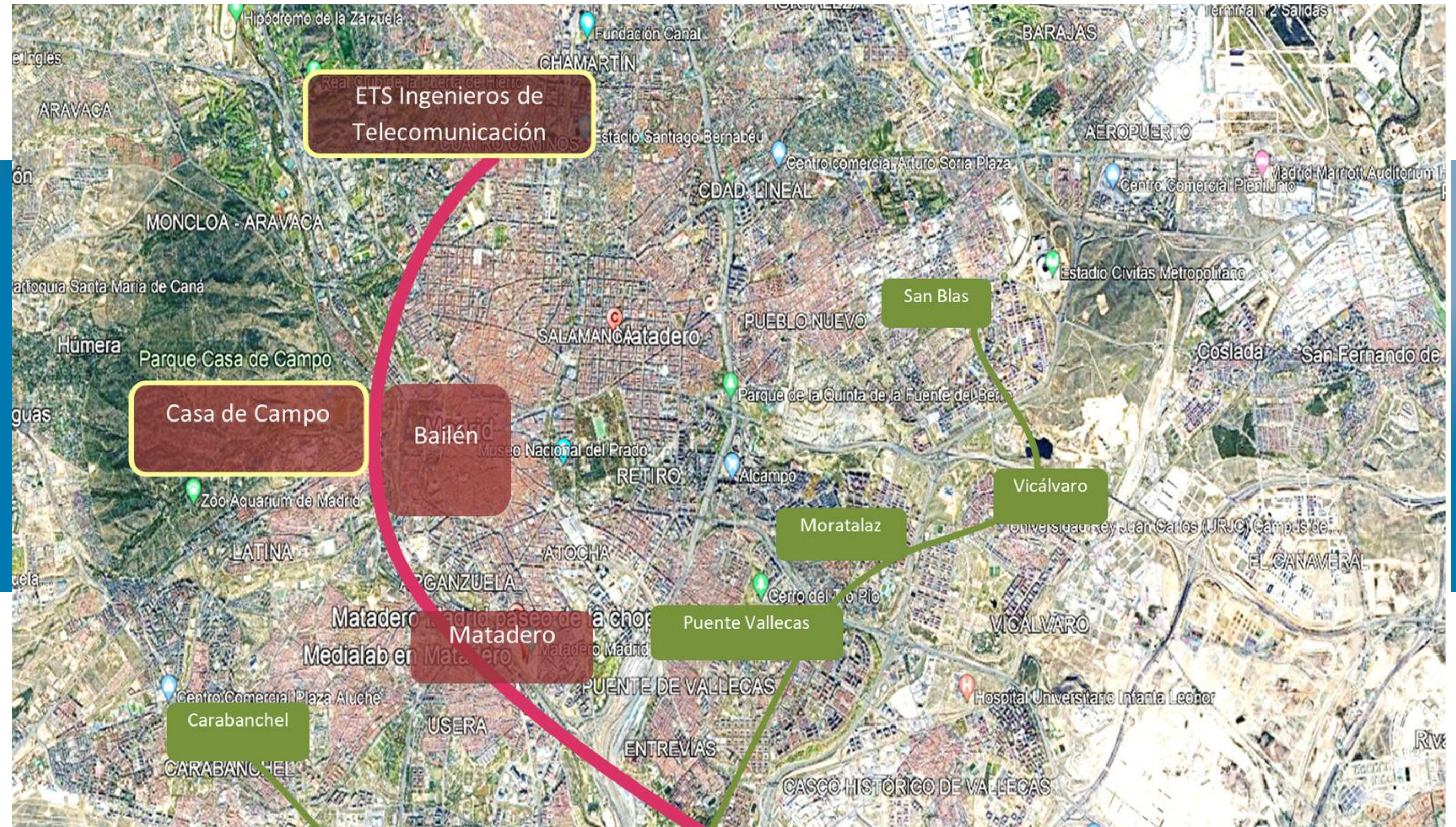
PERFORMANCE EVALUATION OF 5G MMWAVE CONNECTIVITY UNDER MOBILITY



The map shows the 26 GHz throughput along the drive route, highlighting strong correlation between high data rates and line-of-sight coverage from the mmWave sectors.

The 26 GHz (mmWave) band achieved peak throughputs over 2.5 Gbps, delivering very high capacity but showing greater variability depending on LoS conditions and antenna alignment.

04. 5G URBAN CORRIDORS



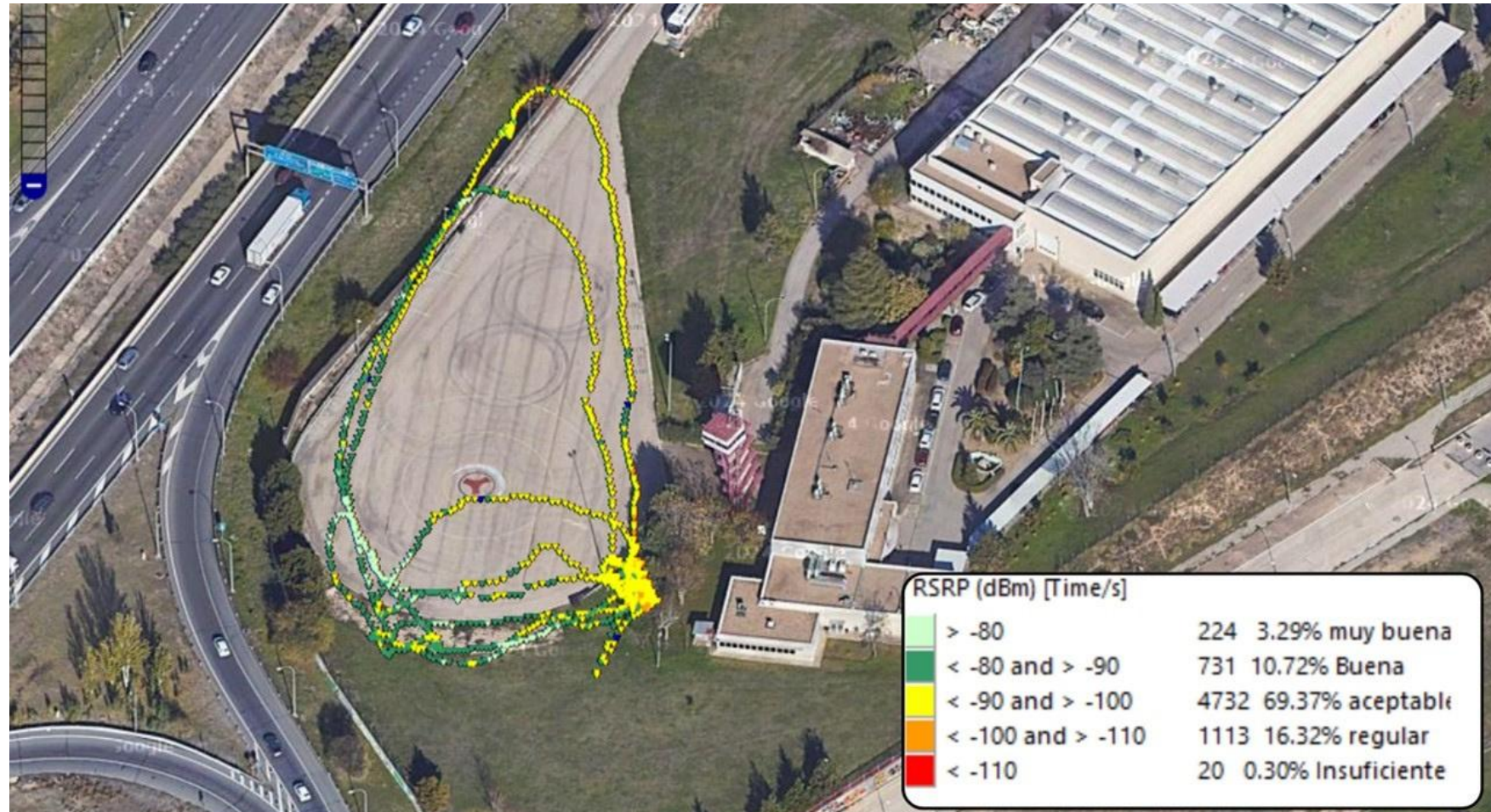
5G URBAN CORRIDORS

5G SA connectivity to INSIA through integration with the 5GMADnet Core

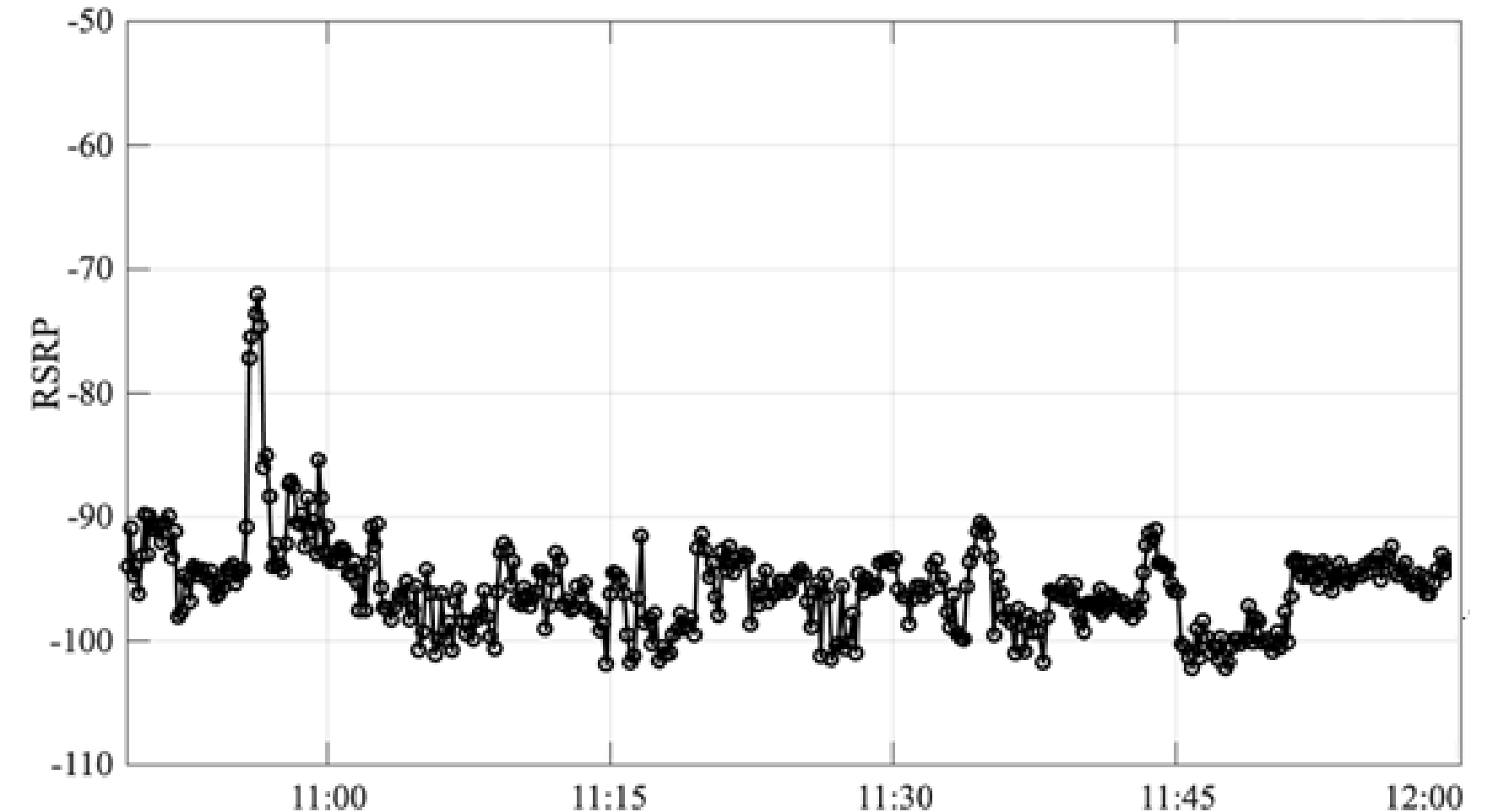


5GMADnet Coverage

5GMADNET COVERAGE ASSESSMENT IN THE INSIA 5G URBAN CORRIDOR



RSRP map along the INSIA route, highlighting stable 3.5 GHz 5GMADnet coverage with mostly acceptable to good signal strength.



RSRP variation over time measured during the mobility test, reflecting consistent signal levels around -90 dBm with short fluctuations due to the environment and vehicle movement.