Simulation of Vehicle to Network Communication in Real Environment

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Track: Communication Engineering

Content

- Background
- Related Work
- System Model
- Result and Analysis
- Key Findings and Conclusion

Background

- Traditional Verification:
  - V2N systems tested via resource-intensive physical field testing.
  - Conducted late in the development process.
- Challenges:
  - Late discovery of design issues threatening project timeline and budget.
  - Difficult to identify root cause of field quality issue
- OEMs demand:
  - Predict and evaluate V2N communication performance early in the development process .

Research Question and Goals

- Research Question:
  - How can we use simulation predict and evaluate V2N performance early?
  - What factors impact V2N performance in real driving environment?

- Goals:
  - Summarize and Compare Existing V2N Simulation tools
  - Develop a V2N Simulation and Evaluation workflow
  - Evaluate Performance under Various Conditions/Setups

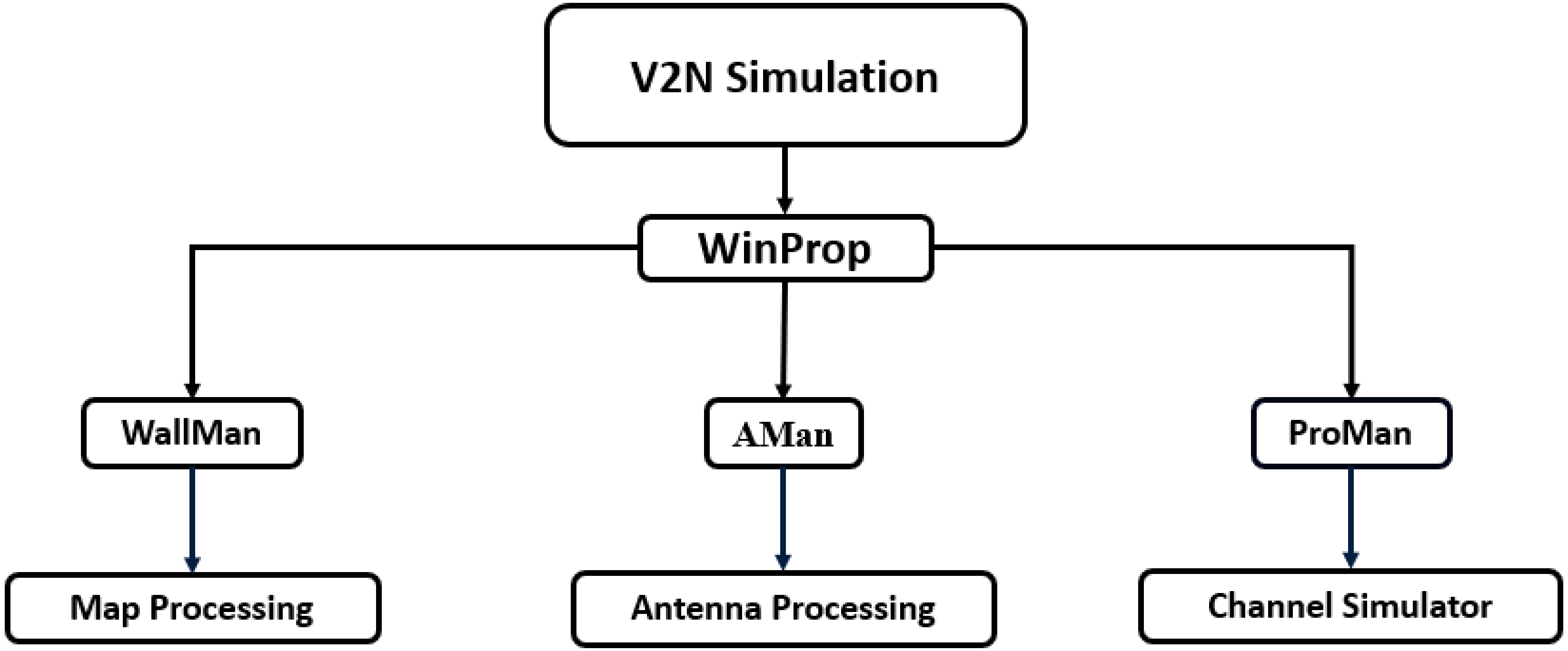
Related works

- Open Source:
  - Simulation and Verification of Wireless Technologies (SIVERT)
    - Only for V2V.
    - Combining Unity 3D NS3 and SUMO
    - SIVERT 2 project is ongoing for V2N simulation
  - New York University Channel Simulator (NYUSIM)
    - Urban, suburban, highway
    - User Friendly

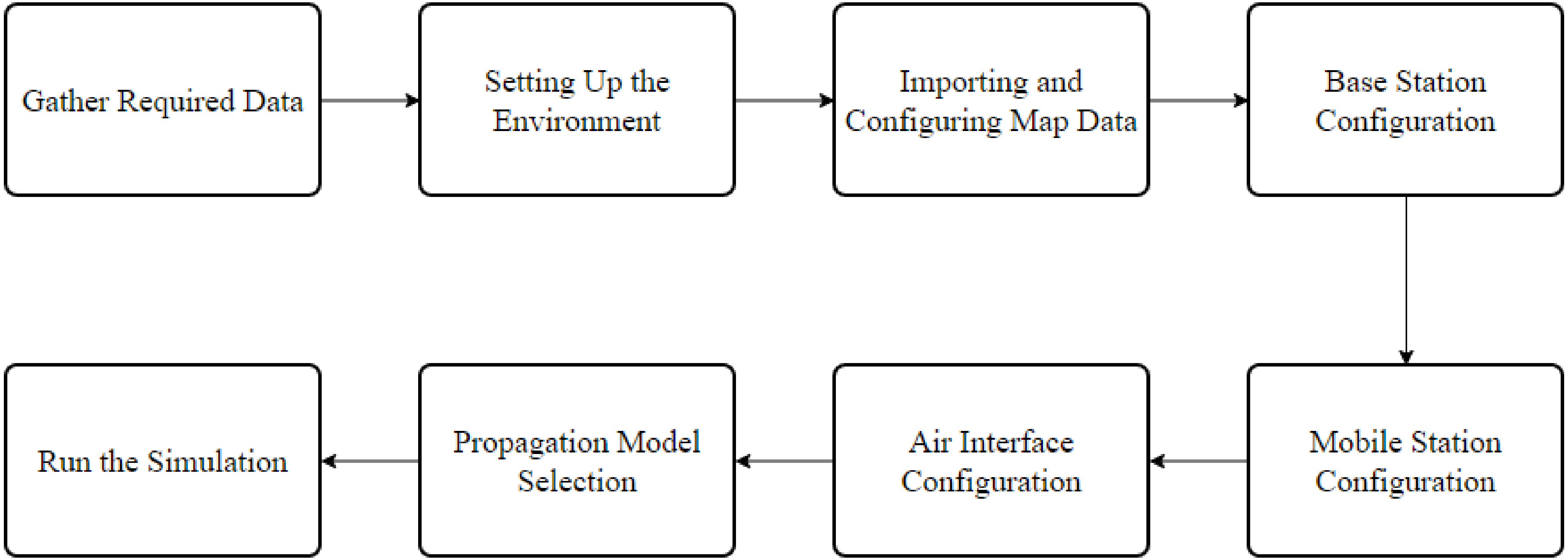
Related works

- Commercial:
  - MATLAB
    - channel customization
    - computation-resource demanding.
  - WinProp (Altair)
    - User friendly
    - Robust Simulation Engine

WinProp Component



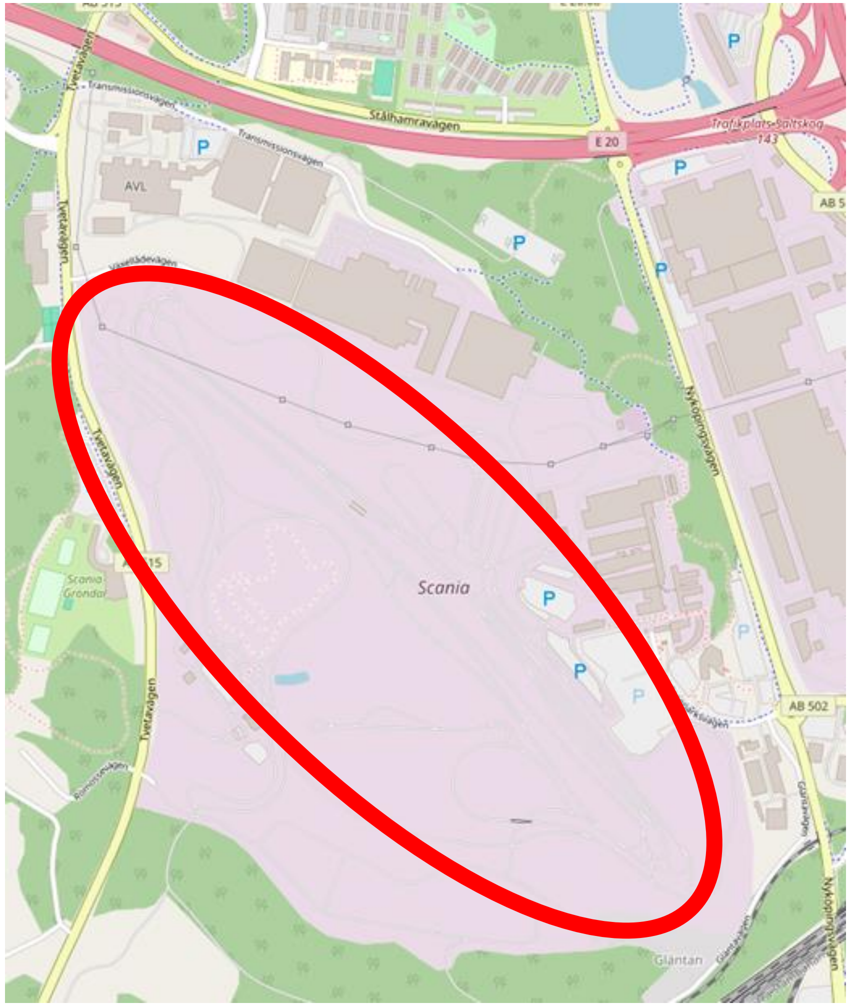
Workflow



Gather Required Data
Setting Up the Environment
Importing and Configuring Map Data
Base Station Configuration
Mobile Station Configuration
Air Interface Configuration
Propagation Model Selection
Run the Simulation

Planned Simulation Cases

- Channel Model (DPM versus IRT)
- Map/Driving environment
- Base station (BS) height
- Frequency Band
- Mobile station (MS)/vehicle setup
  - Speed
  - Antenna Gain
  - SISO versus MIMO
  - Antenna Spacing
- Update Map details



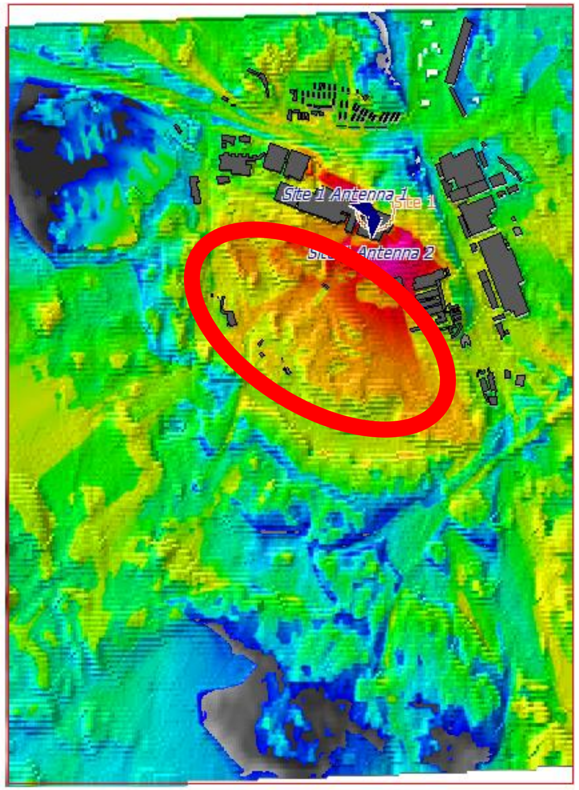
Simulation area: Scania STC test track

Base case(As Reference)

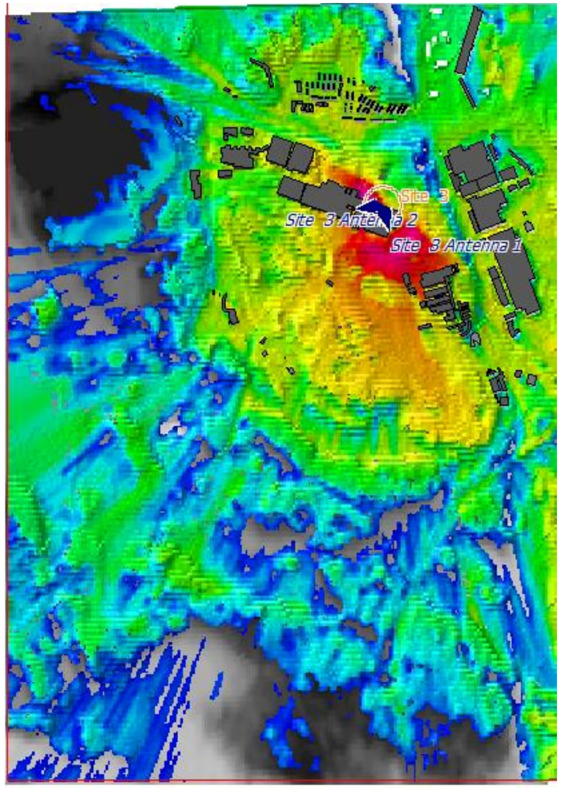
- V2N performance KPI
  - RSRP (Reference Signal Received Power)
  - RSRQ (Reference Signal Received Quality)
  - RSSI (Received Signal Strength Indicator)
  - Throughput
  - Data Rate

Map	Open Street Map + Topography
Base Station	Original information from operator
	48 m height
	Tilt 4°
Mobile Station	2 isotropic antenn with 0 dBi gain
	Speed 90 km/h
Frequency	3.5GHz(5G n78)
Bandwidth	80MHz
Simulation Scope	Area and Trajectory
Channel Model	Dominant Path Model

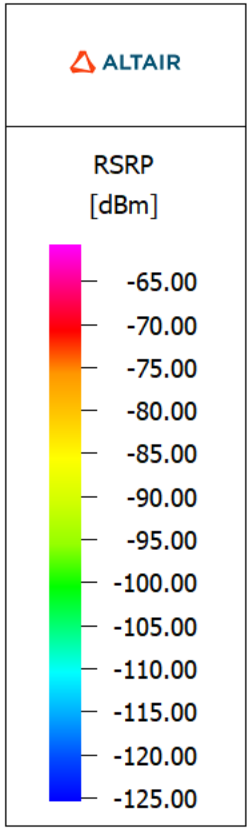
Case 1: Channel Model



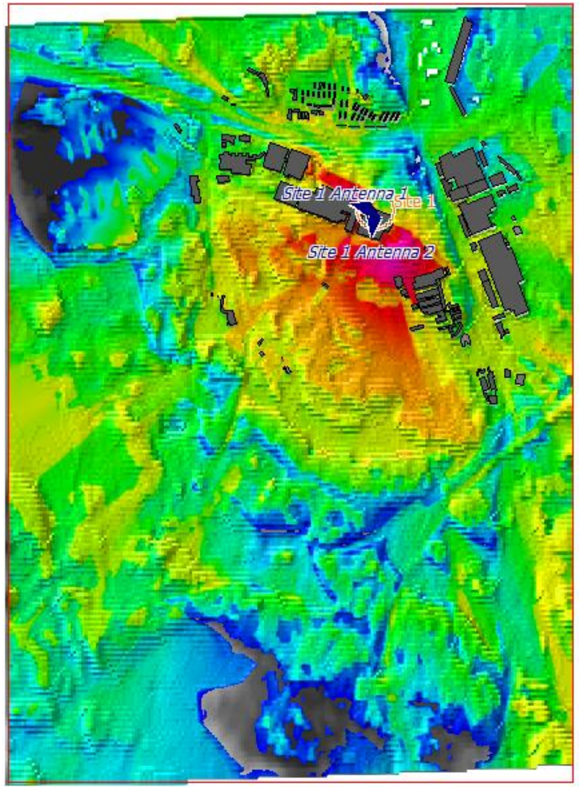
DPM



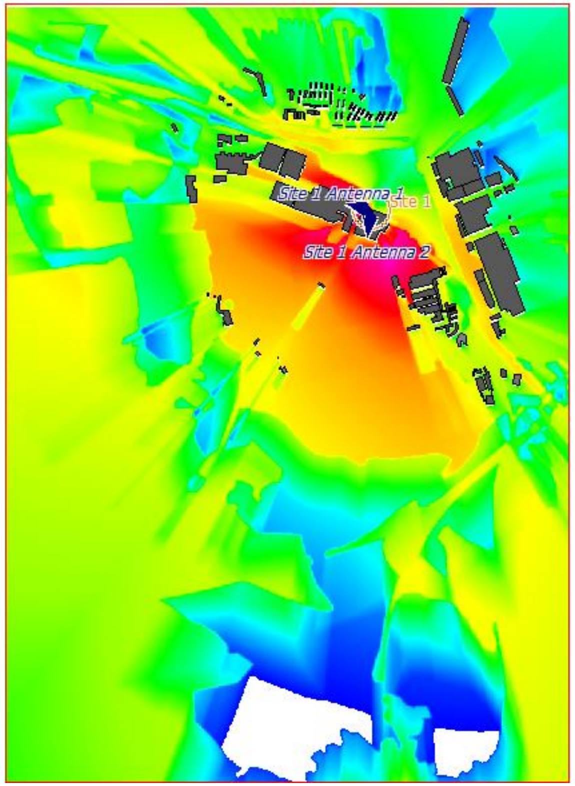
Intelligent Ray Tracing (IRT) Model



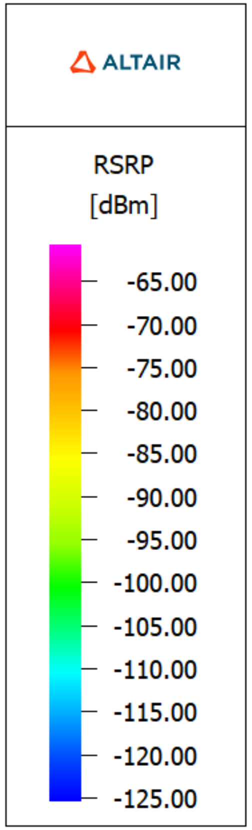
Case 2: Map



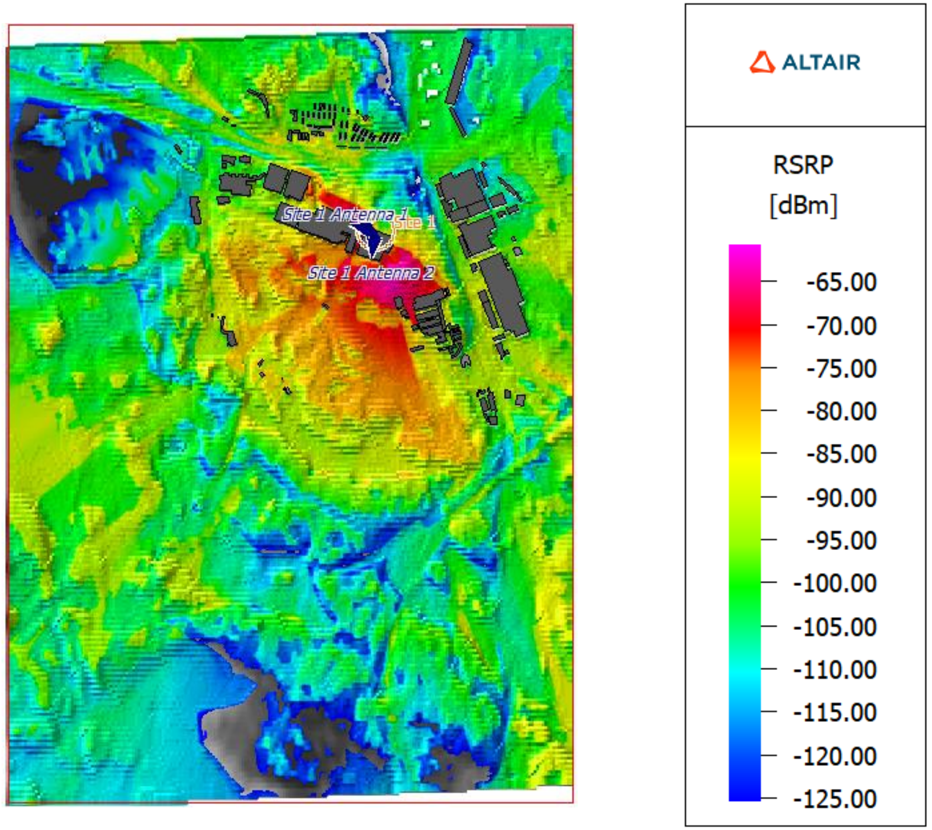
Map with Topography



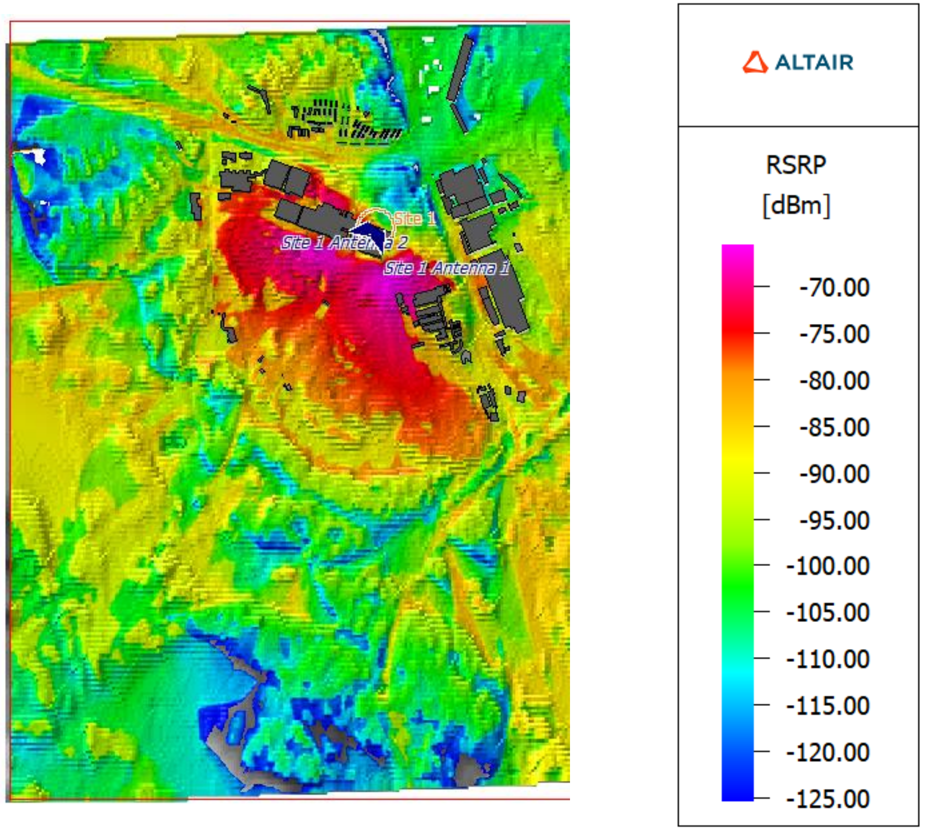
Map without Topography



Case 3: BS height

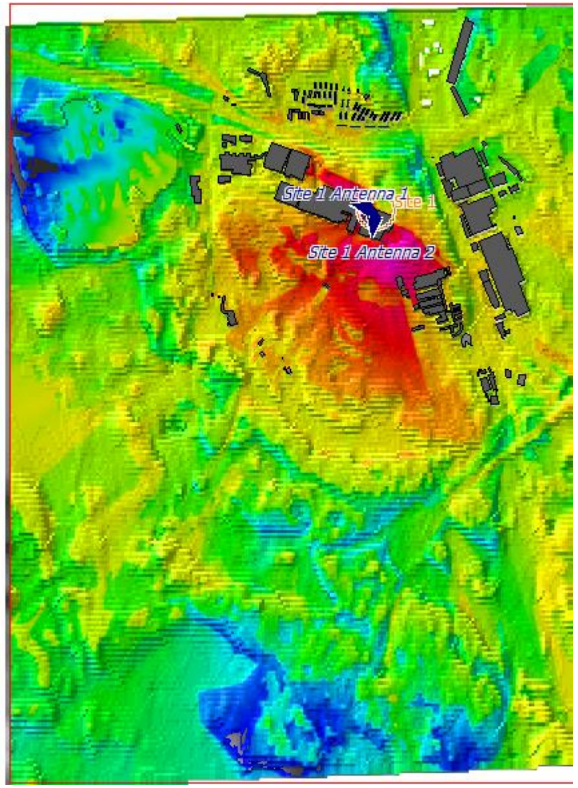


BS Height = 48m

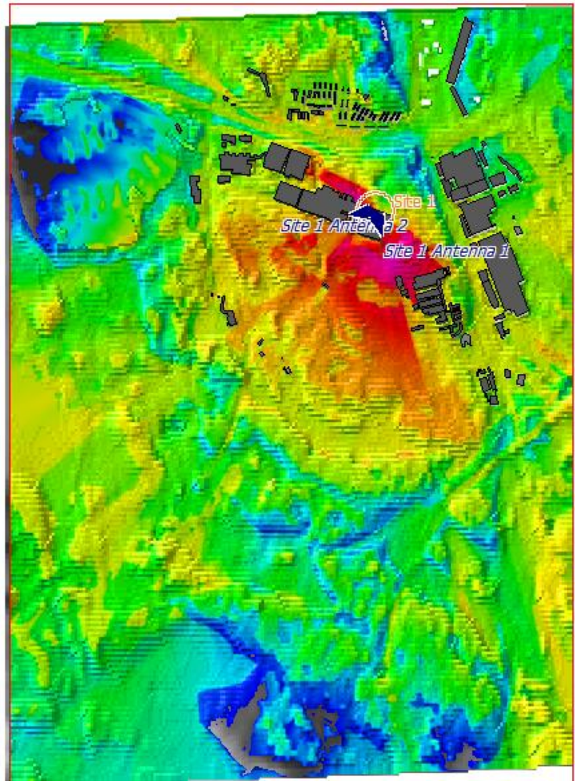


BS Height = 100m

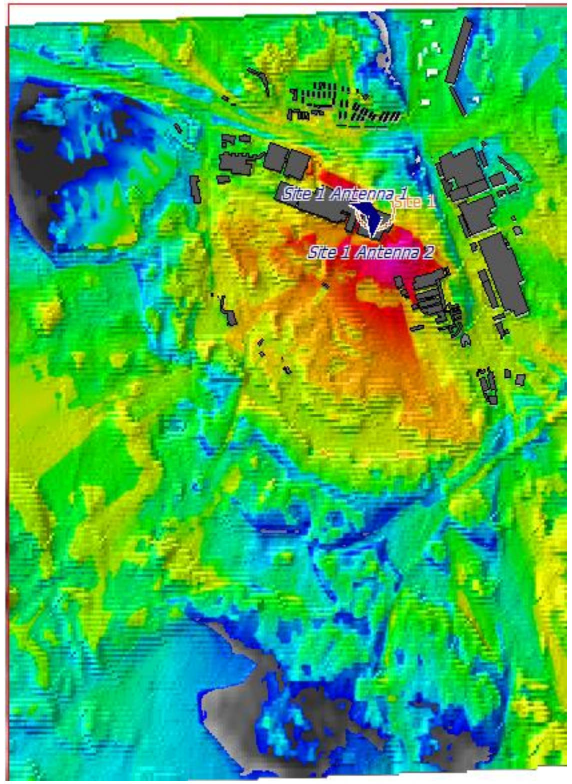
Case 4: Frequency Band



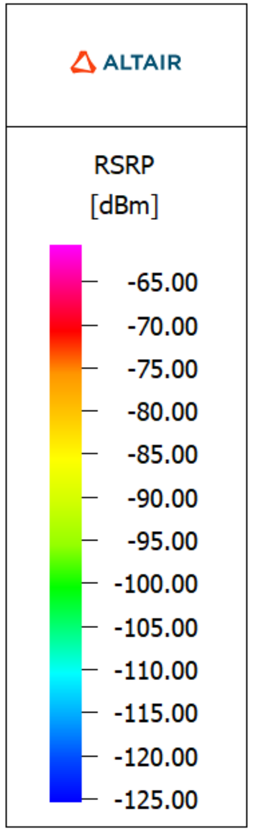
800MHz



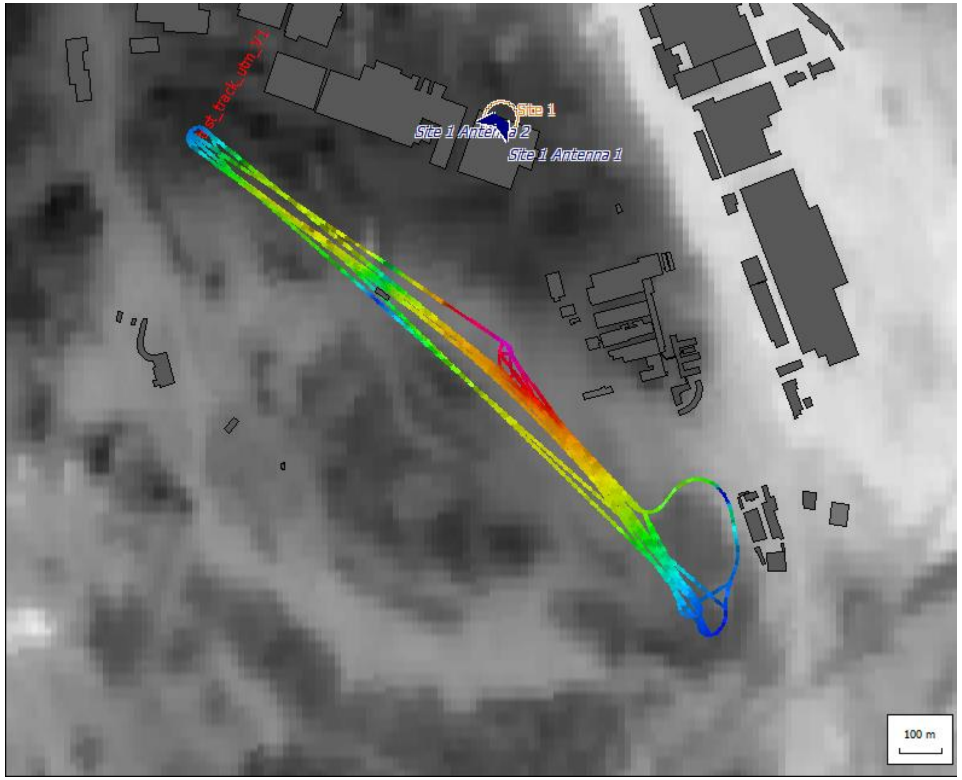
2.6GHz



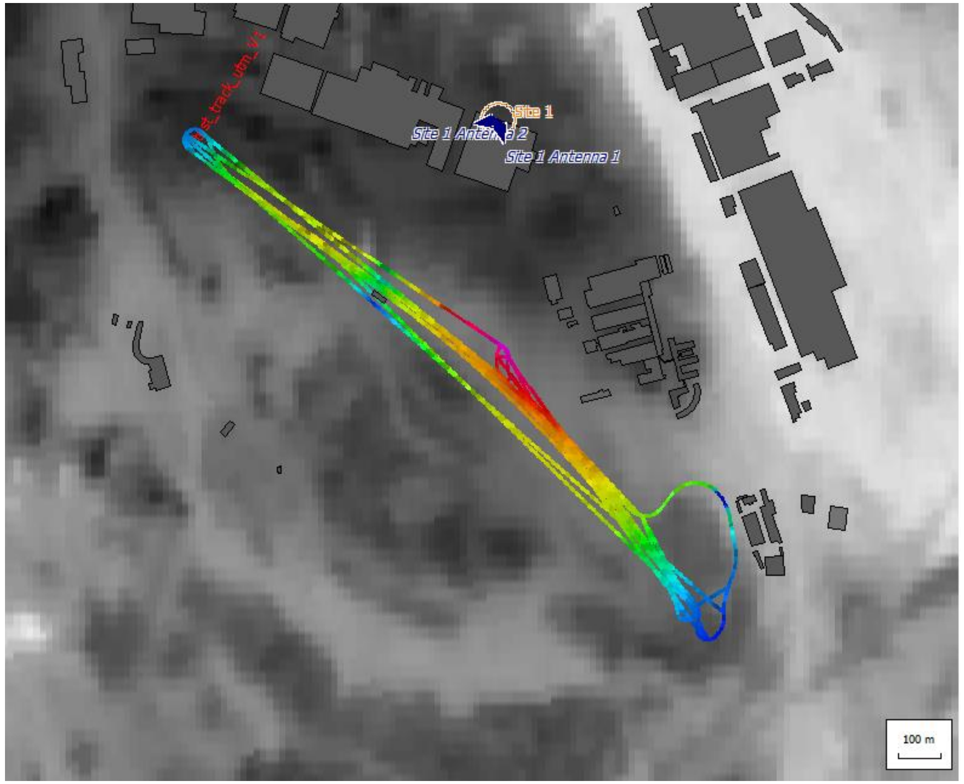
3.5GHz



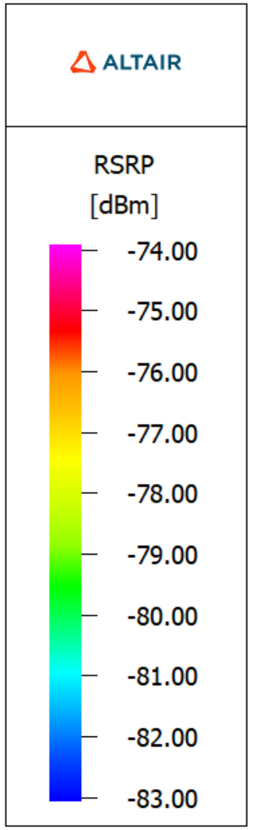
Case 5: Mobile Station (Speed)



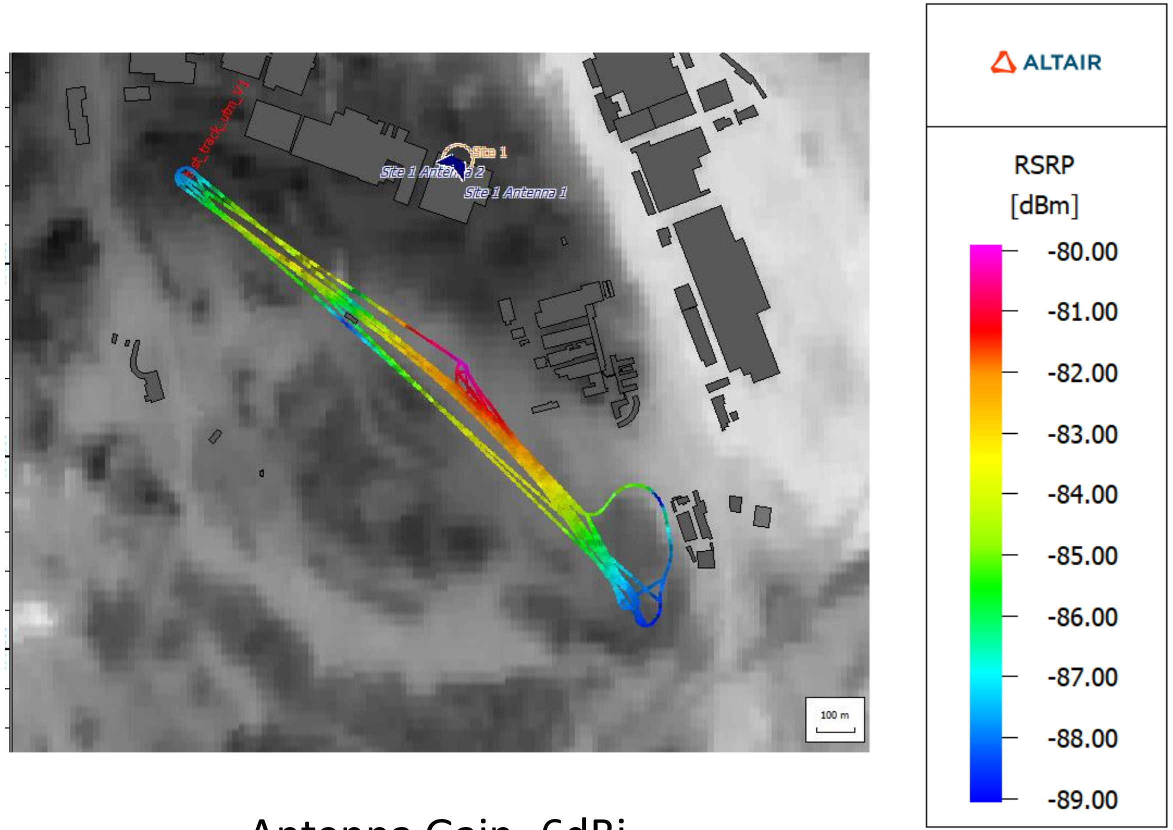
Vehicle Velocity 90km/h



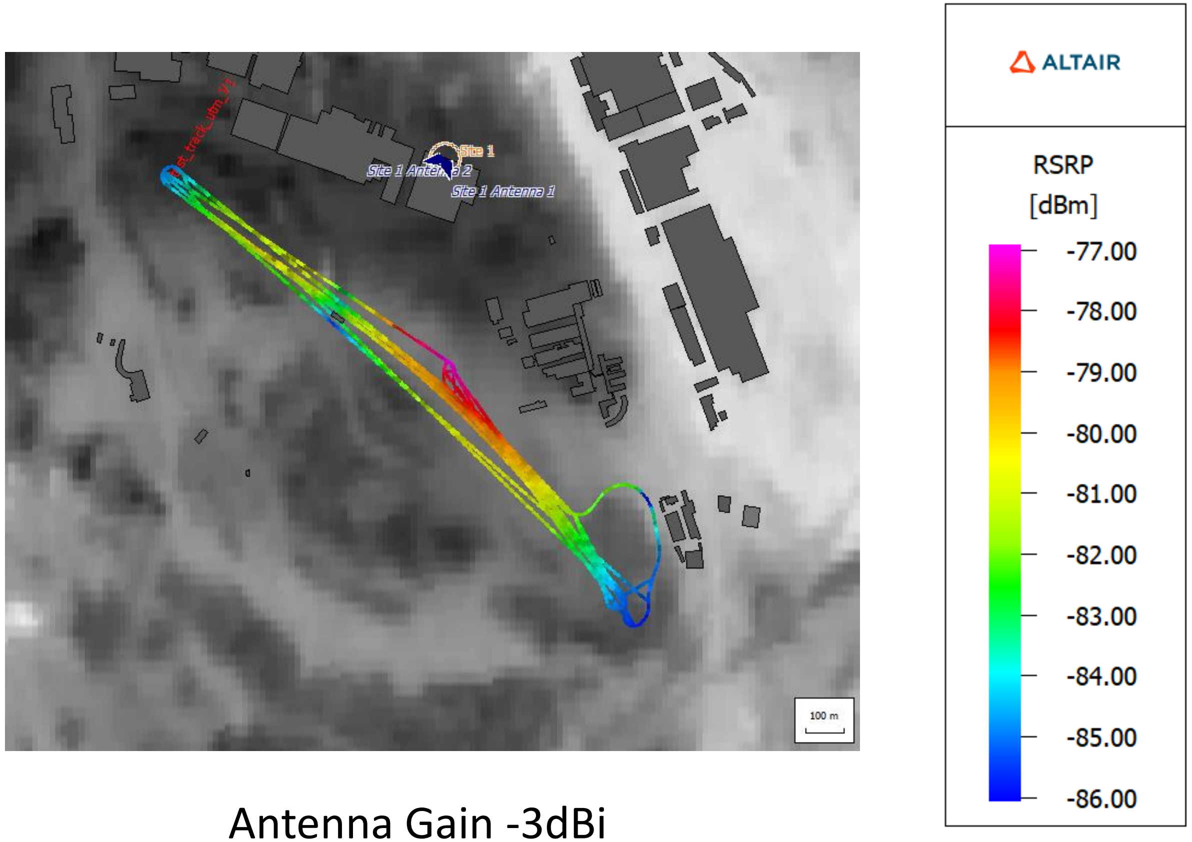
Vehicle Velocity 200km/h



Case 5: Mobile station(Antenna Gain)

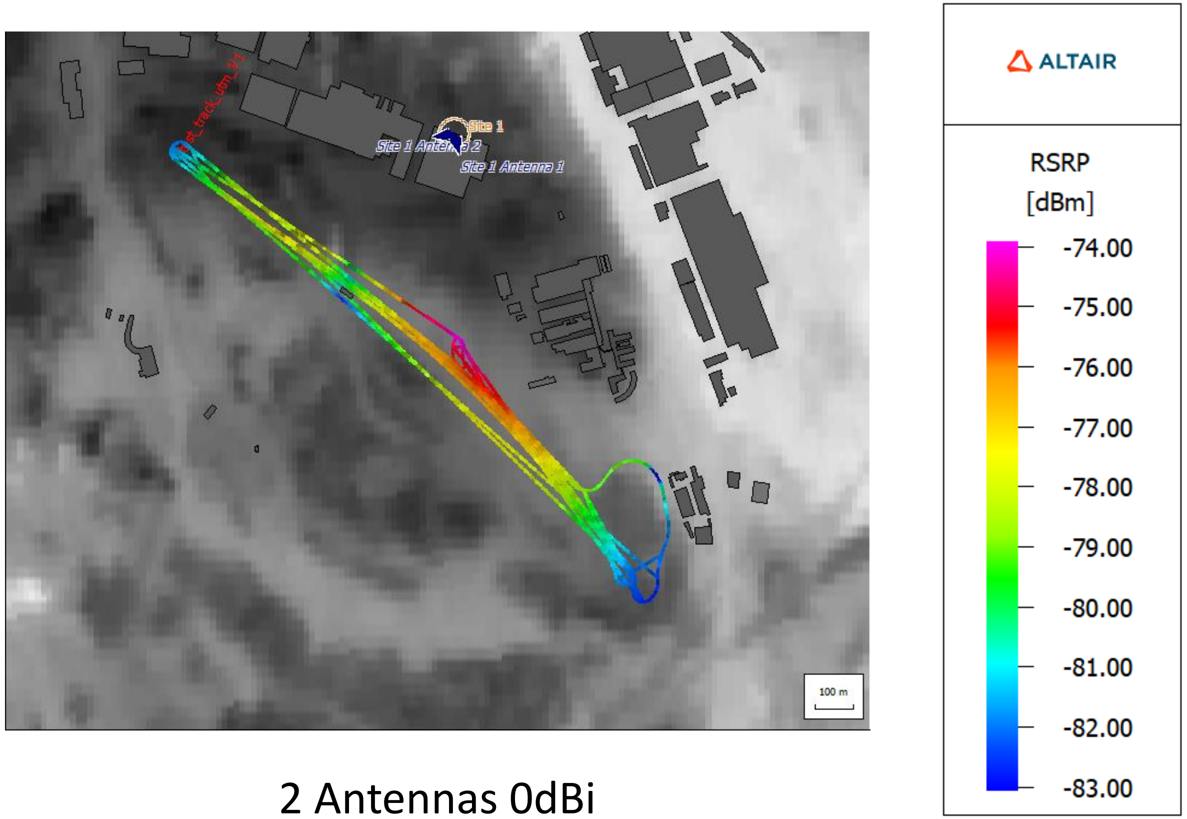


Antenna Gain -6dBi

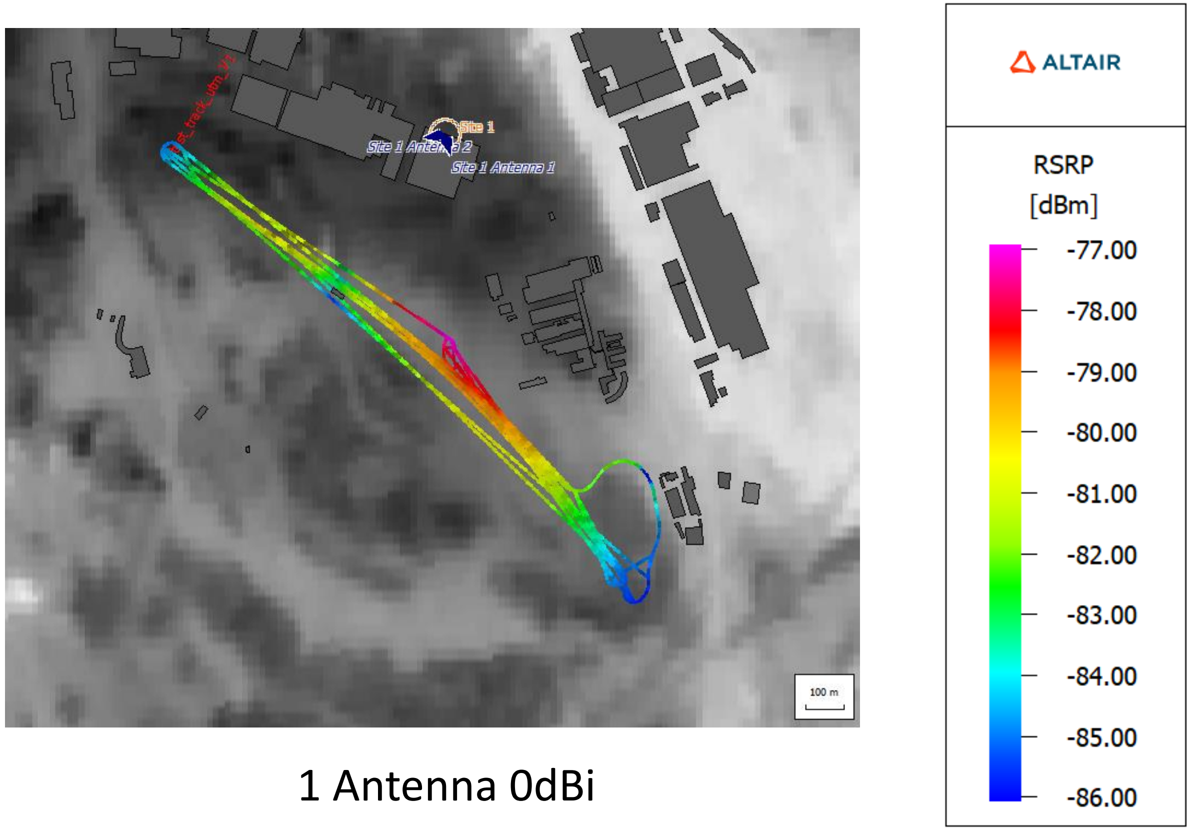


Antenna Gain -3dBi

Case 5: Mobile Station(MIMO vs. SISO)

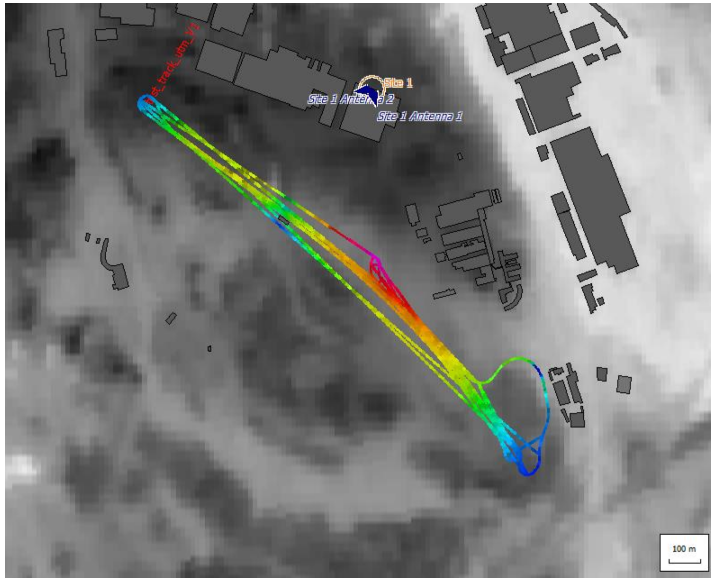


2 Antennas 0dBi

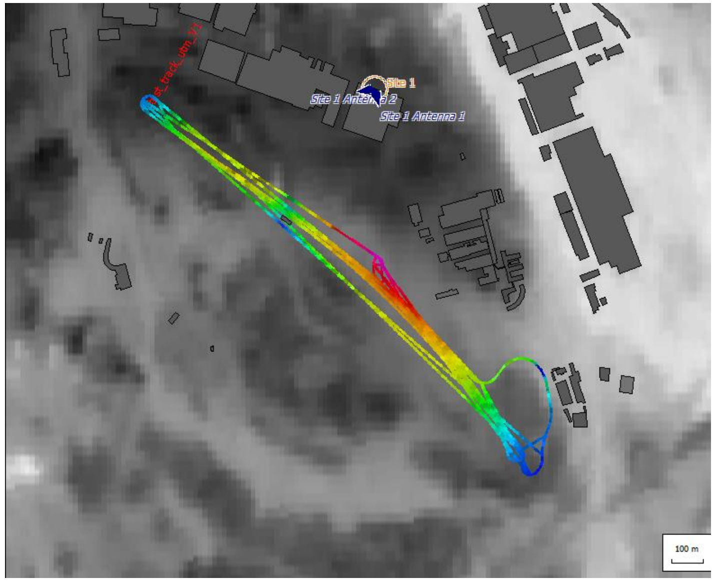


1 Antenna 0dBi

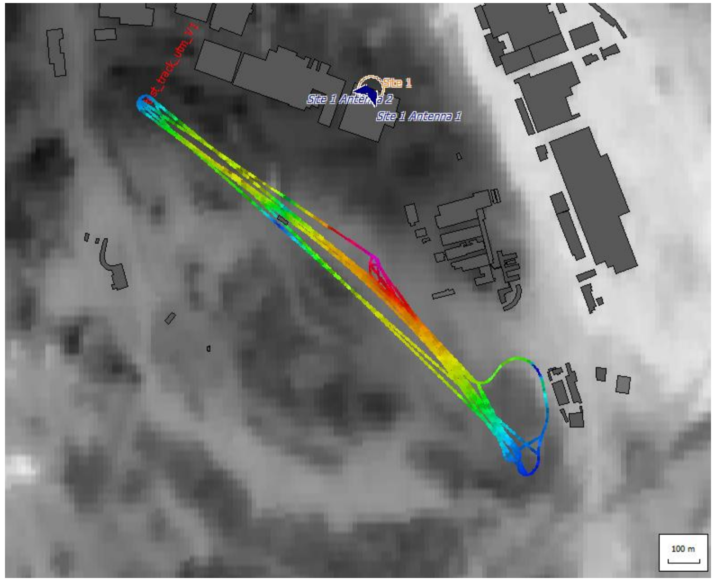
Case 5: MS(Antenna Spacing)



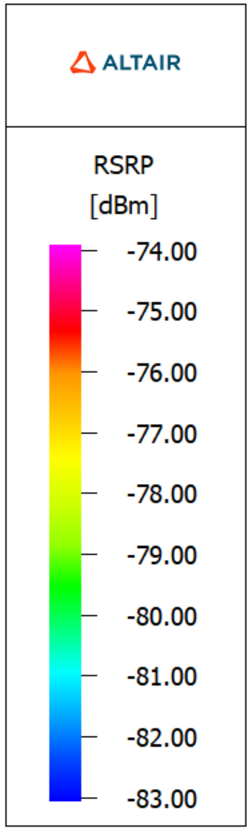
1.0 wavelength



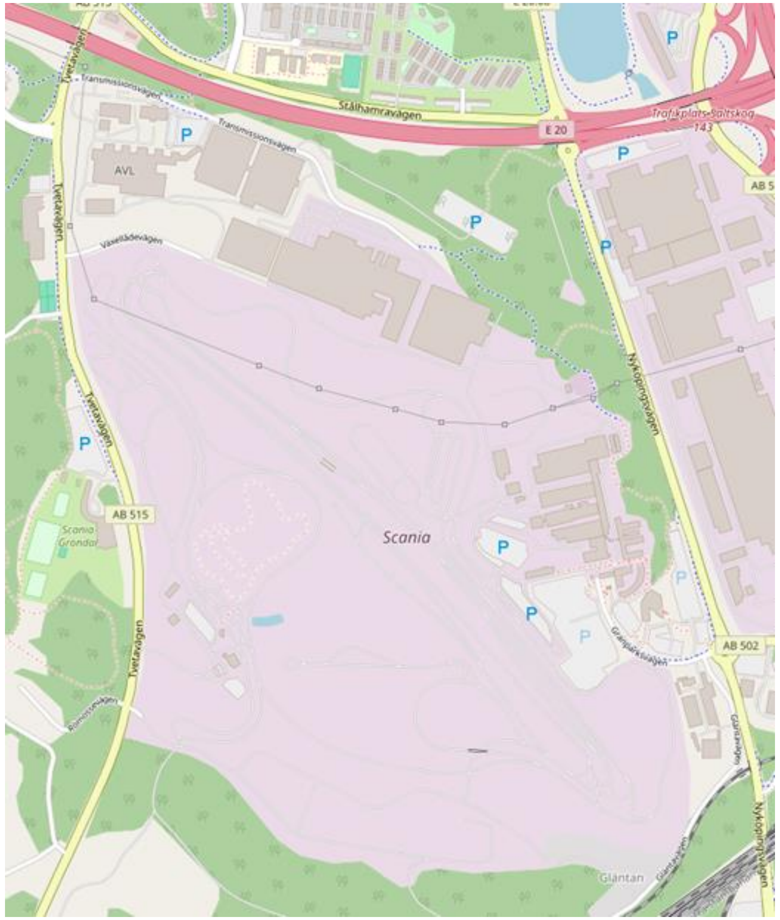
0.5 wavelength



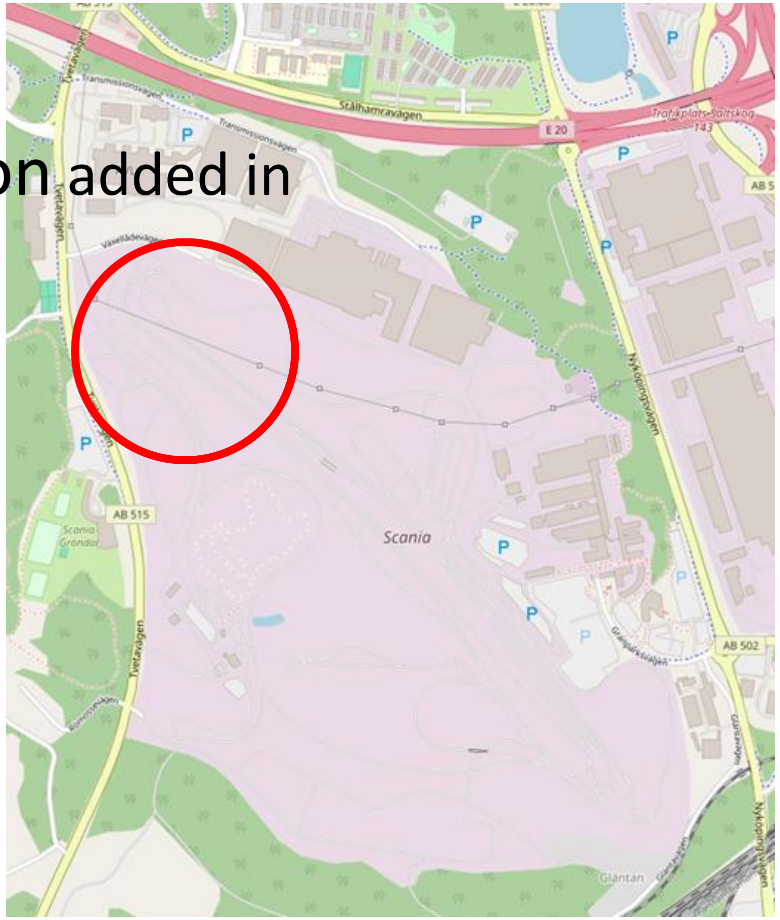
0.25 wavelength



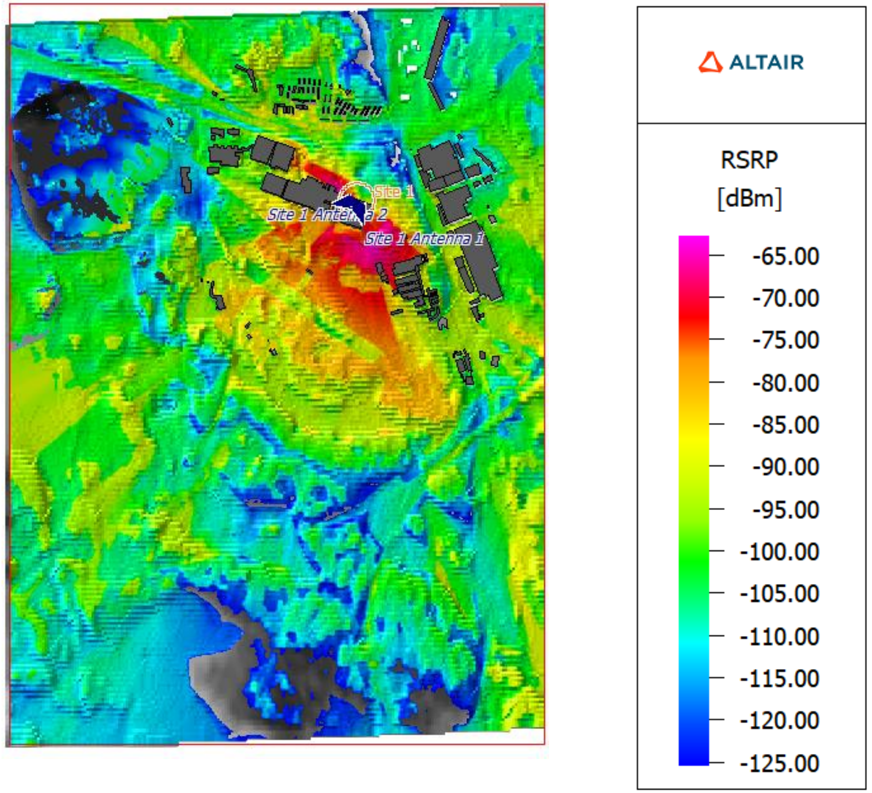
Update Map details



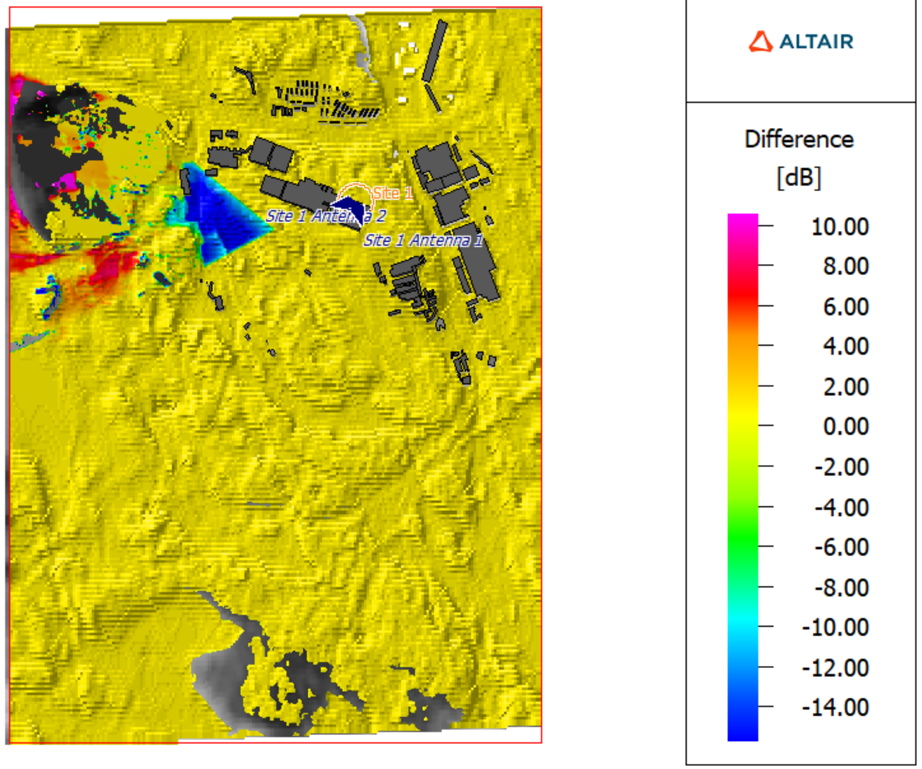
Vegetation added in WinProp



Update Map details



Updated Map



Subtraction result

Key Findings

- Accurate environmental modeling is crucial.
- Comparison of DPM and IRT showed similar results; IRT recommended for new scenarios.
- Low-frequency signals transmit farther; LOS critical for high-frequency communication at 3.5GHz.
- Increasing base station height enhances signal coverage.
- Mobile station gain and spatial diversity are essential; antenna spacing requires further investigation.
- Speed of the mobile must be considered in time-variant simulations.

Conclusion

- Critical Need Addressed:
  - Early verification and prediction of V2N communication performance.
- Methodology Development:
  - Complete simulation and evaluation methodology developed.
- Workflow and Simulation Methodology:
  - Feasible and effective for assessing V2N performance in real-world.
  - Emphasis on the impact of driving environment, topography, and vegetation on signal performance.

Future Work

- Expand scenarios for driving environment
  - Current project scenario: rural/ subrural
  - Potential expansion of scenarios to: urban, suburban, highway

- Potential applications in development process of telematic systems
  - Predict system performance in typical scenarios: urban, suburban, highway, rural
  - Buidling up system models for benchmarking and evaluation
    - For example, evaluate impact of new antennas on system performance

Q&A