KEYSIGHT

EXata - Network and RF Digital Twins

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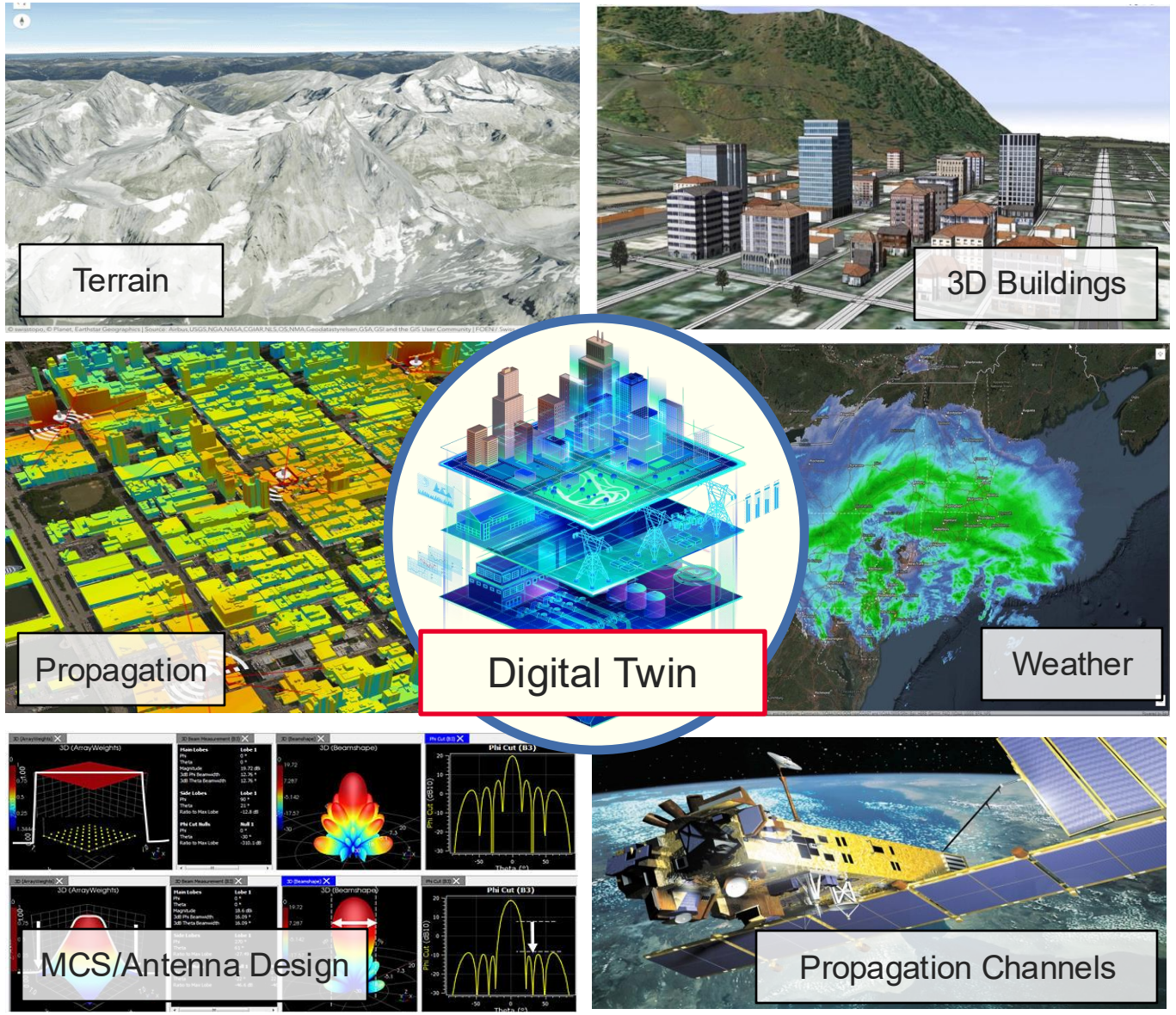
Keysight Digital Twin Product Line

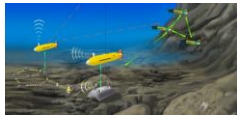
What is a Digital Twin?

Digital Twins: Accurate living models of real-world systems

- **Model**:
  - simulation or emulation model
  - mix of software and hardware
- **Living** (Dynamic):
  - model is linked with its physical twin
  - Digital Twin is updated at some regularity
- **Keysight Advantage:**
  - Keysight Classic typically represents single technology or interface
  - EXata provides end-to-end multi-technology emulation
  - Combination of EXata and Keysight Classic provides higher fidelity end-to-end solution



Technologies



Wargaming
- Immersive Environ.
- Training
- C3 systems

5G
- Network Planning
- Performance eval.
- Cyber Resiliency

Cyber
- Attack Emulation
- Large Scale networks
- Cyber Resiliency

Military Comms
- Link-16
- Interferers
- Adversarial environ

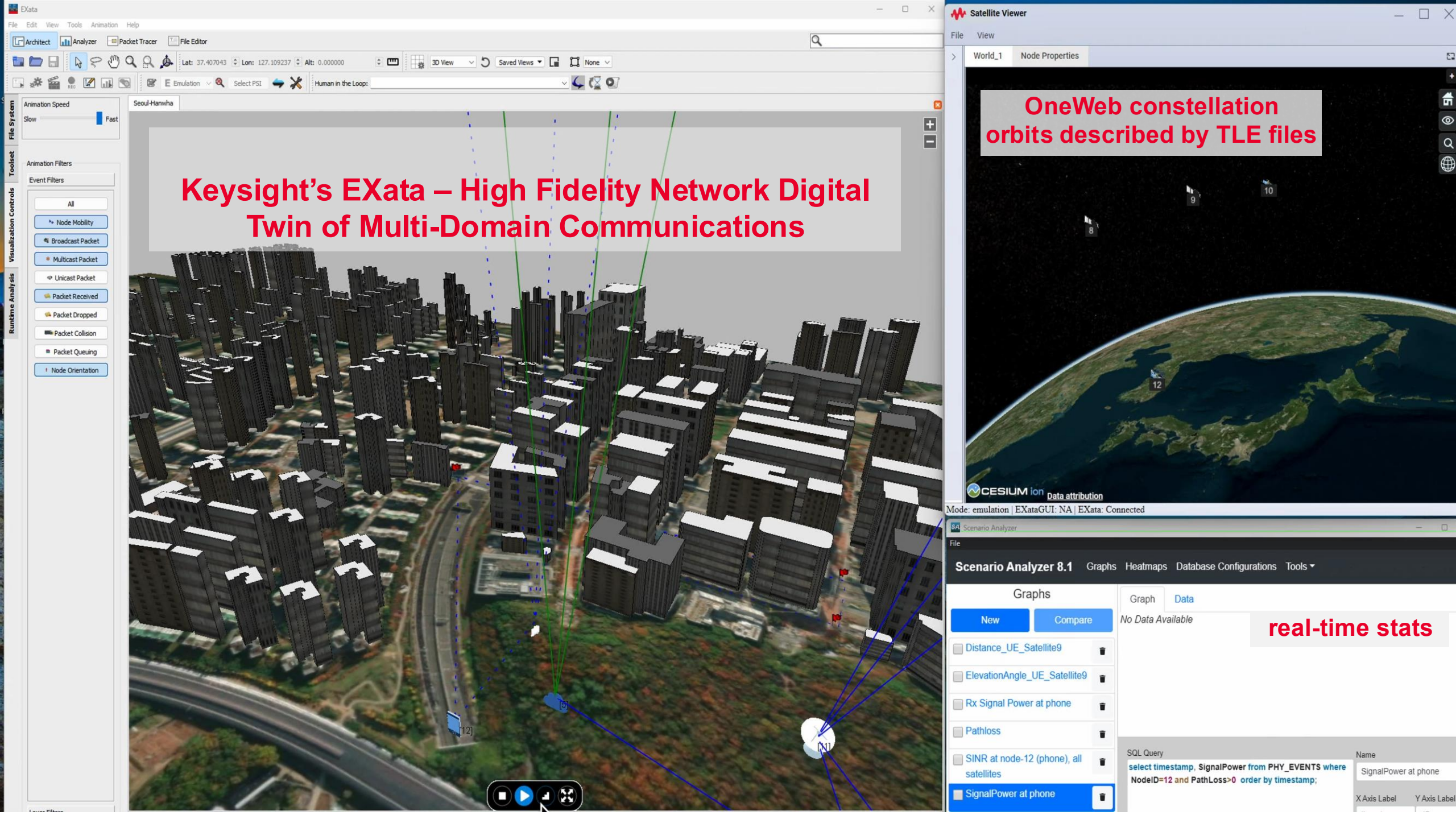
IoT
- Devices & Comms
- Multi-technology
- Networks

ELINT
- Identification
- Multi-domain
- Geospatial analytics

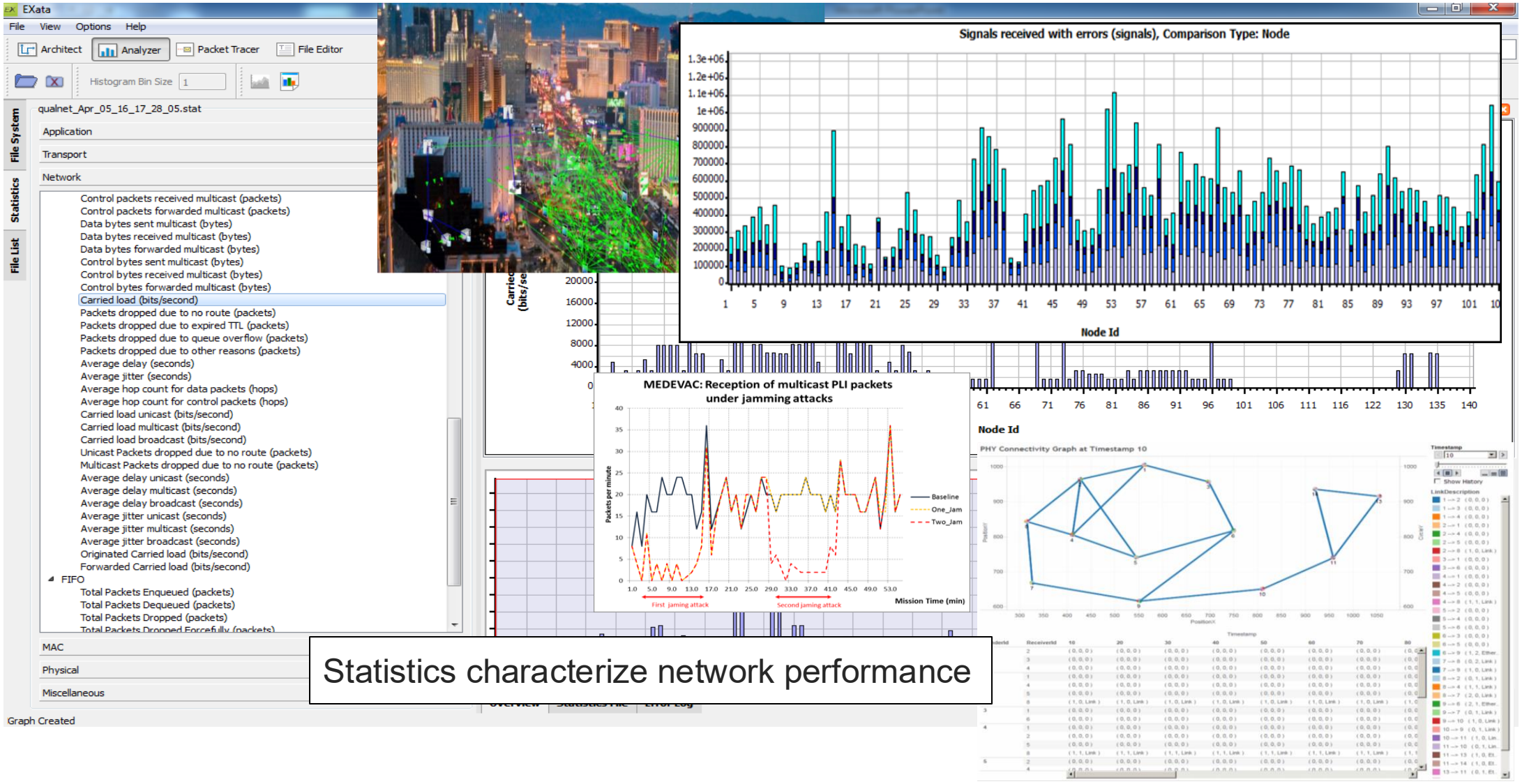
Supply Chain
- Smart Warehouse
- Smart City
- Communications

Underwater
- Acoustics
- Free-space Optical
- Propagation

Satellite
- C3 systems
- LEO and GEO sensors
- Adversarial scenarios


Keysight's EXata – High Fidelity Network Digital Twin of Multi-Domain Communications
OneWeb constellation orbits described by TLE files
real-time stats
Satellite Viewer
Scenario Analyzer 8.1
Graphs
Heatmaps
Database Configurations
Tools
Distance_UE_Satellite9
ElevationAngle_UE_Satellite9
Rx Signal Power at phone
Pathloss
SINR at node-12 (phone), all satellites
SignalPower at phone
No Data Available
select timestamp, SignalPower from PHY_EVENTS where NodeID=12 and PathLoss>0 order by timestamp;

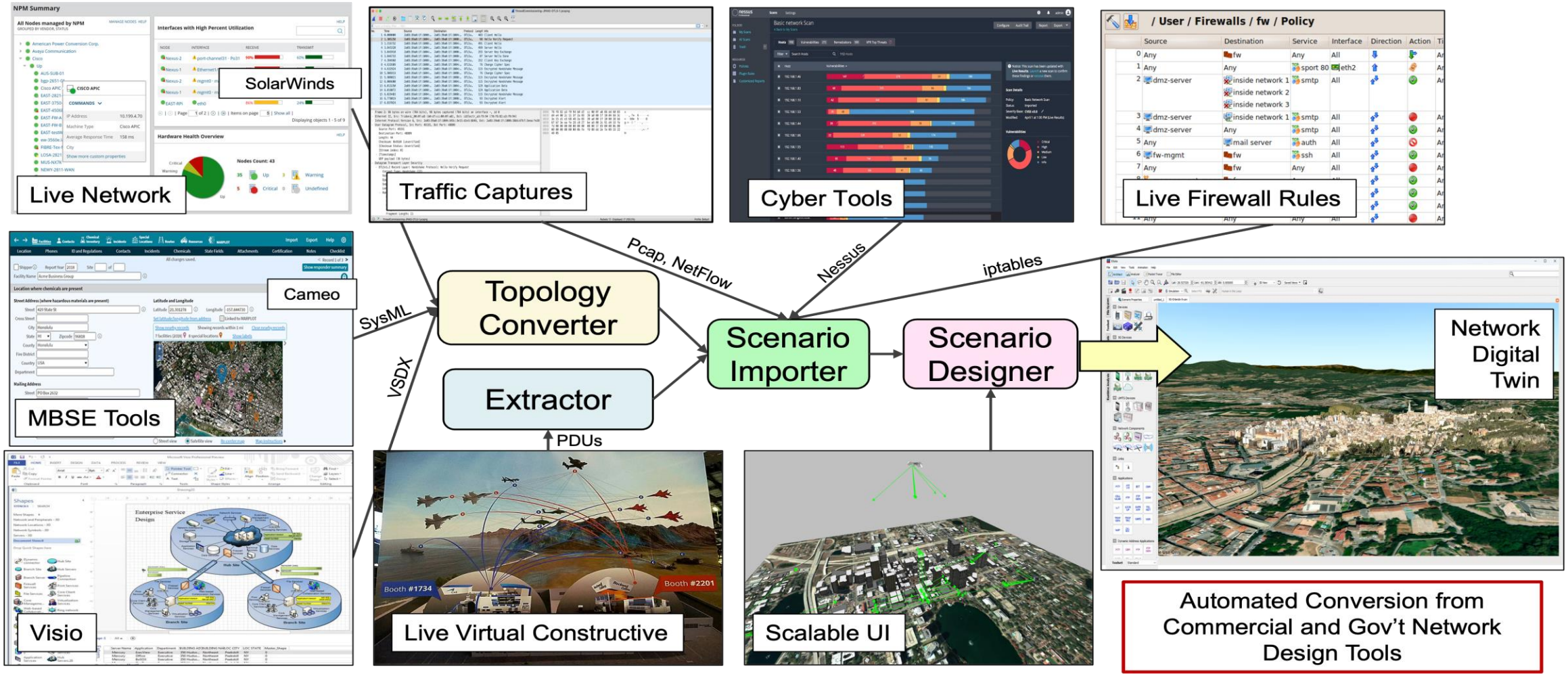
EXata Statistics and Analytics



Statistics characterize network performance

Network Digital Twin

Automated Creation



DoD / NATO focused Integration

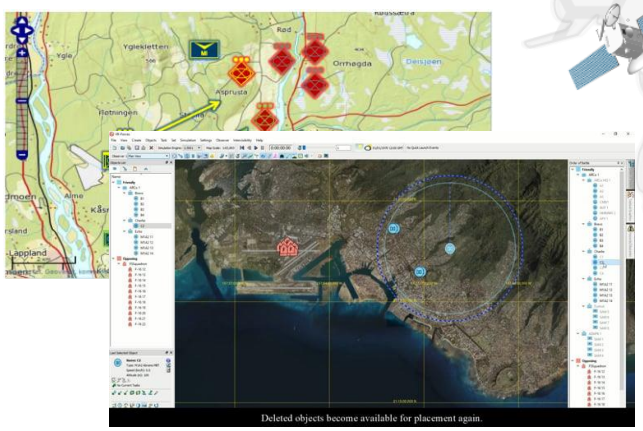
Live, Virtual and Constructive (LVC)

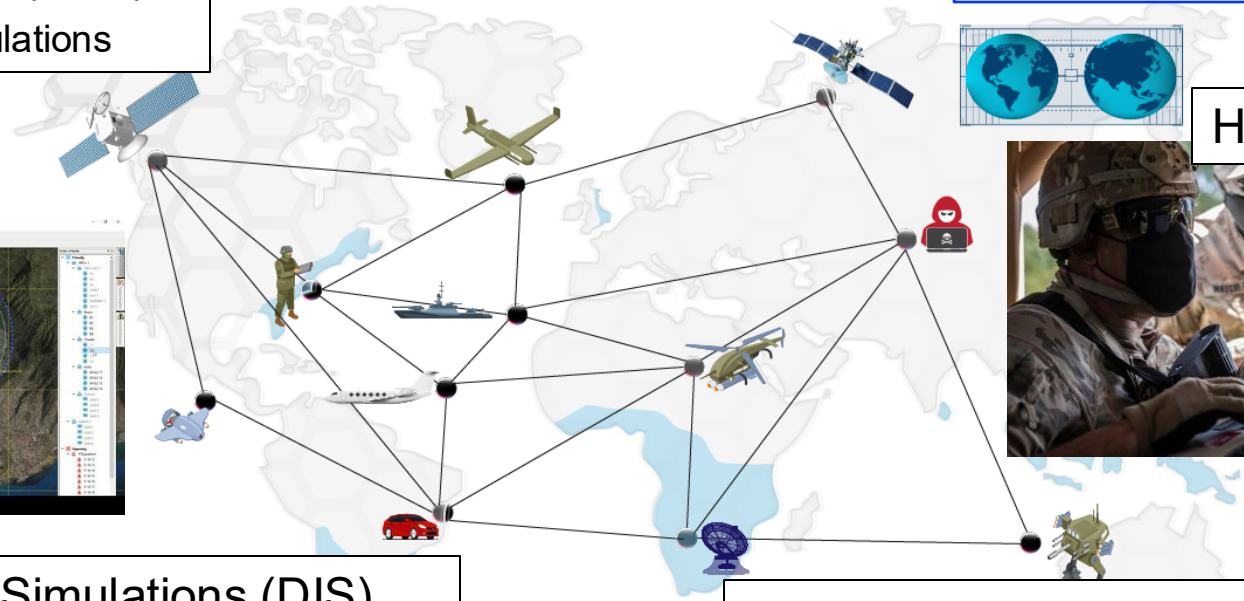
simulation and emulation

emphasis on DoD / NATO use cases

High Level Architecture (HLA)

Constructive large-scale simulations

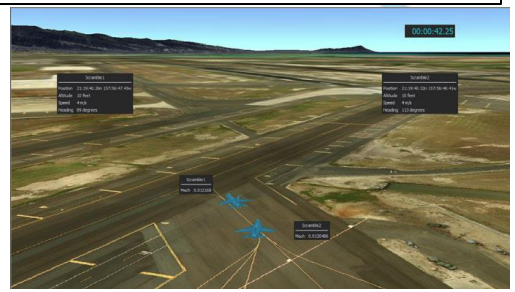




Human-in-the-Loop (HWIL)

Distributed Interactive Simulations (DIS)

Real-time wargaming across multiple hosts



Hardware-in-the-Loop (HWIL)

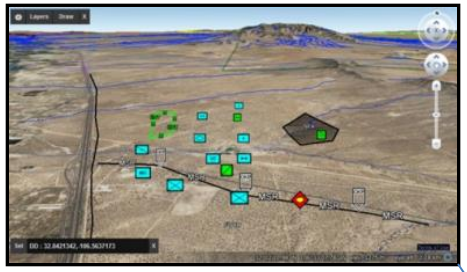
Live hardware mapped into an EXata simulated network

EXata Connection Manager “maps”
external hardware to EXata virtual nodes

Network Digital Twin: External Interfaces

Constructive Simulations

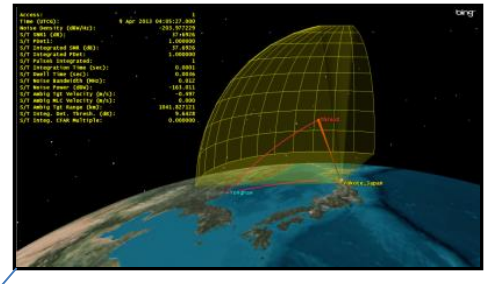
AFSIM, OneSAF, VR-Forces, Command PE, NGTS, STAGE, VBS, ASCOT, …



Live Applications

Sensor streams, voice, video, BFT, GCCS-M, CPOF, SCADA, …

Traditional Cyber Ranges

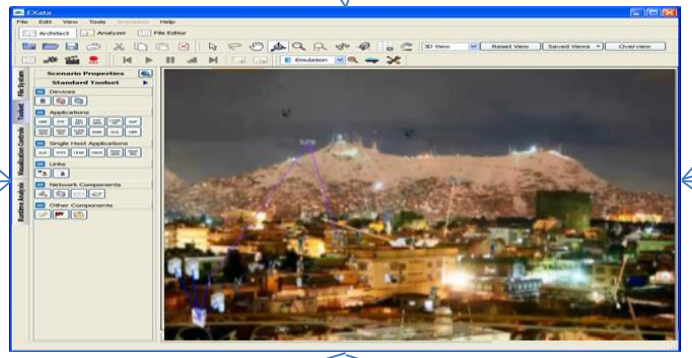


AGI STK

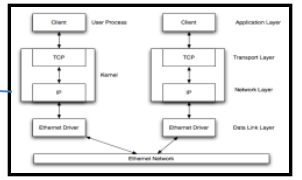
Internet

Humans in the Loop

Role players, watch stations, HMI, C2, red team, blue team

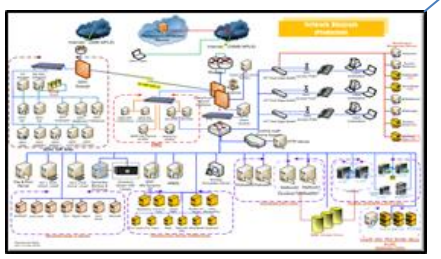


EXata Engine



Sockets

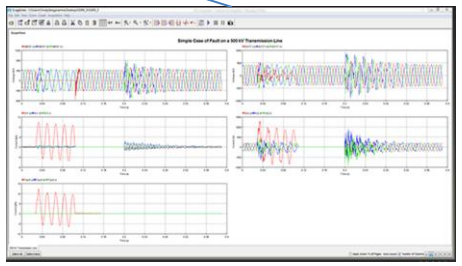
Custom I/F



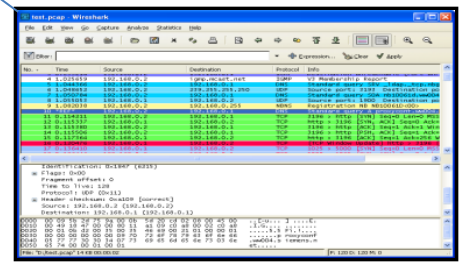
Live Networks

Devices

Computers, VMs, tactical radios, smart phones, sensors, IEDs, …



Keysight Interface to SystemVue



Tools

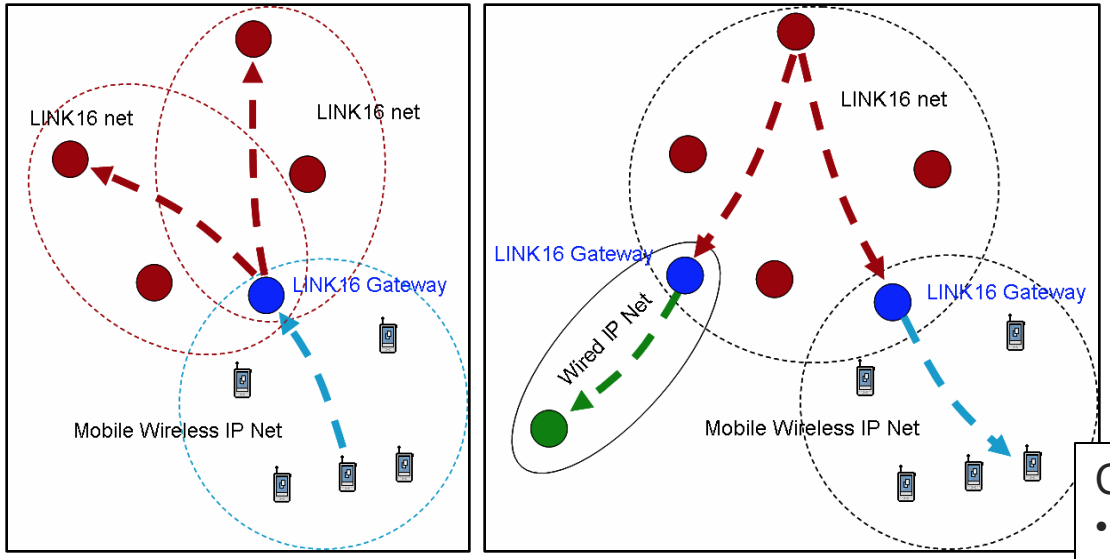
Wireshark, SNMP, Ping, Metasploit, …

Military Radios
Link-11 and Link-16

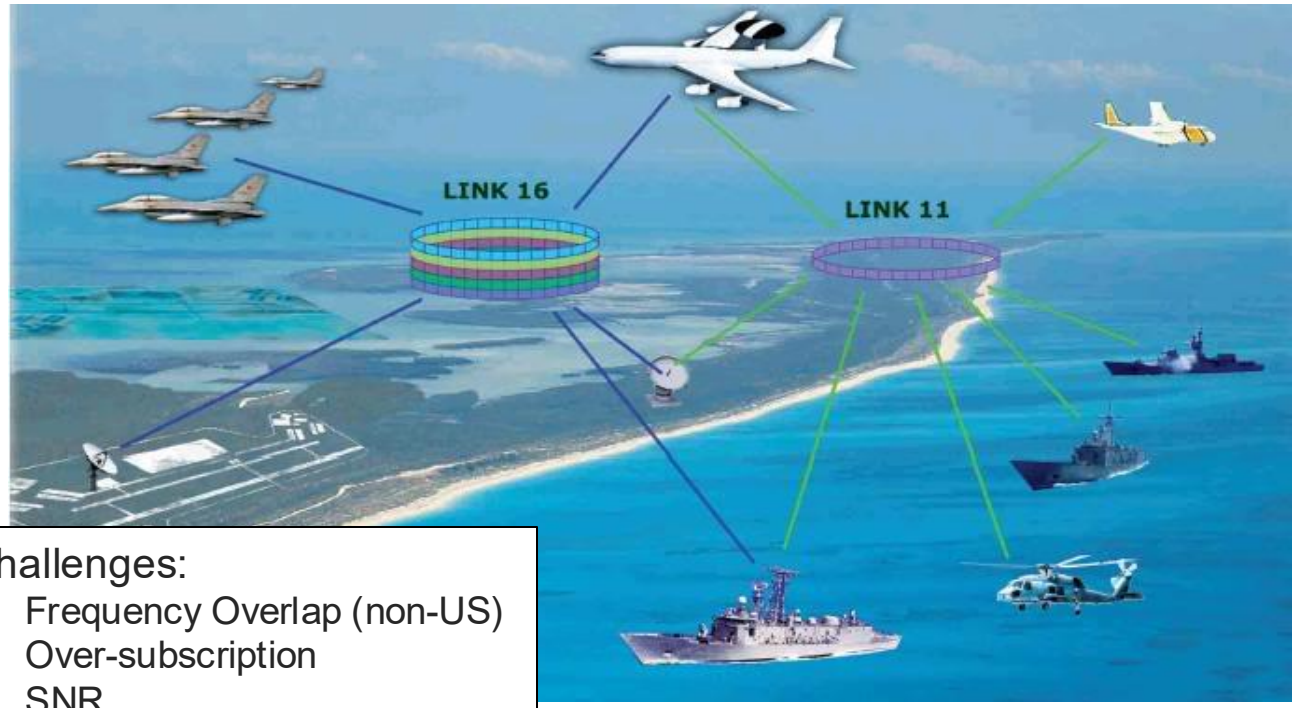
Communications for fighter aircraft, ground forces and anti-aircraft

EXata Link-11 and Link-16 modeling for US military Joint Tactical Data Information Link (JTIDS)

Time Division Multiple Access (TDMA) from 950 MHz and 1215 MHz



Link-16 connection to IP Networks



Challenges:

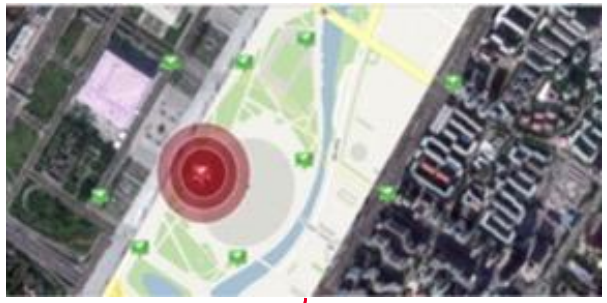
- Frequency Overlap (non-US)
- Over-subscription
- SNR

Cyber Library

Network security	Data exfiltration
Firewalls	Worm and virus propagation
Port and network scanning	Antivirus
Internet Protocol Security model (IPSec)	Backdoors, rootkits
Hacking attacks	Host models
Denial of service	Botnets
Packet modification	Coordinated attacks
Stimulate intrusion detection system	Adaptive attacks
Operating system resource models	Social media attacks
Vulnerability exploitation	Ransomware

Electromagnetic Spectrum Library

From Source:
Live Sensor Feed

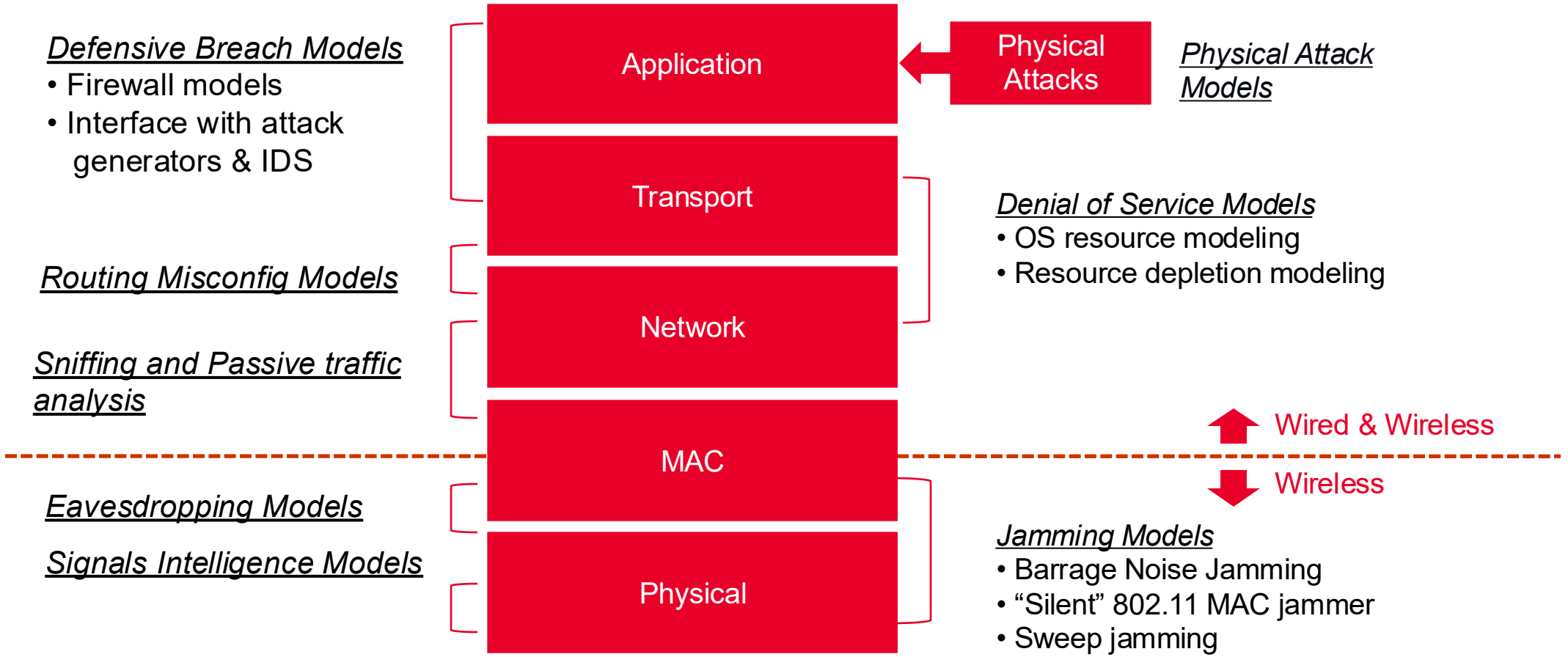


At Destination

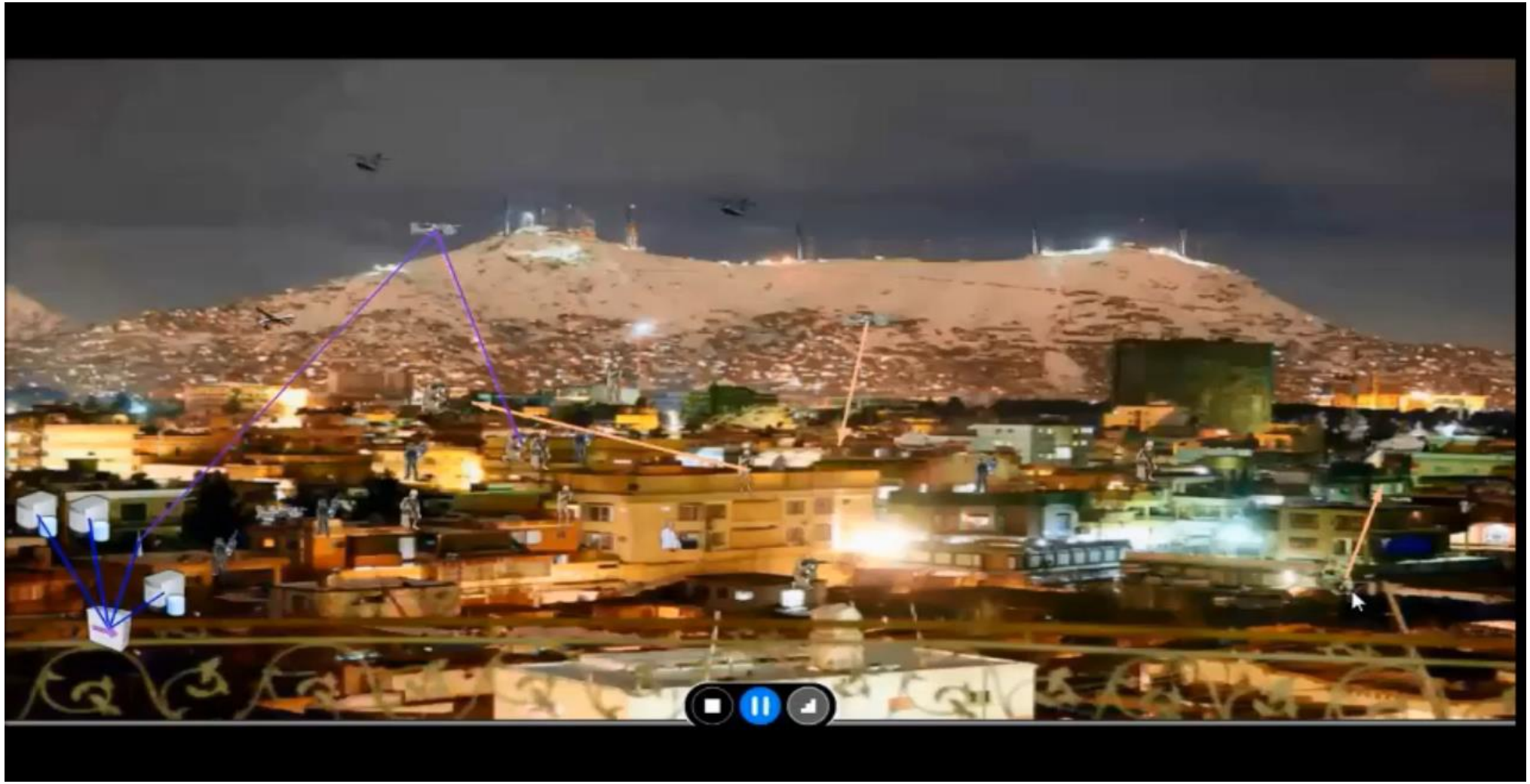
Blind Jamming attacks
Jamming attacks
Eavesdropping attacks
Signal Intelligence attacks (SIGINT)

Cyber Models Encompass the Protocol Stack

Modular design; supports composition with other LVC tools



Electromagnetic Spectrum Attack



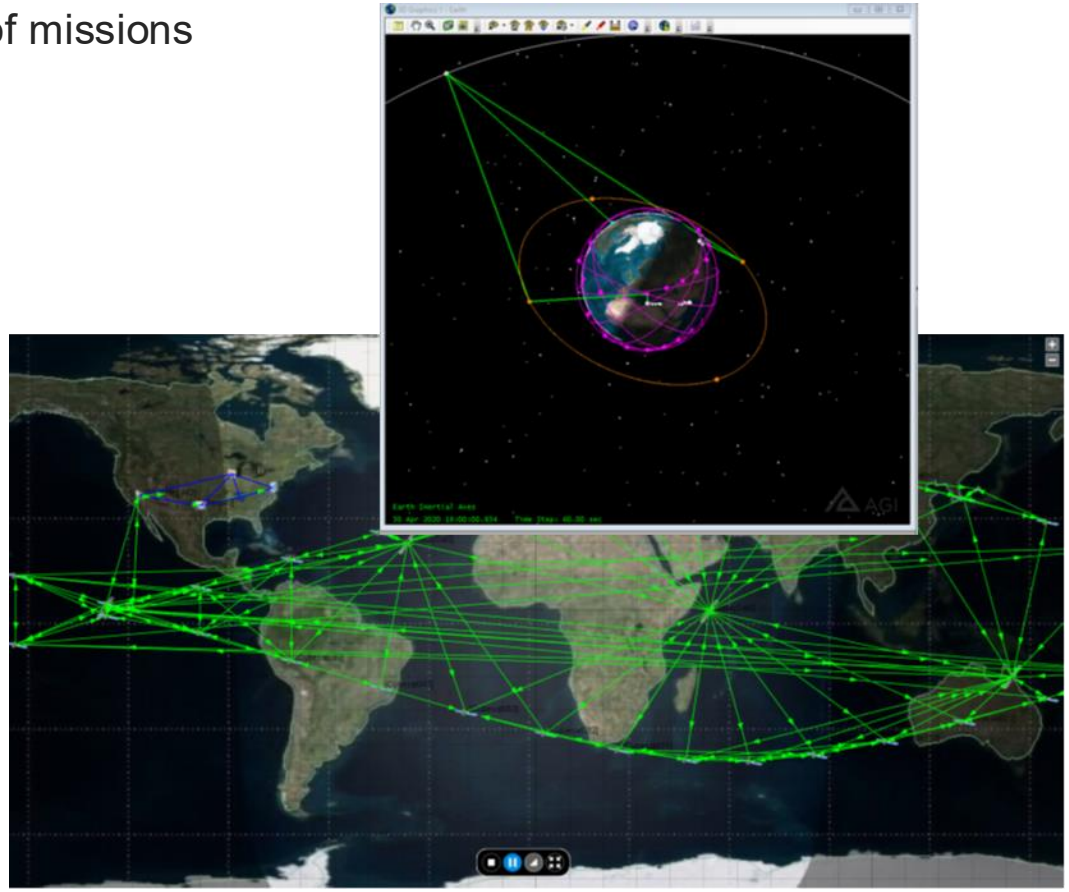
Partner Product Integration

EXata-STK

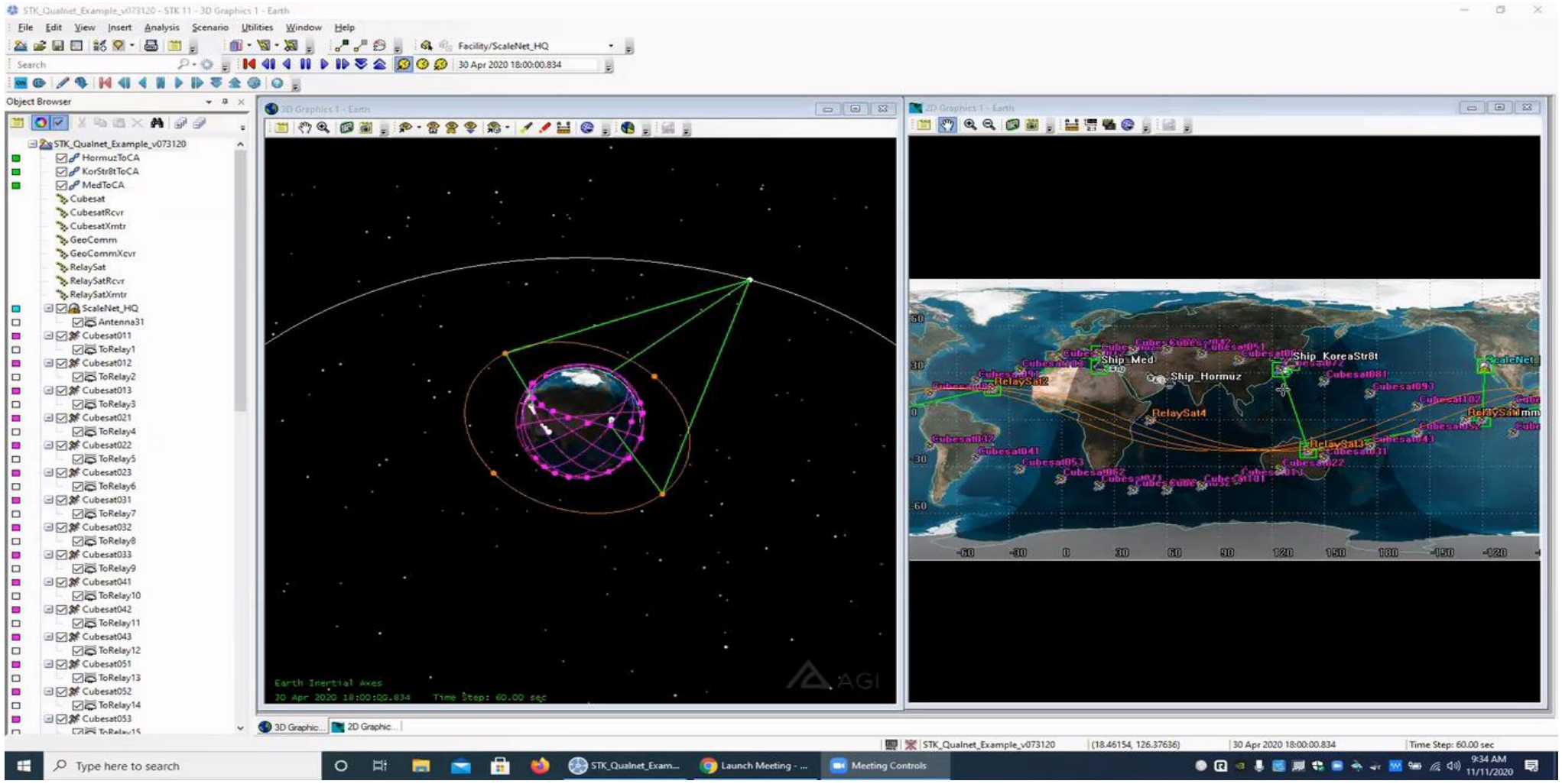
- Co-simulation brings network performance into the context of missions
- Single GUI to create and run experiments and obtain results

- STK contributions
  - Overall scenario
  - Trajectories, satellite orbits
  - Antenna geometry
  - RF, optical link simulation

- EXata contributions
  - Network protocol simulation
  - Background traffic simulation
  - Routing
  - Data prioritization modeling
  - Latency, dropped packets, etc.
  - Wired (ground) networks
  - Cyber attack simulation



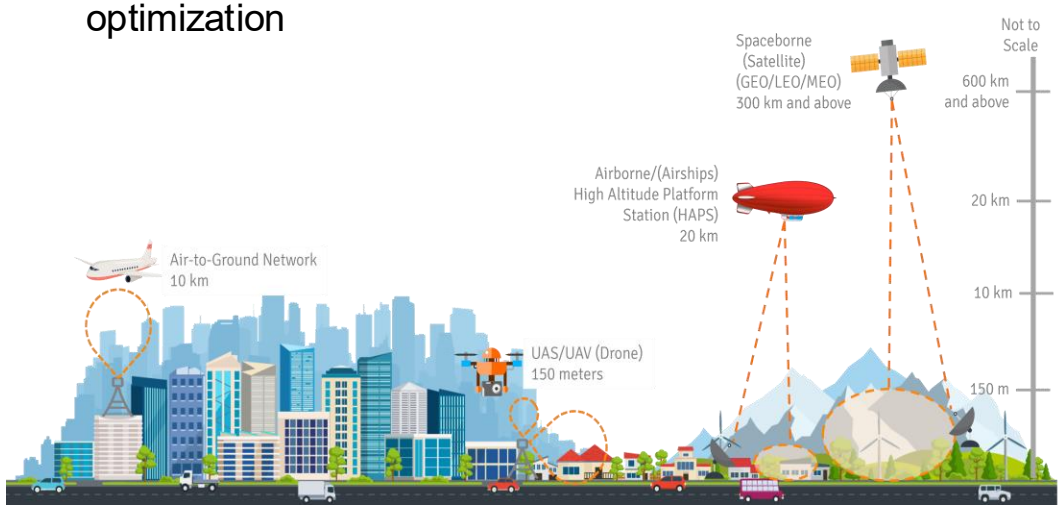
EXata/STK – Interface

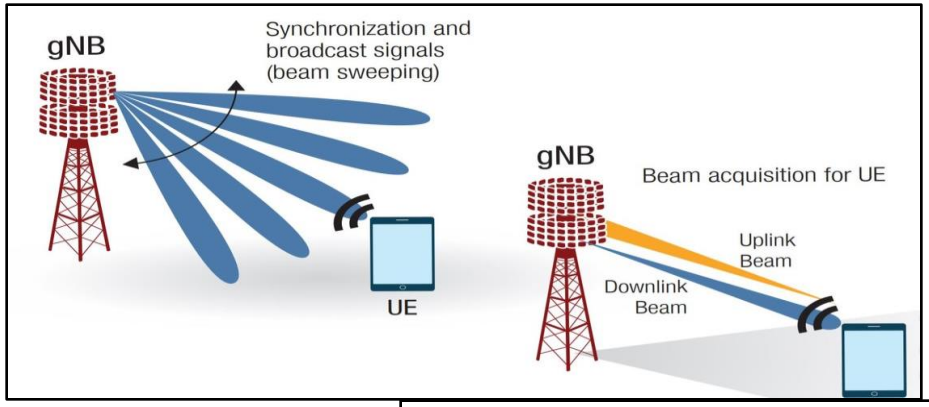


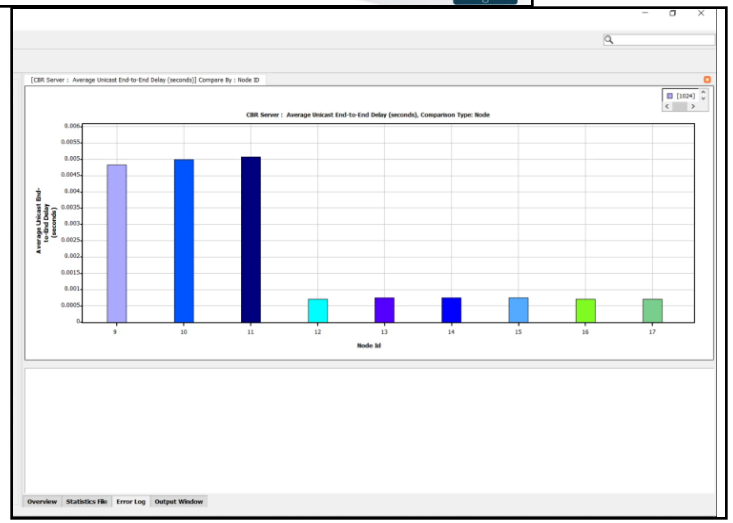
Typical Customer Problem

5G Performance

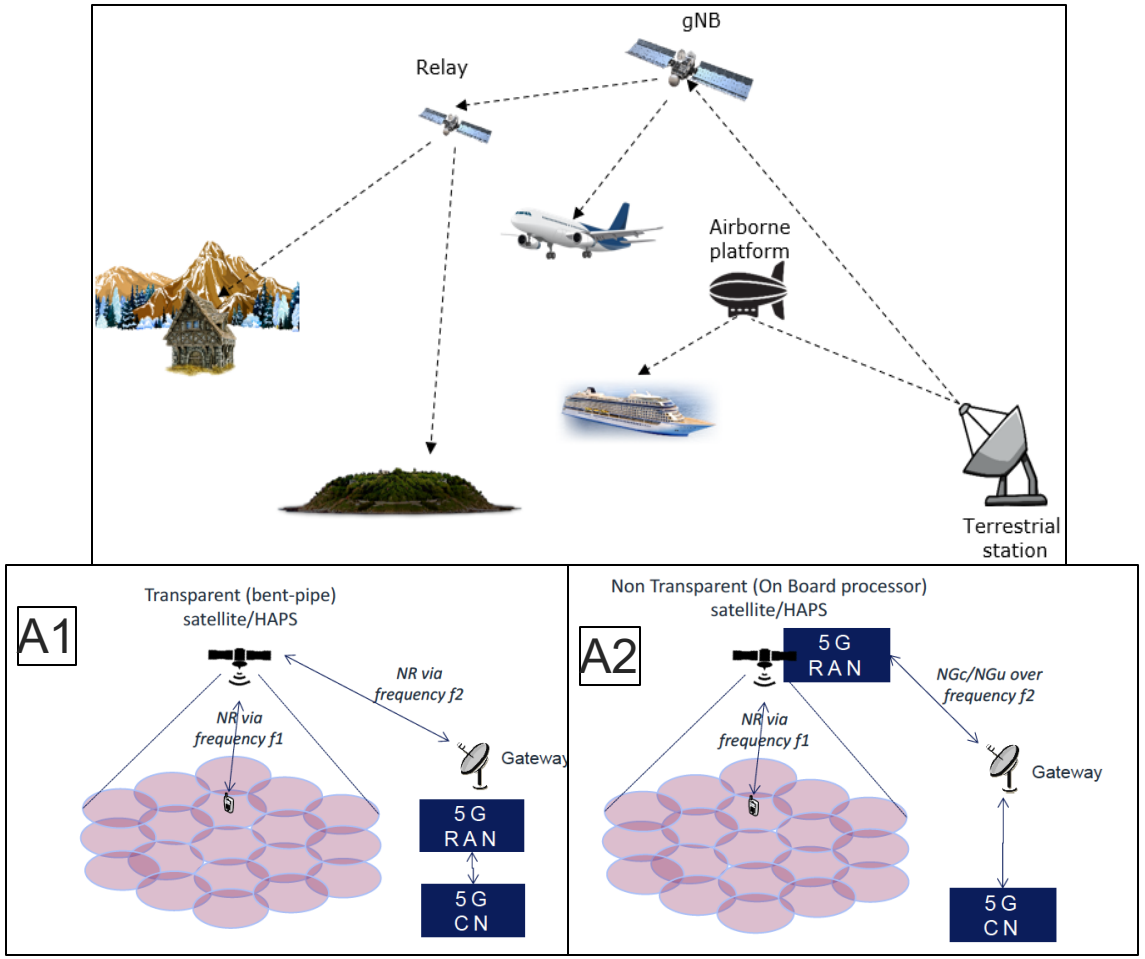
- Waveform support. Comprehensive 4G/5G protocols (core and RAN) and Over-The-Air (OTA) signal modeling
- Service coverage and drop-out zone estimation. Accurate effects of path loss, interference, malicious nodes
- Release 17 Non-Terrestrial Networks (NTN)
- Live equipment interaction (hardware in the loop)
- 5G network placement, parameter and performance optimization







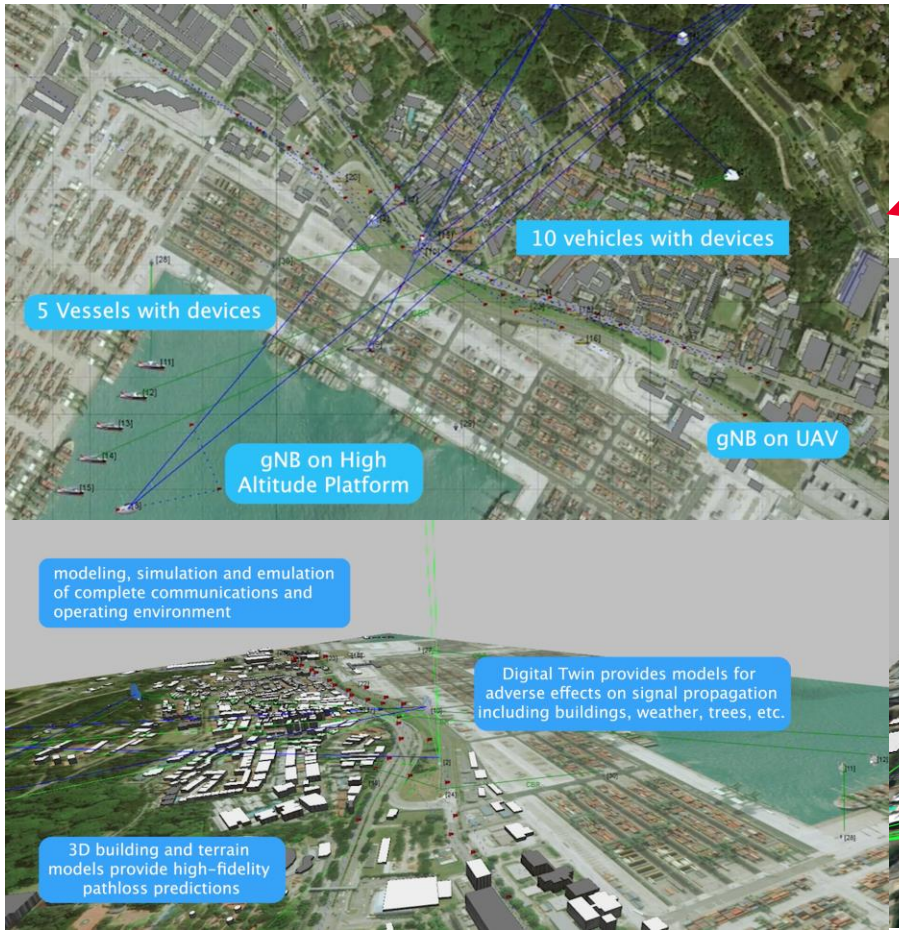
EXata NTN Capabilities



Capabilities Overview

- NTN A1 : Transparent satellite-based NG-RAN architecture using Bent pipe satellite
- NTN A2 option 1: gNB on a satellite-based NG-RAN architecture
- Timing Advance
- NTN in FDD mode
- NTN mode configuration in following 3gpp bands: n1, n2, n3, n5, n7, n8, n12, n20, n25, n28, n34, n38, n39, n40, n41, n50, n51, n66, n70, n71, n74, n77, n78, n79, n257, n258, n260, n261.
- NTN can be configured in any frequency range (except the above) using Custom Frequency/bandwidth feature.
- MAC/RRC/PDCP/5GCore Timer handlings/adjustments for initial attach procedure and handovers in NTN
- Omnidirectional antennas at UE and gNB
- Beamforming with Directional Antenna at gNB

EXata NTN examples

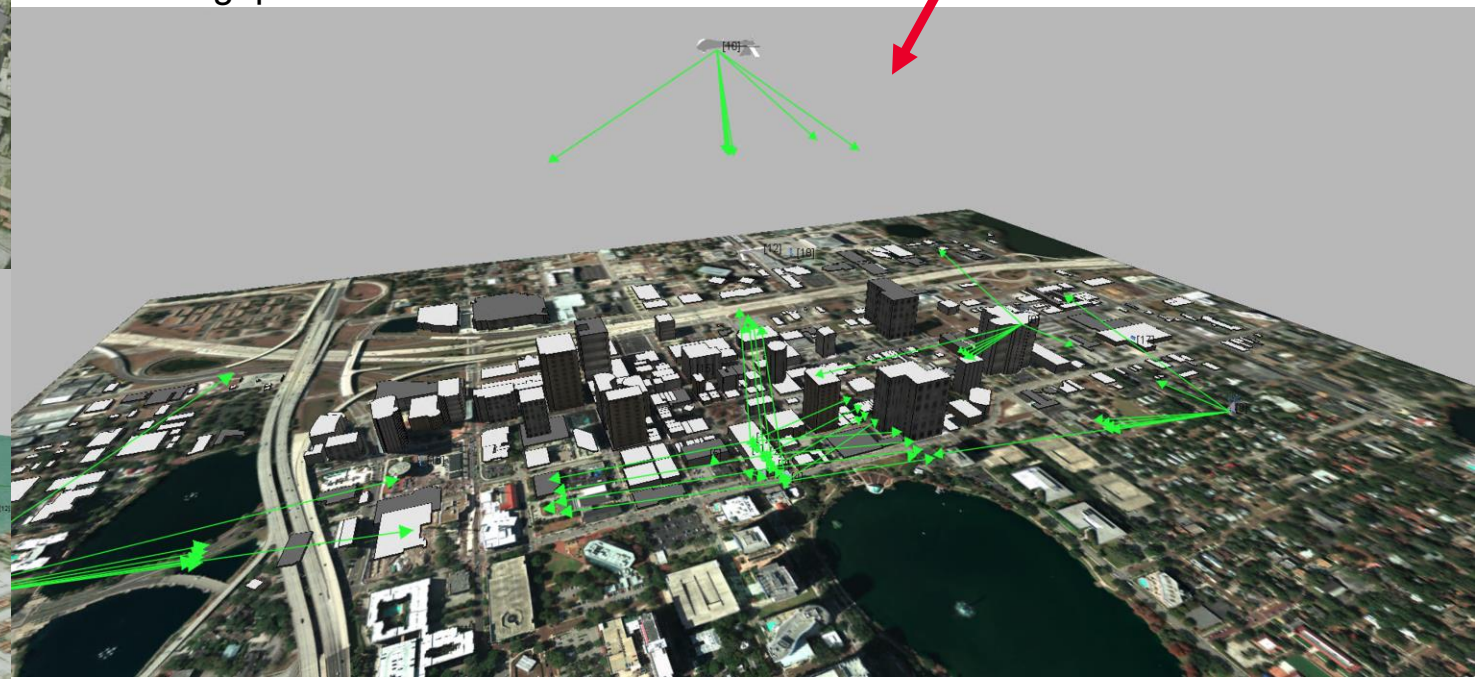


NTN Customer Scenarios

Both scenarios used for network planning

NTN gNB on LEO and HAPS platforms Singapore Harbor

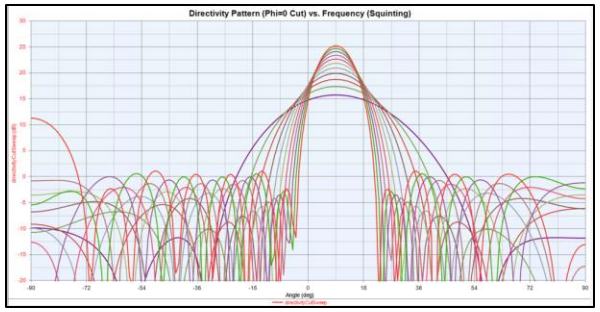
NTN gNB on UAV Orlando Florida

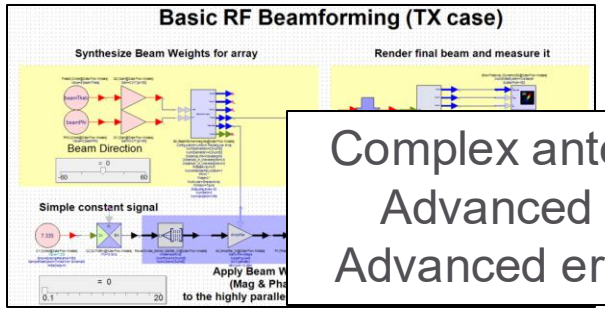


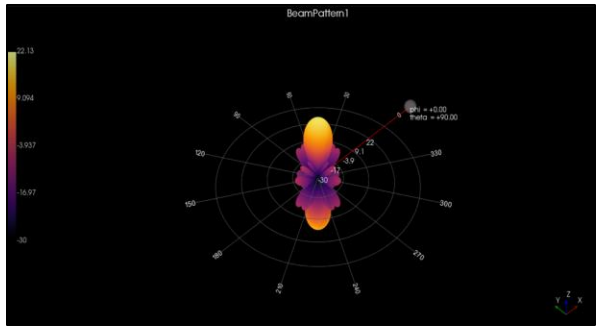
EXata SystemVue Integration

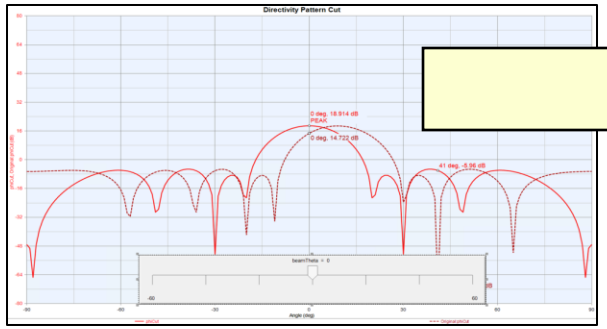
SystemVue
Physical Layer Models

EXata Network Modeling
Simulation and Emulation

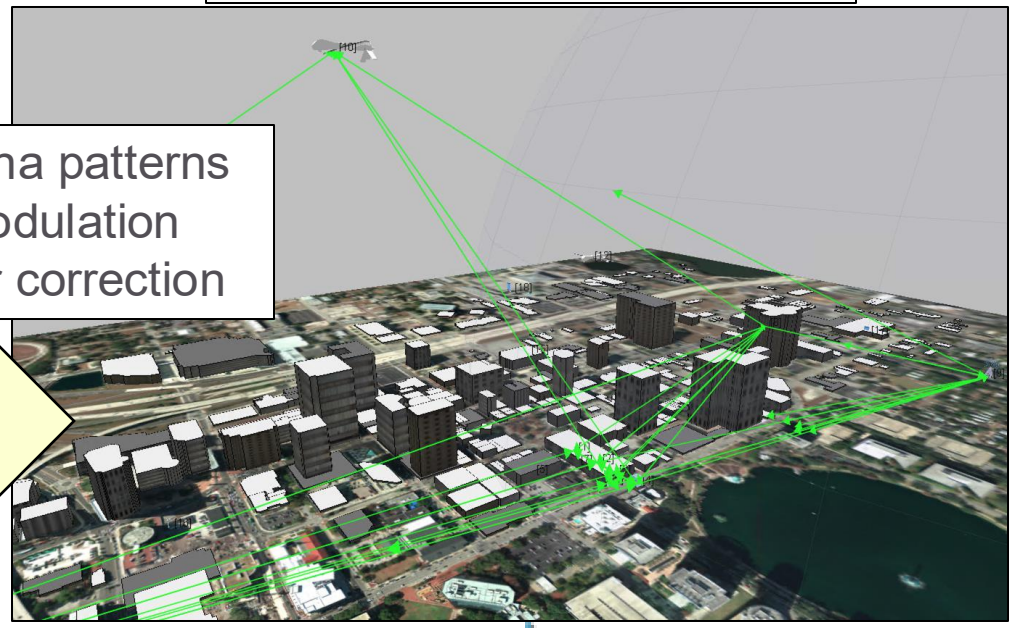








Complex antenna patterns
Advanced modulation
Advanced error correction



EXata

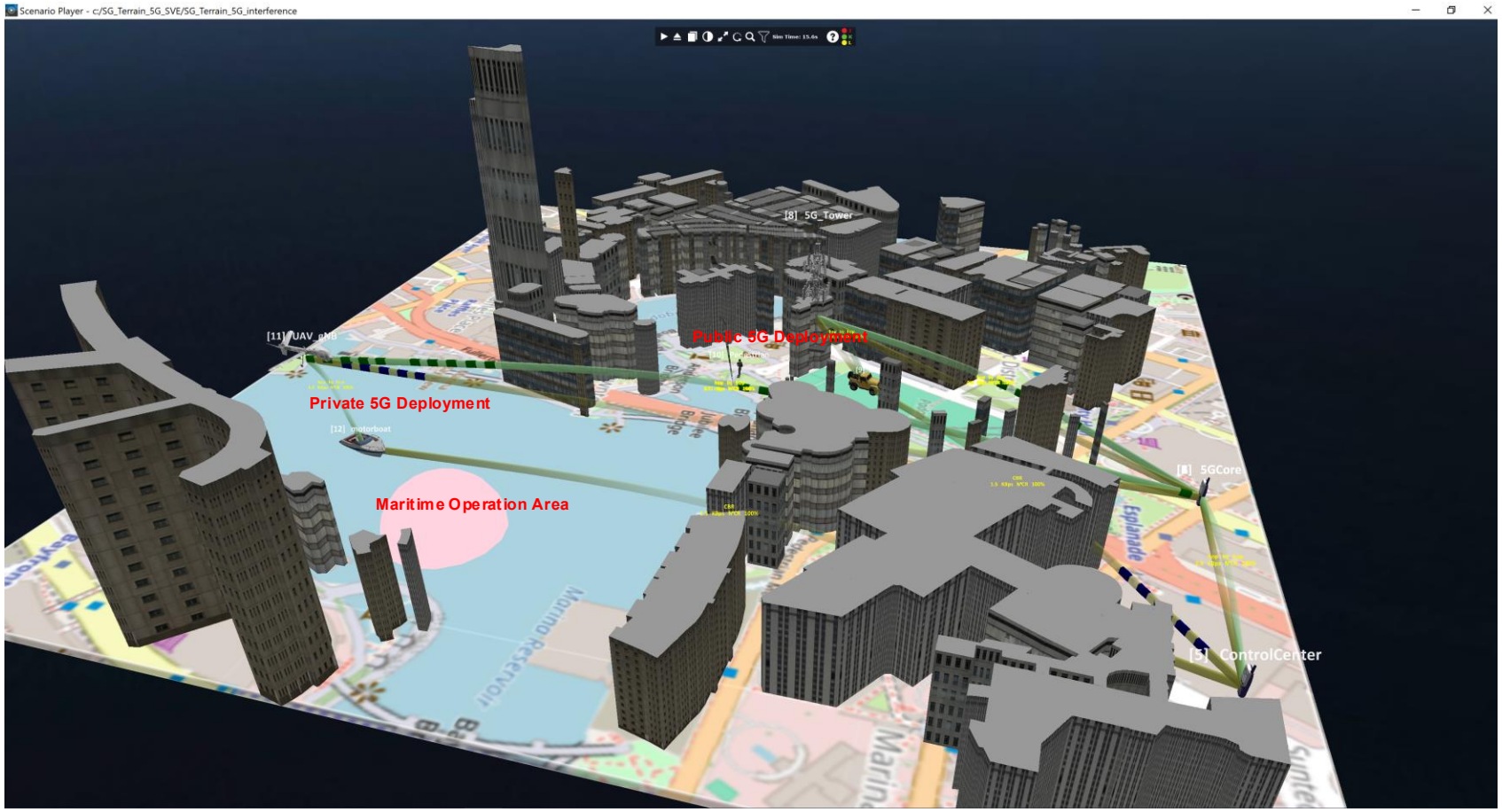
SystemVue provides multi-domain modeling and simulation for RF systems including antenna design, complex modulation and error correction

EXata framework enables testing of a large-scale networks in a low-cost, lab-based setting with a small hardware footprint while reducing risk in fielding dynamic network devices and programs.

Integrated RF and Network Digital Twin Use Case

Interference and Doppler Shift Compensation and its Impact to 5G Communication

- Maritime Authority dispatch a motorboat to the operation area for investigating oil leak
- A mobile gNB deployed on UAV platform is to provide dedicated private coverage for the operation
- Improper spectrum management result in interference between the private deployment and the public 5G TN system



Key Value Proposition EXata + SystemVue

- Fast prototyping of complex RF systems using SystemVue
- Define Network digital twin using EXata to seamlessly incorporate thousands of nodes, essentially each node having its own protocol stack
- High level of accuracy and fidelity into simulation by integration of both Keysight products with key insights into all layers of the protocol stack design
- Faster turnaround and quicker time to market your design into real world applications

Jeremy Smith Bio

- Graduate of American University, Kogod School of Business
- Keysight Business Development Manager for EXata. Responsibilities include North America and DoD.
- Working experience 10+ yrs (INPUT, OPNET, Forcepoint Federal, Keysight) covering BD/Sales for Wired and Wireless Modeling and Simulation, Multi-Domain Data Transfer, Network Security, Cyber Security
- Resides in Arlington, VA


KEYSIGHT