



AAM 2024

FIRST ADVANCED
AIR MOBILITY SYMPOSIUM



جامعة الملك عبد الله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Urban Air Mobility Communications:

Coverage Analysis and Corridor Design



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Baha Eddine Youcef BELMEKKI

Postdoctoral fellow



Mohamed-Slim ALOUINI

Distinguished Professor



Host Institution



King Abdullah University of
Science and Technology



UNESCO

Chair on Education

Connect the Unconnected

Holder of the Chair



Mohamed-Slim ALOUINI

Ground



Bringing Education in Unconnected Area
Connected Remote Villages

Aerial



Connected Aerial Space
Enabling Advanced and Urban Air Mobility

Maritime



Connected Maritime Areas
Connecting Underwater Environment



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NEOM and Volocopter



June 2023: First Electric Air Taxi Flight in Saudi Arabia

Saudia Group and Lilium



July 2024: Signs Largest Global Agreement to Acquire Up to 100 eVTOL

Eve and Joby



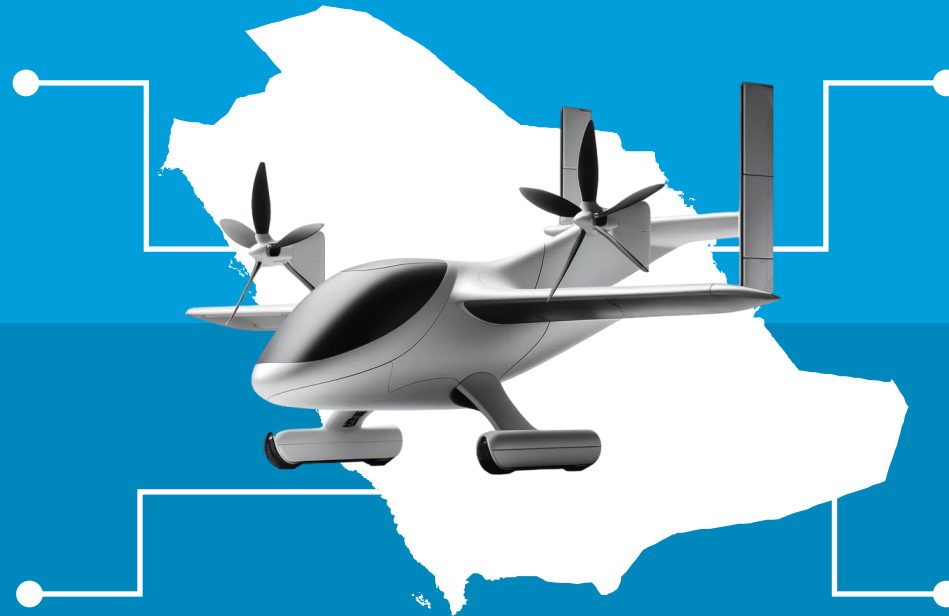
June 2024: Sign eVTOL Aircraft Agreements in Saudi Arabia

EHang



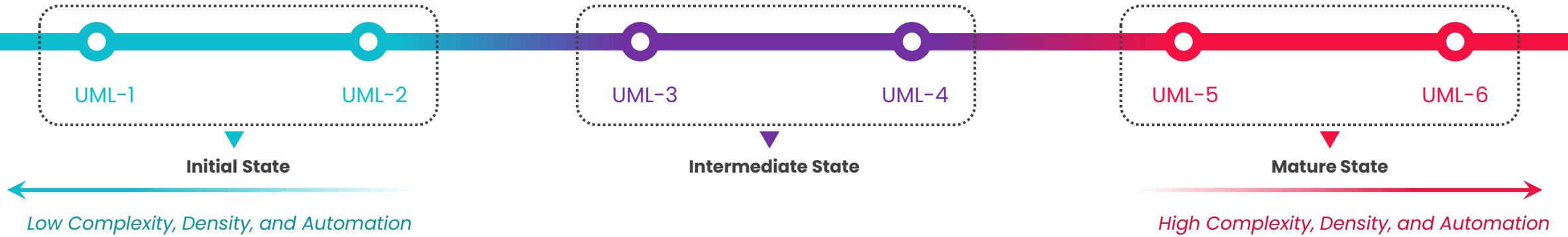
June 2024: Saudi Arabia trials EHang eVTOL for Mecca pilgrims

Advanced Air Mobility



Urban Air Mobility

UAM Maturity Level (UML)



Real-Time Decisions

Traffic Coordination

Safety & Navigation

Control & Monitoring

Passenger Services

Emergency Response





WHAT

Communication Infrastructure for eVTOL ?

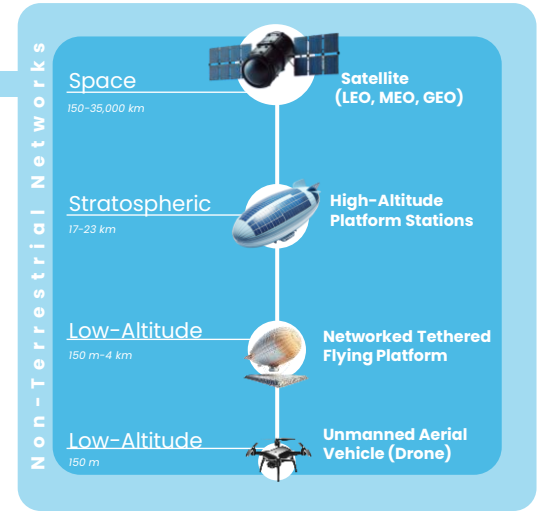
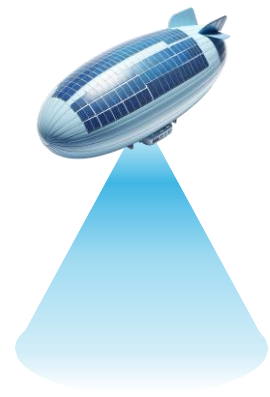


Cellular Tower

- ✗ Down tilted Antenna
- ✗ Redesign Required
- ✗ Limited Coverage
- ✗ Multiple Handovers
- ✗ Limited Line-of-Sight (LOS)

NTN Tower

- ✓ Technology Agnostic
- ✓ Easy and A quick Deployment
- ✓ Cost-Efficient
- ✓ Large Coverage
- ✓ Few Handovers
- ✓ Clear and Non-Obstructed LOS



WHY

Analyze The Performance ?

- Understand of its potential impact
- Design architectures and protocols
- Optimize UAM network infrastructure
- Correlation between different parameters

WHY

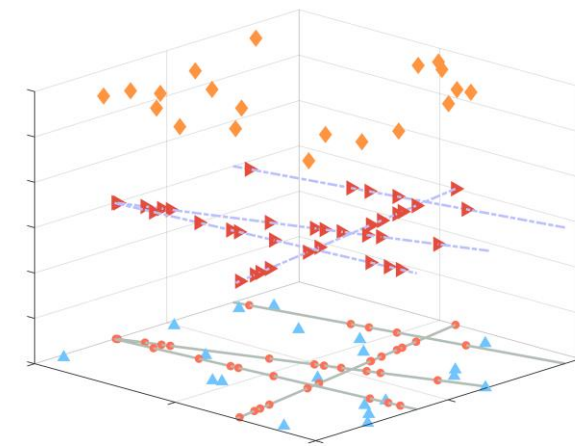
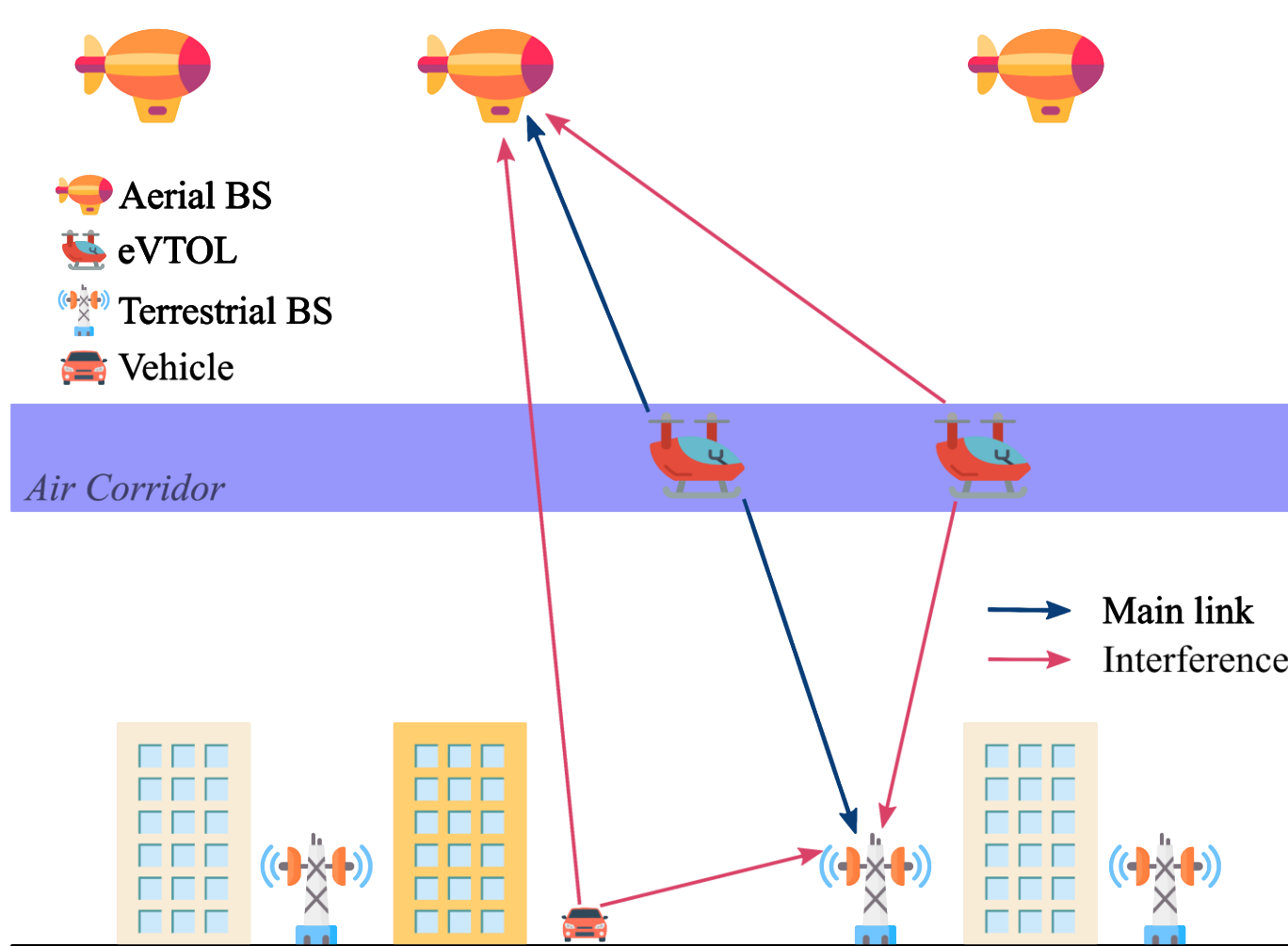
Large-Scale Networks ?

Single/Few Cells	Large Number of Cells
Easy to analyze ●	Real-world configuration ●
Unrealistic performance ●	Increased complexity ●
Misleading insight ●	High levels of interference ●

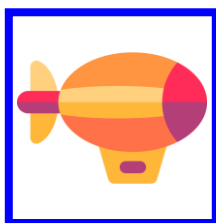
WHY

Using Stochastic Geometry ?

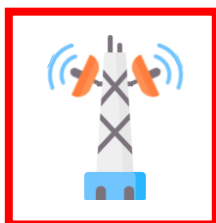
Hexagonal Model	Stochastic Geometry	Simulations
Structured farmwork ●	Accurate & tractable	Accurate performance ●
Unrealistic deployment ●	Computationally efficient	Extensive computation ●
Unrealistic insight ●	Variable set of parameters	Fixed set of parameters ●
	Realistic deployment & insight	



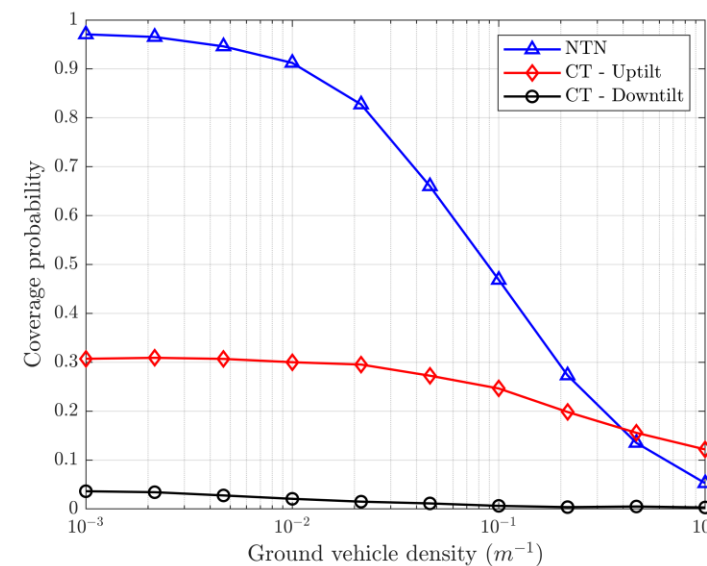
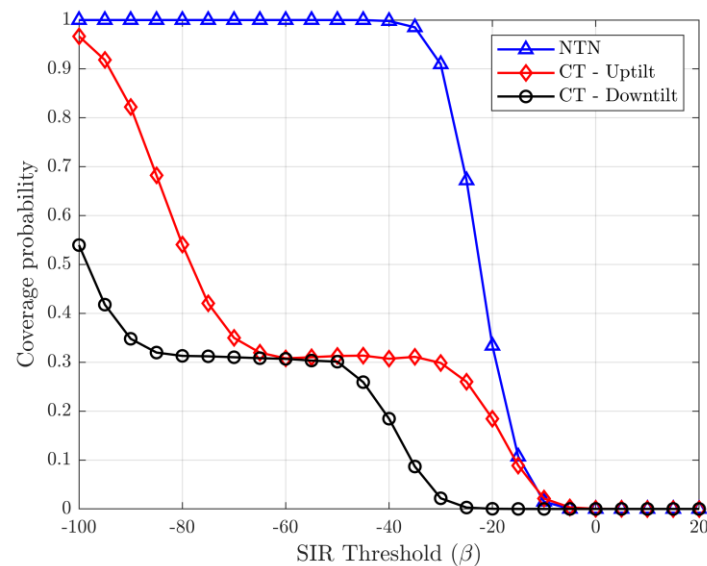
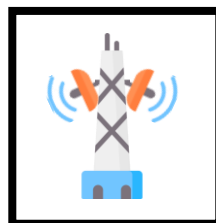
NTN

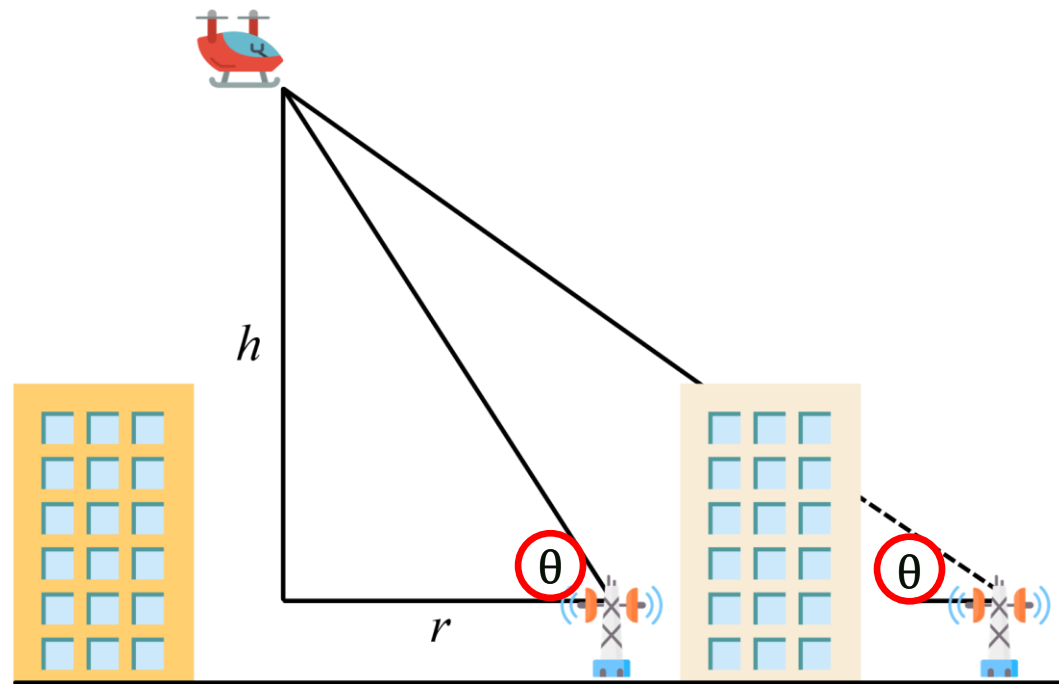


CT Up



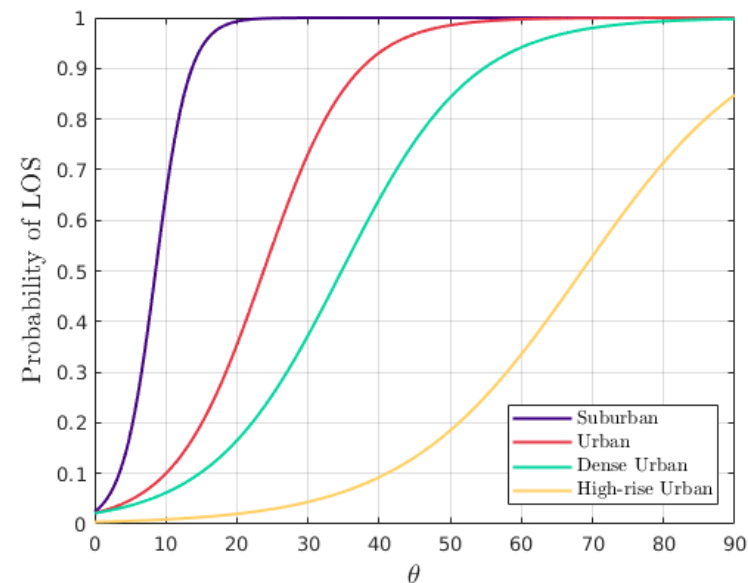
CT Down

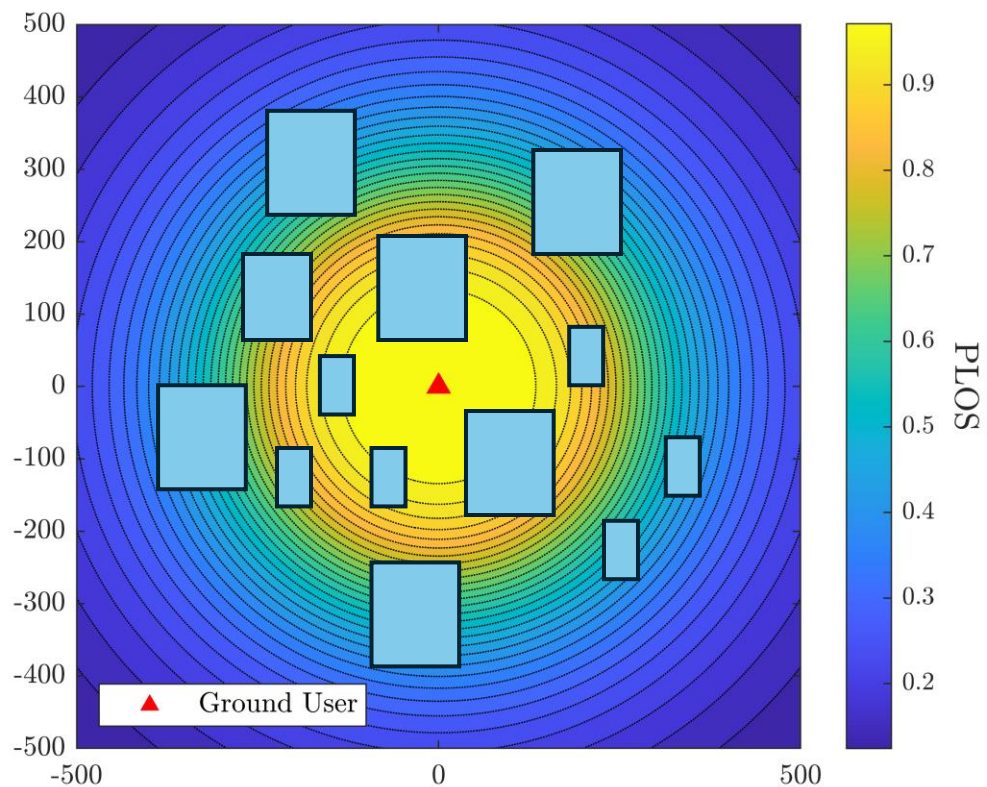




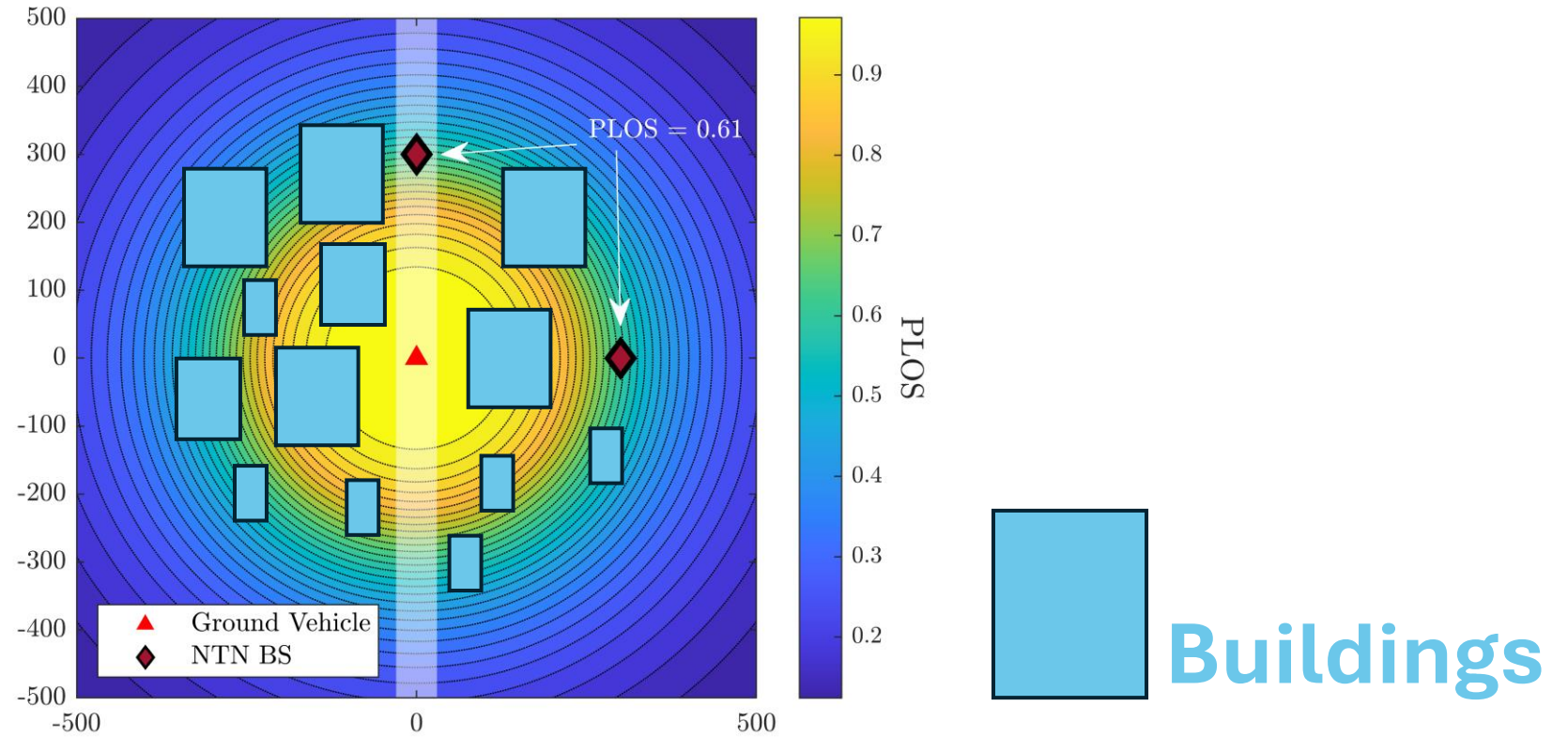
$$P_{\text{LOS}}(r) = \frac{1}{1 + a \exp(-b(\theta - a))}$$

$$\theta = \tan^{-1}(h/r)$$





Buildings



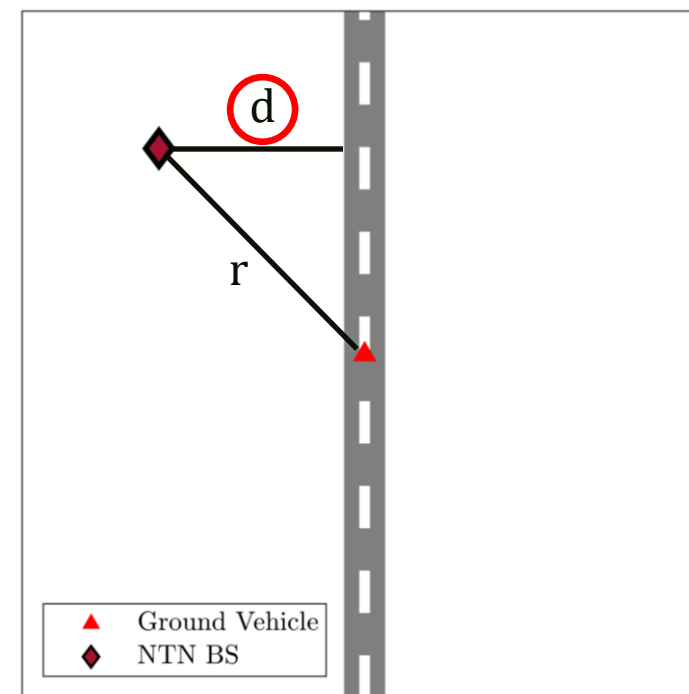
Parameters that depend on the street density – congestion, obstacles, etc.

Perpendicular distance to the street

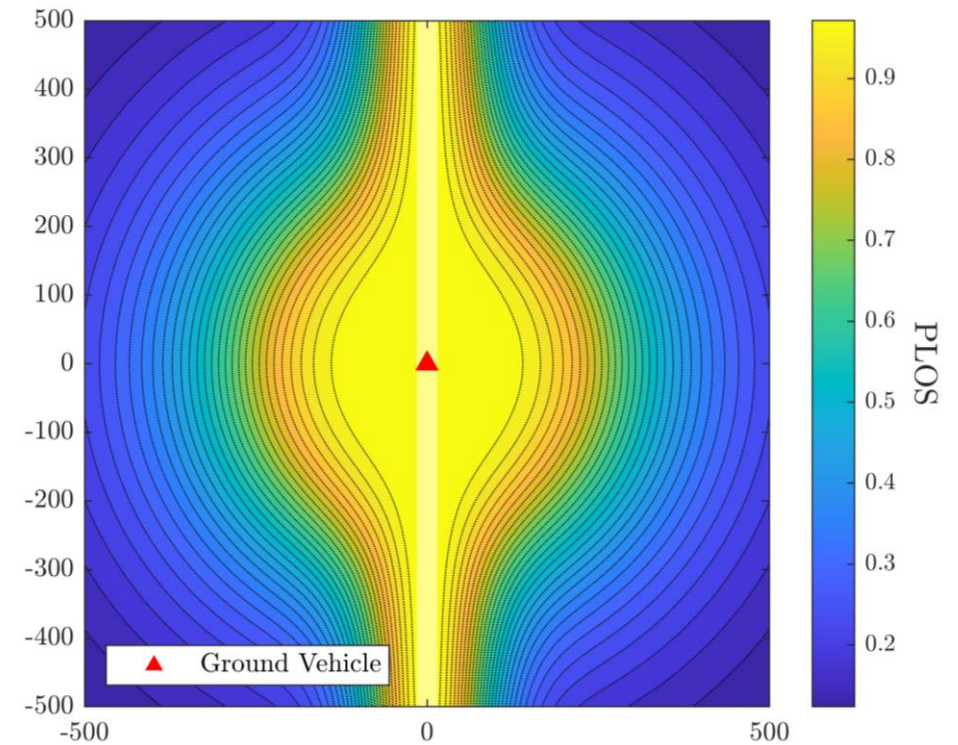
$$P_{LOS}(r) = \exp(-cd^2) \times \frac{1}{1 + a_1 \exp(-b_1(\theta - a_1))} + (1 - \exp(-cd^2)) \times \frac{1}{1 + a \exp(-b(\theta - a))}$$

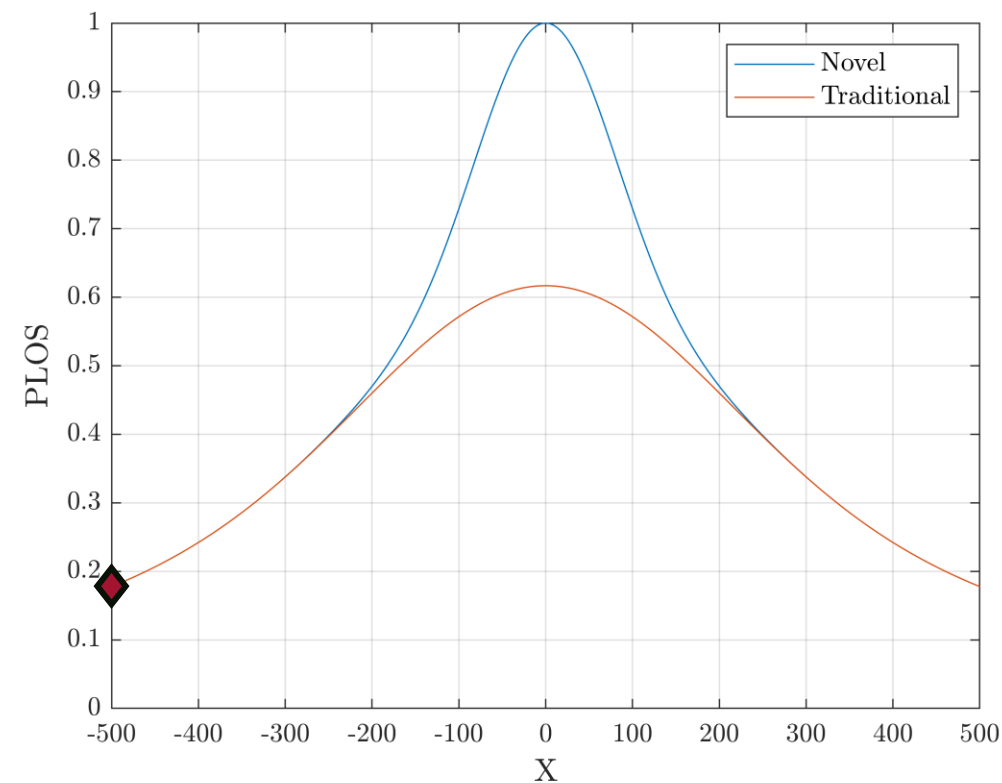
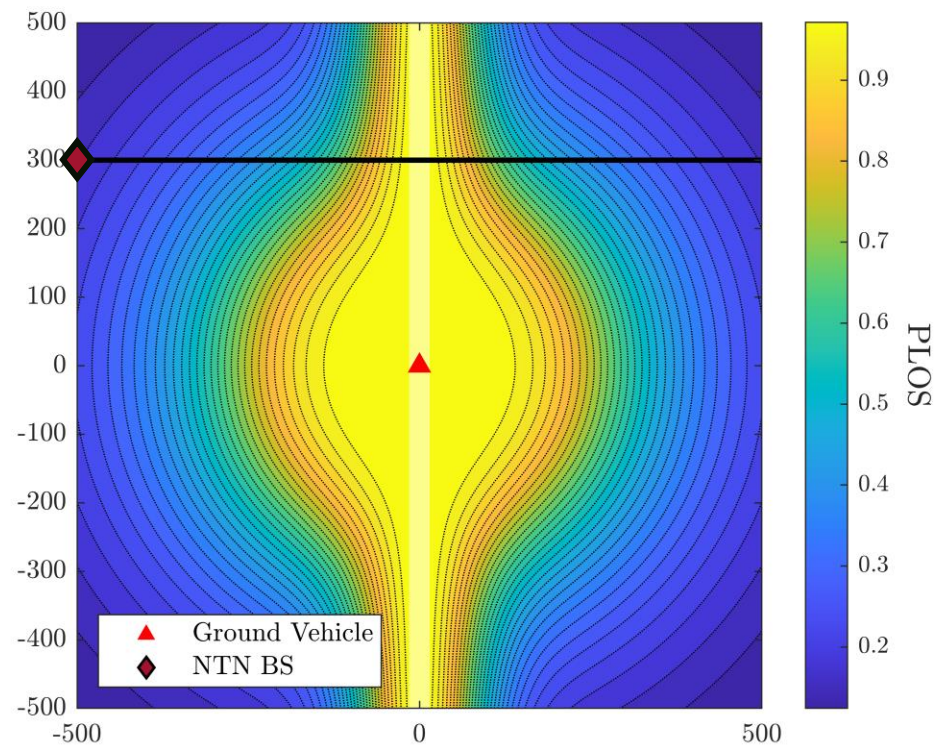
Parameter that depends on the street width

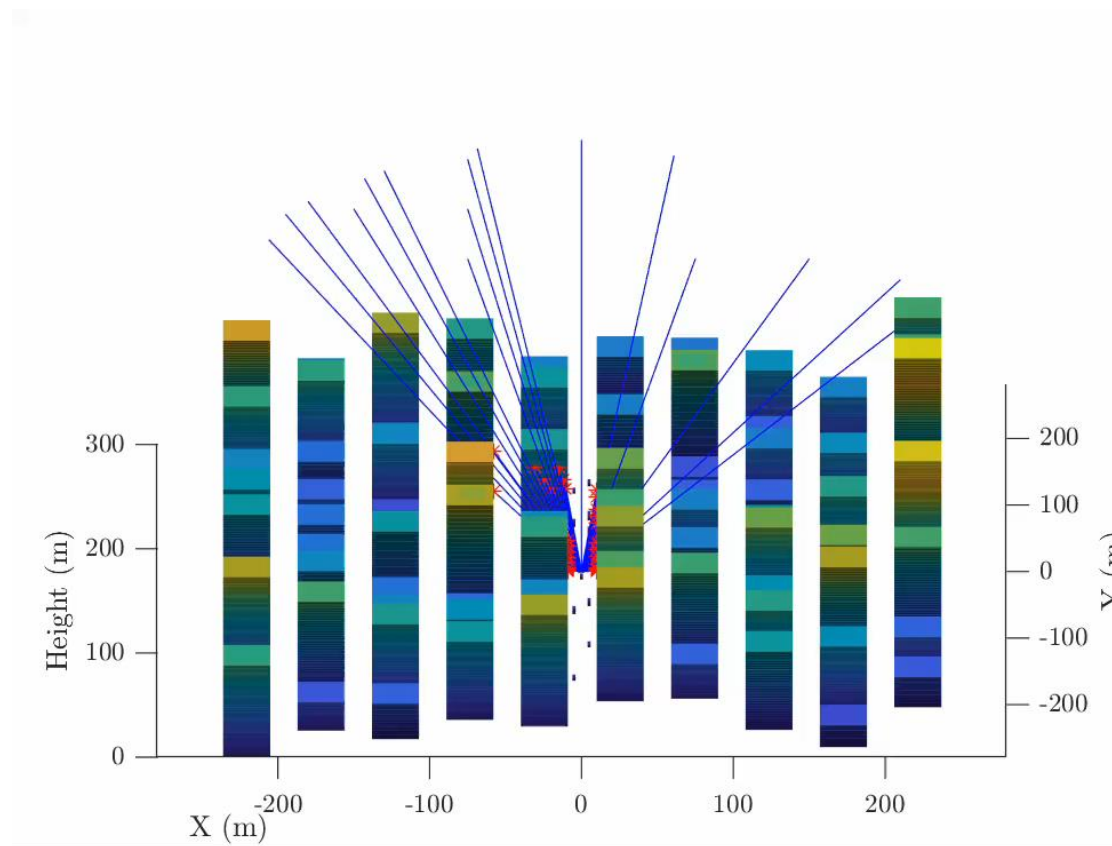
Parameters that depend on the environment density



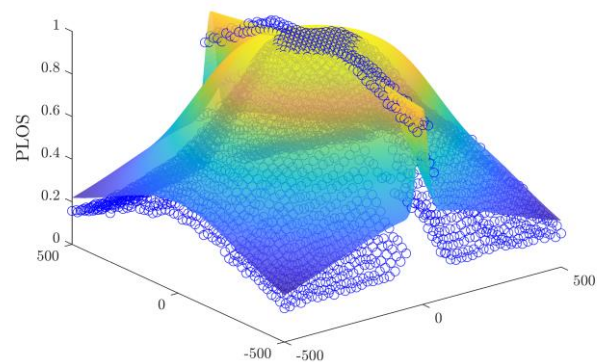
$$P_{\text{LOS}}(r) = \exp(-cd^2) \times \frac{1}{1 + a_1 \exp(-b_1(\theta - a_1))} + (1 - \exp(-cd^2)) \times \frac{1}{1 + a \exp(-b(\theta - a))}$$



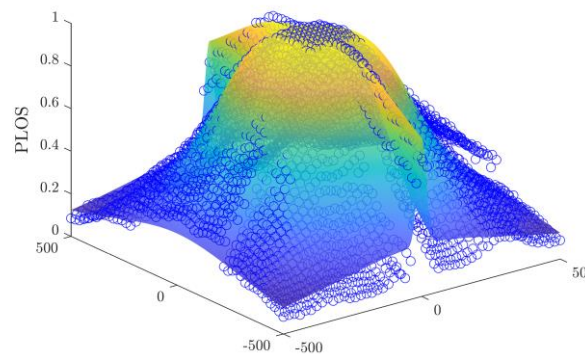




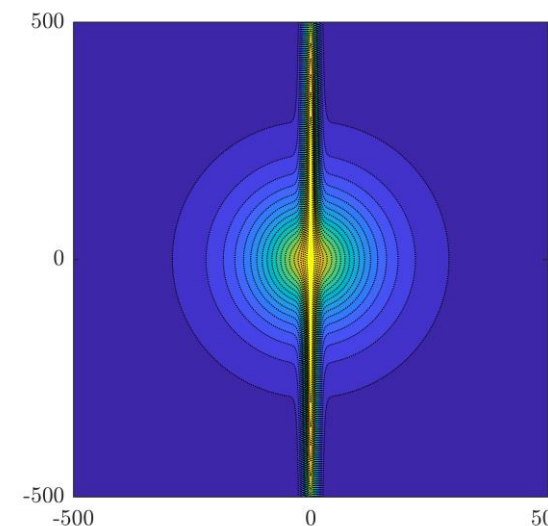
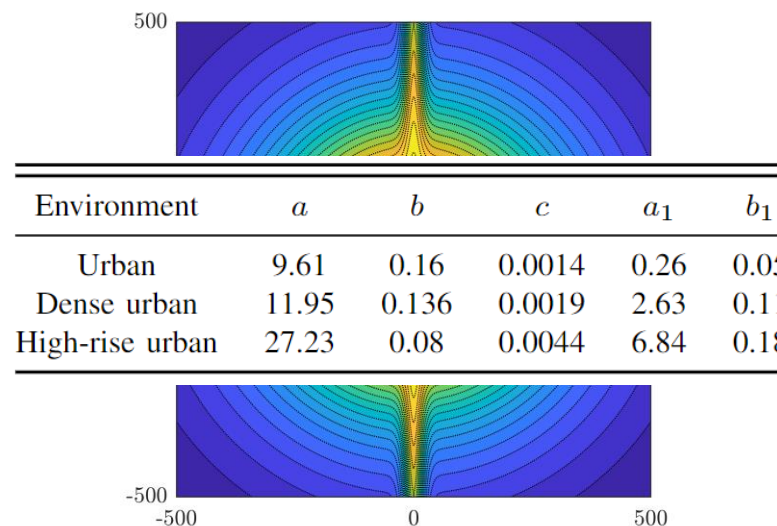
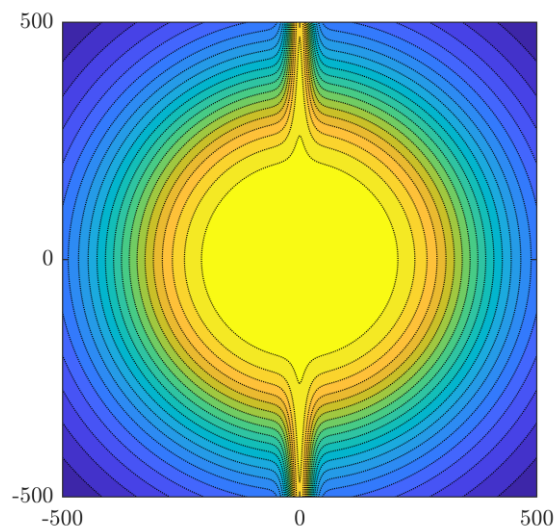
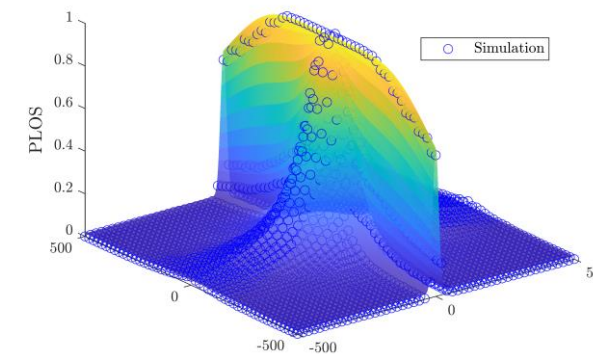
Urban



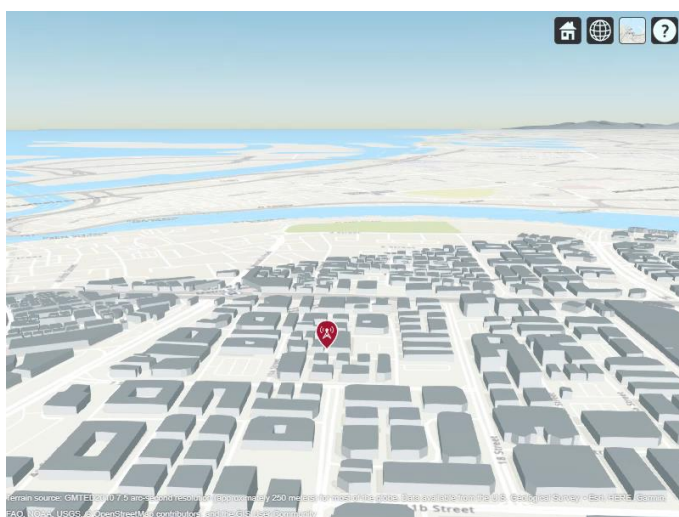
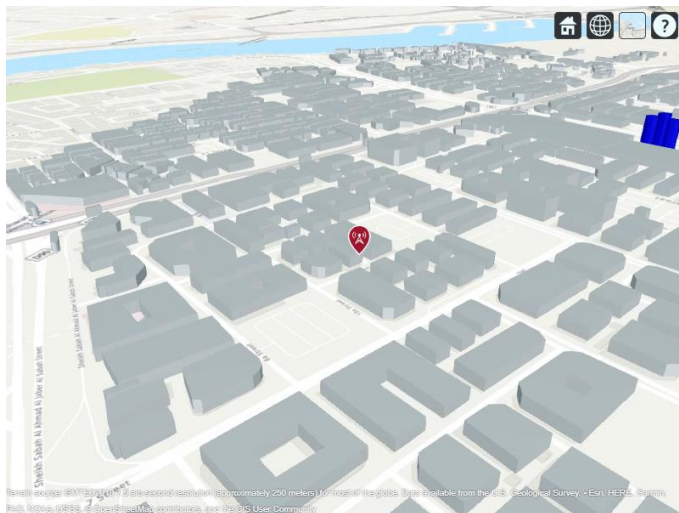
Dense Urban



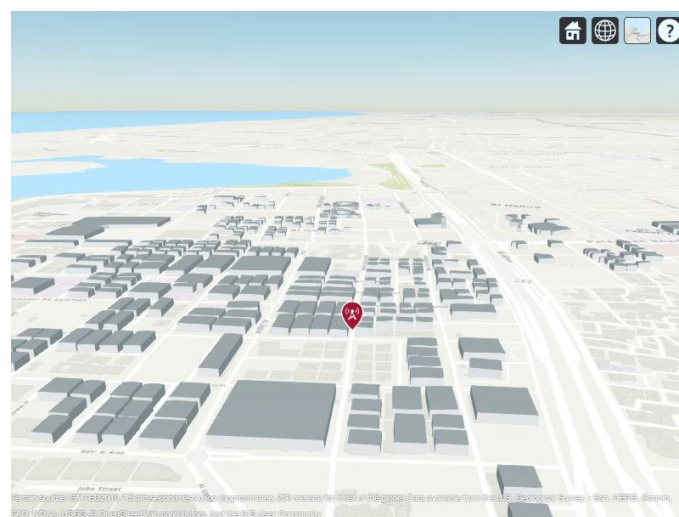
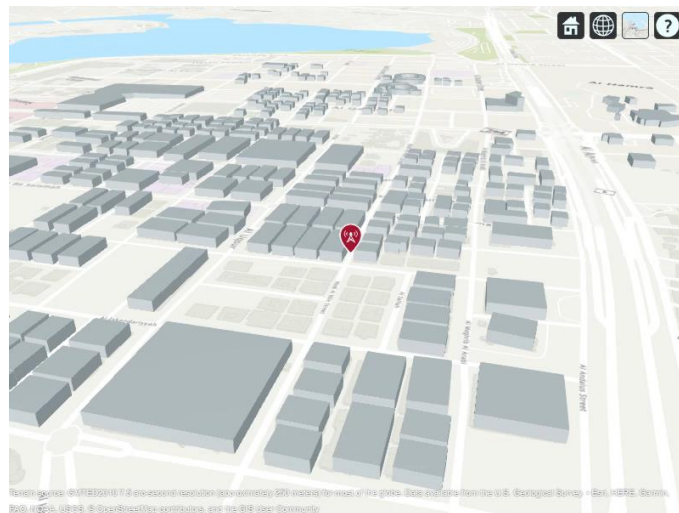
Highrise Urban



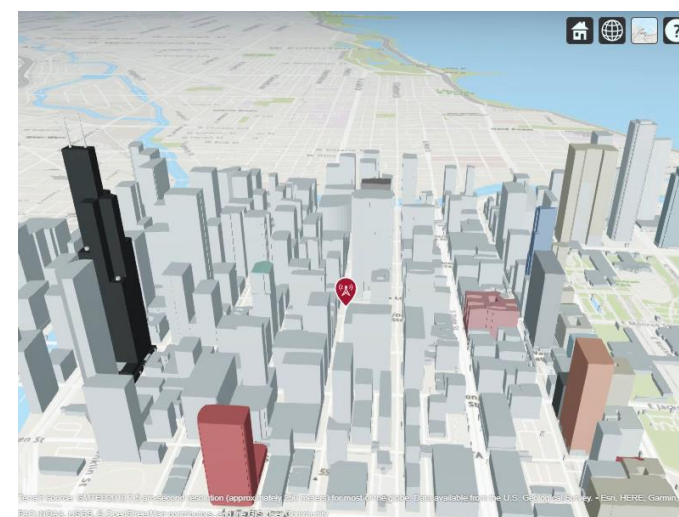
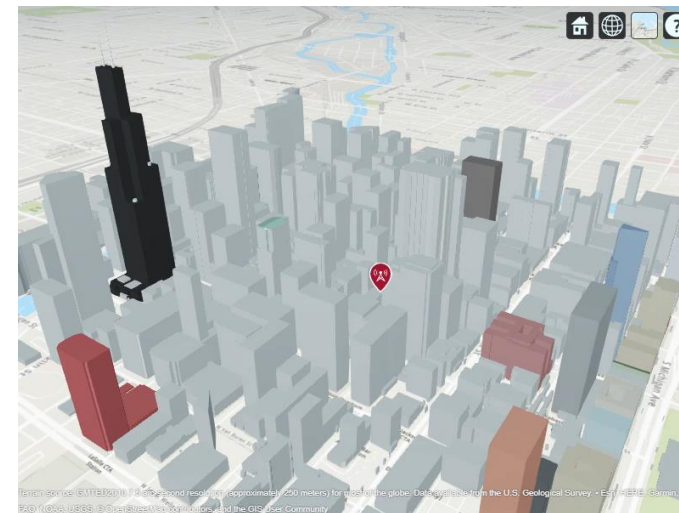
Urban - Dubai



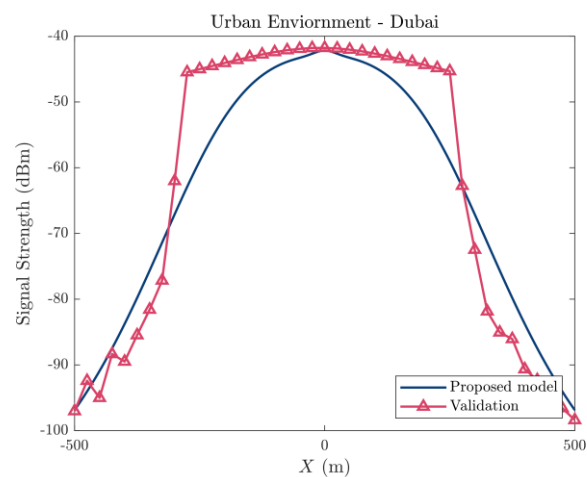
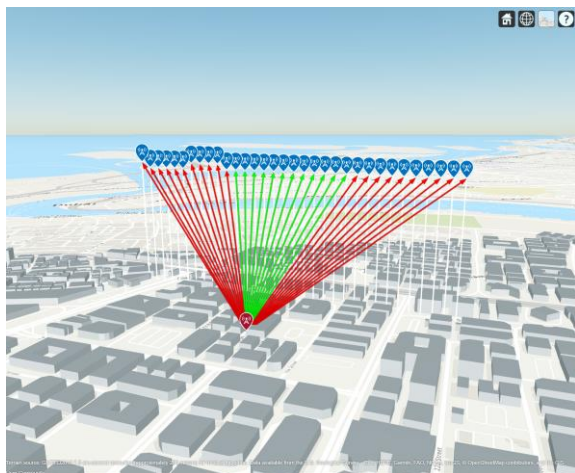
Dense Urban - Jeddah



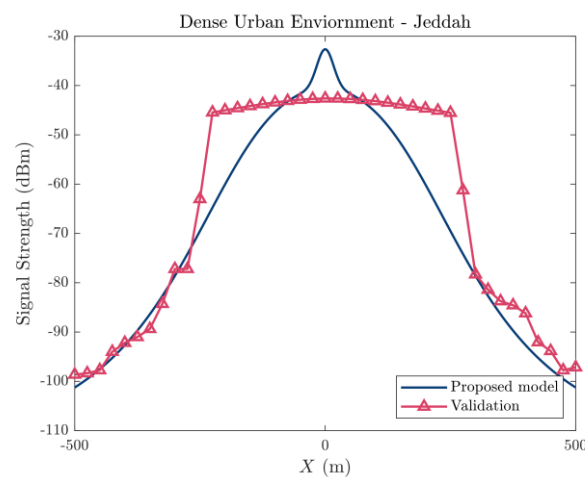
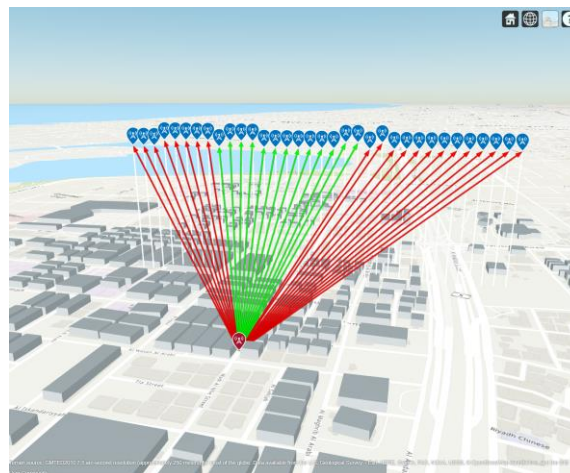
Highrise Urban - Chicago



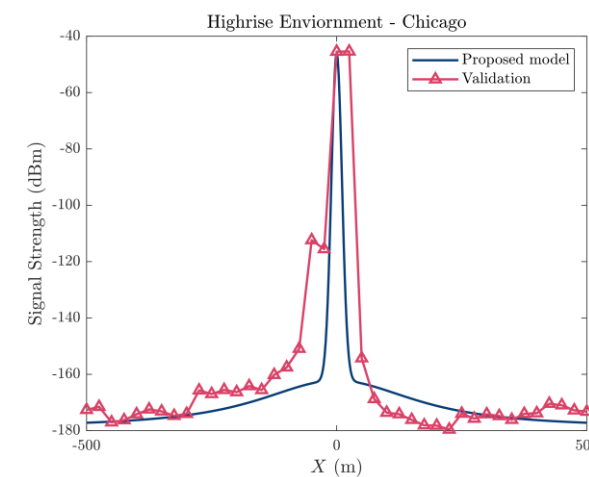
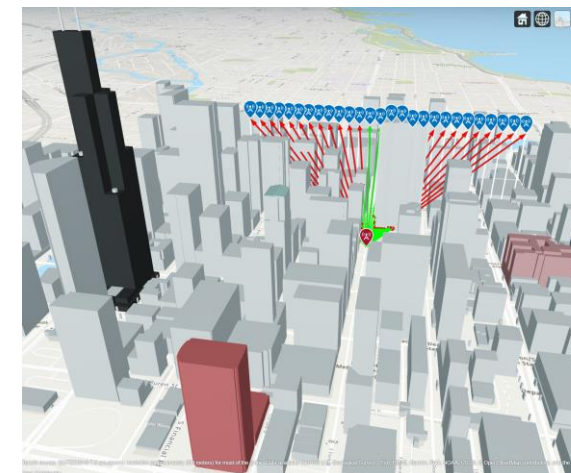
Urban - Dubai



Dense Urban - Jeddah



Highrise Urban - Chicago



Urban – Dubai



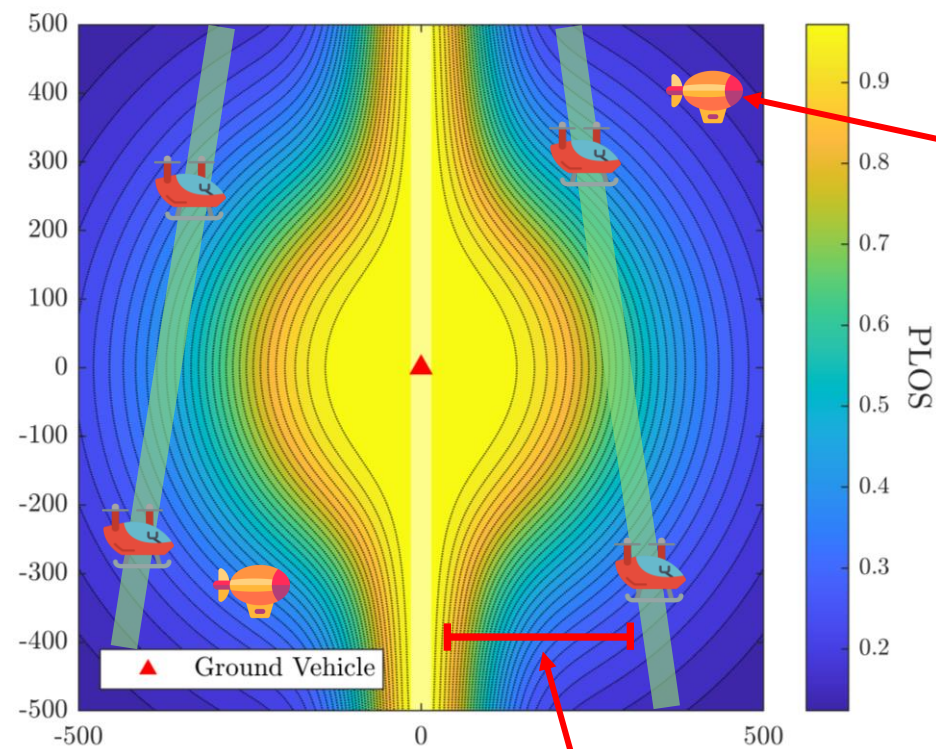
Dense Urban – Jeddah



Highrise Urban – Chicago



Overpredicts by 38%!



Avoid placing NTN above roads

- Maximize separation distance
- Minimize intersections



LinkedIn



YouTube



Website