Accelerating NTN deployment to beat the Goldrush

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February 2025

From Exploration to Commoditization

The Path to a Goldrush

Commoditization

GOVERNMENTAL ERA

Commercialization

ENTREPRENEURIAL ERA

Exploration

GOLD RUSH

Sputnik

Apollo Program

First Commercial GPS Receiver

Satellite TV service

$4K/kg to LEO orbit

First Space Tourists

1957

1960 - 1990

1988

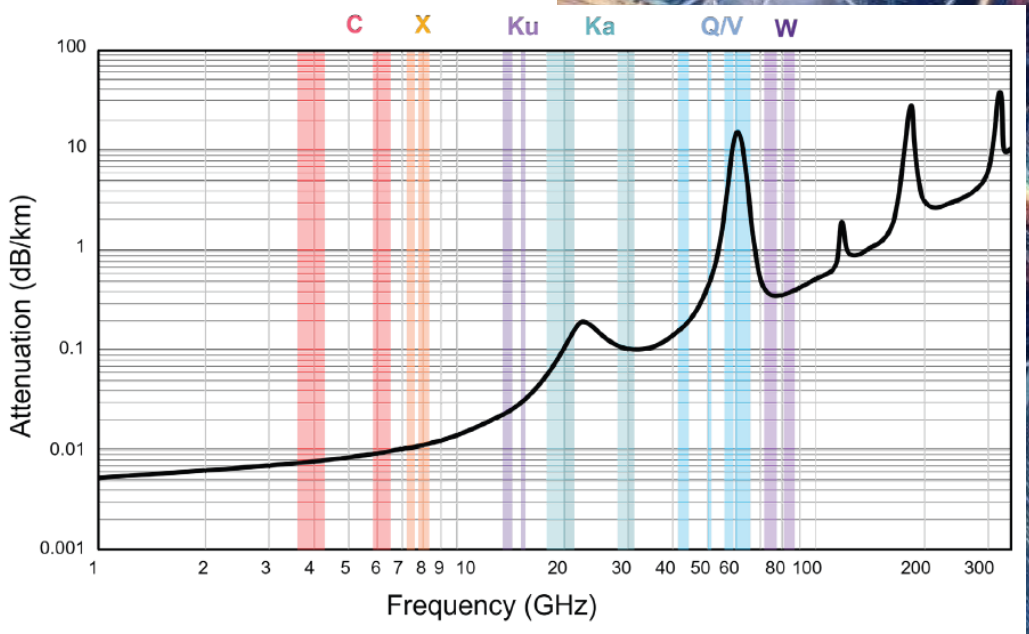
1990 - 2020

2020 - 2050

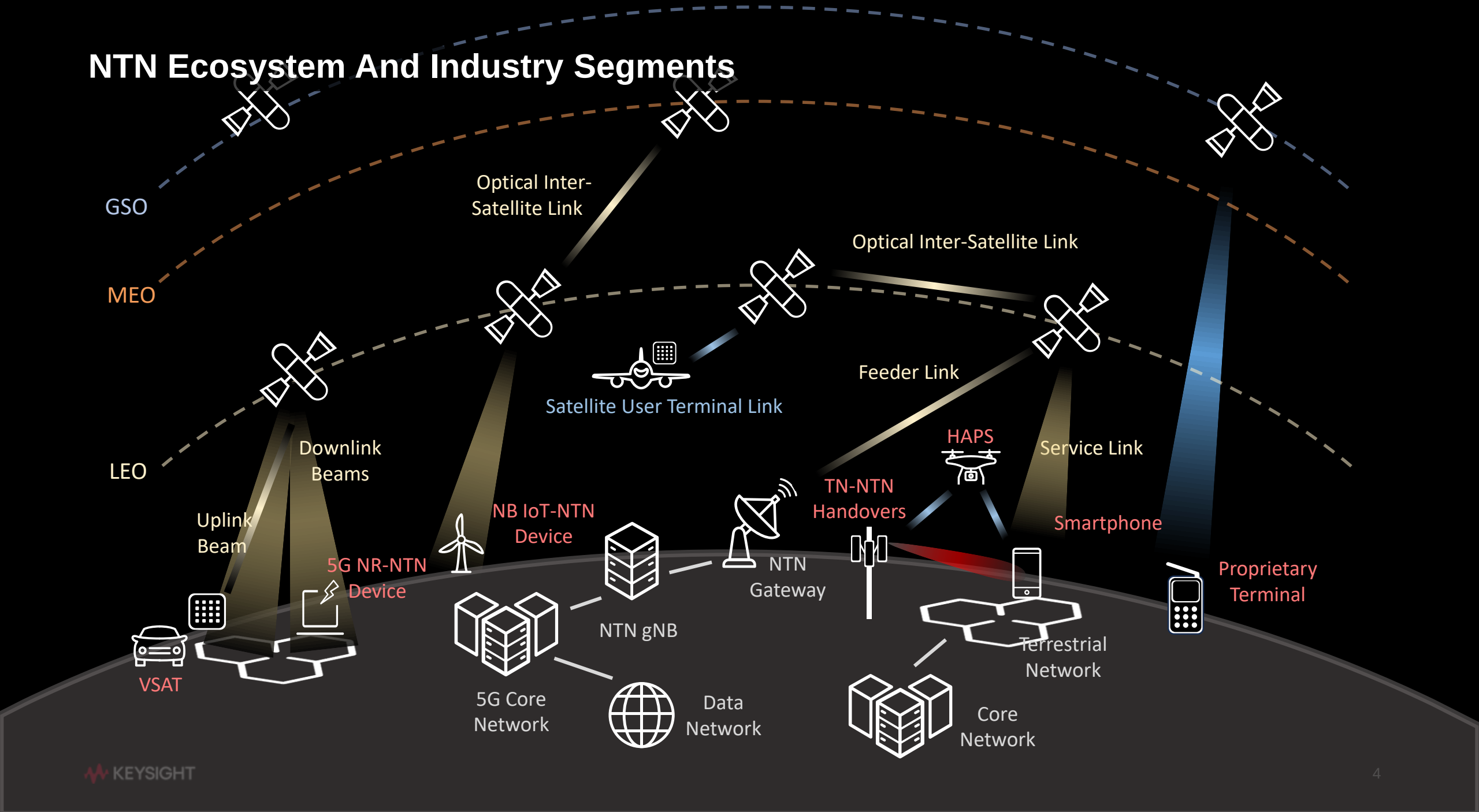
Where’s the rush?

Stake your claim on spectrum and orbits

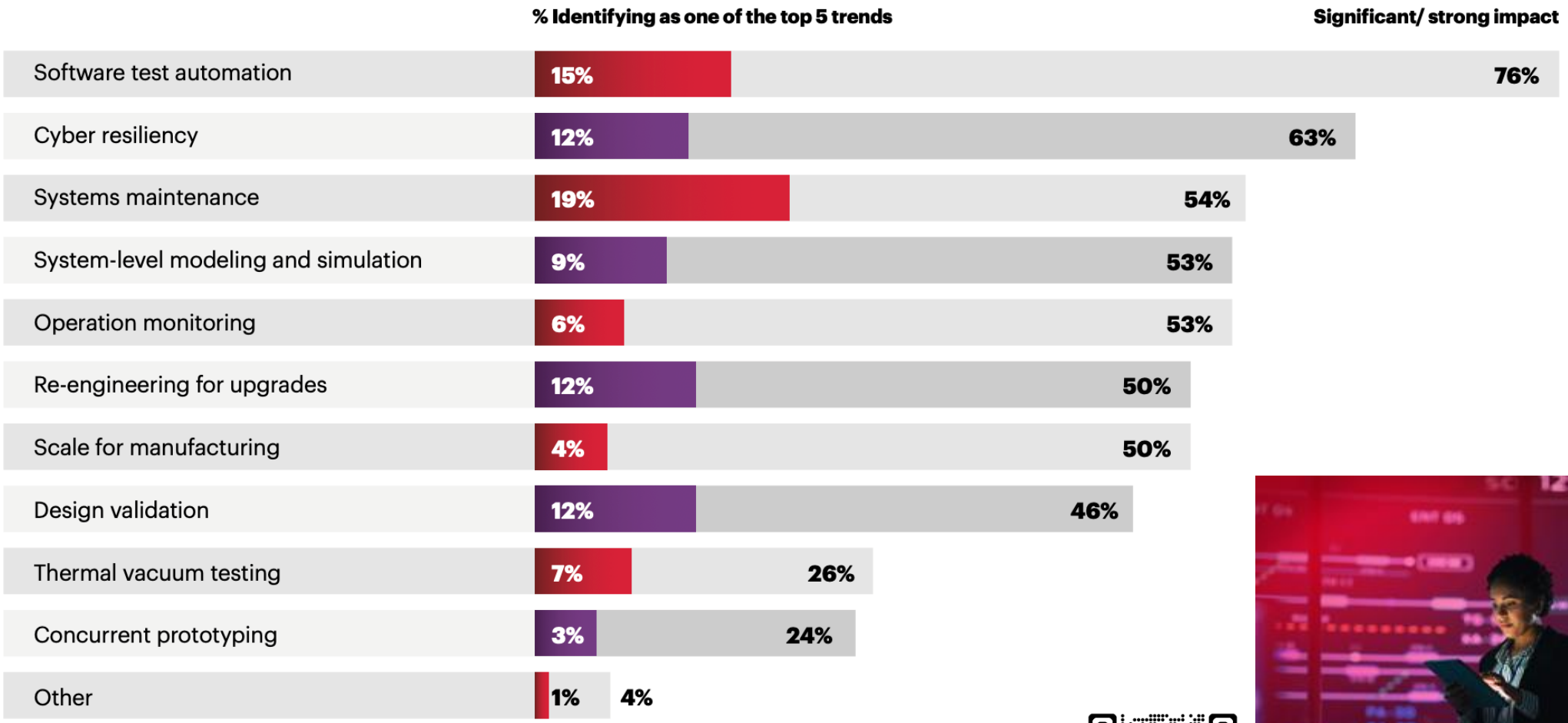
- ITU Licenses for spectrum and orbits “first-come, first-served”
- Interference is then YOUR problem
- Clock starts ticking
- Money is being spent
- The competition is not waiting for you…



NTN Ecosystem And Industry Segments



The Most Important Technical Challenges



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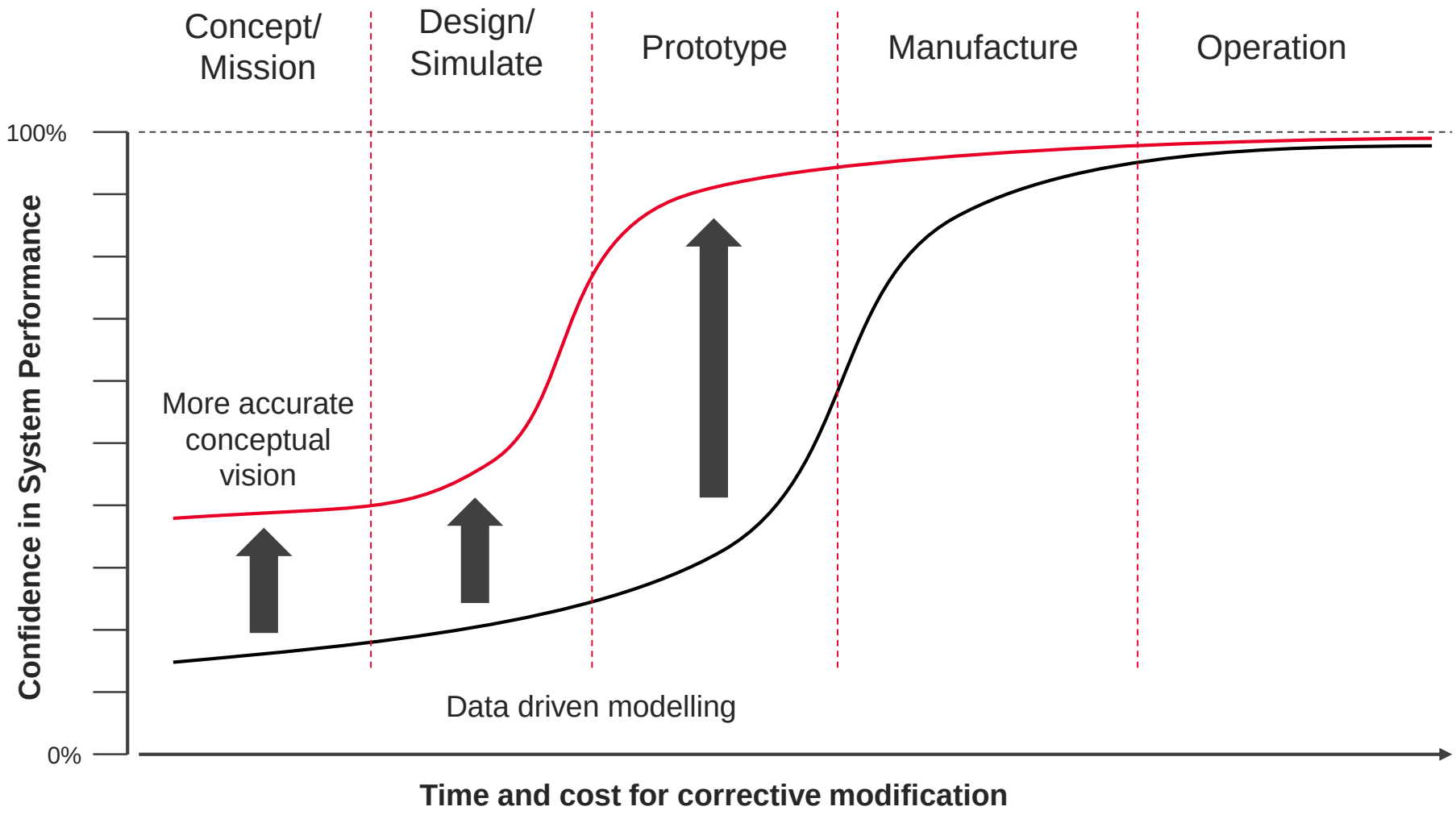
Source: “Defying Gravity”, Market report (2023)

Shifting Left: Earlier confidence in system performance

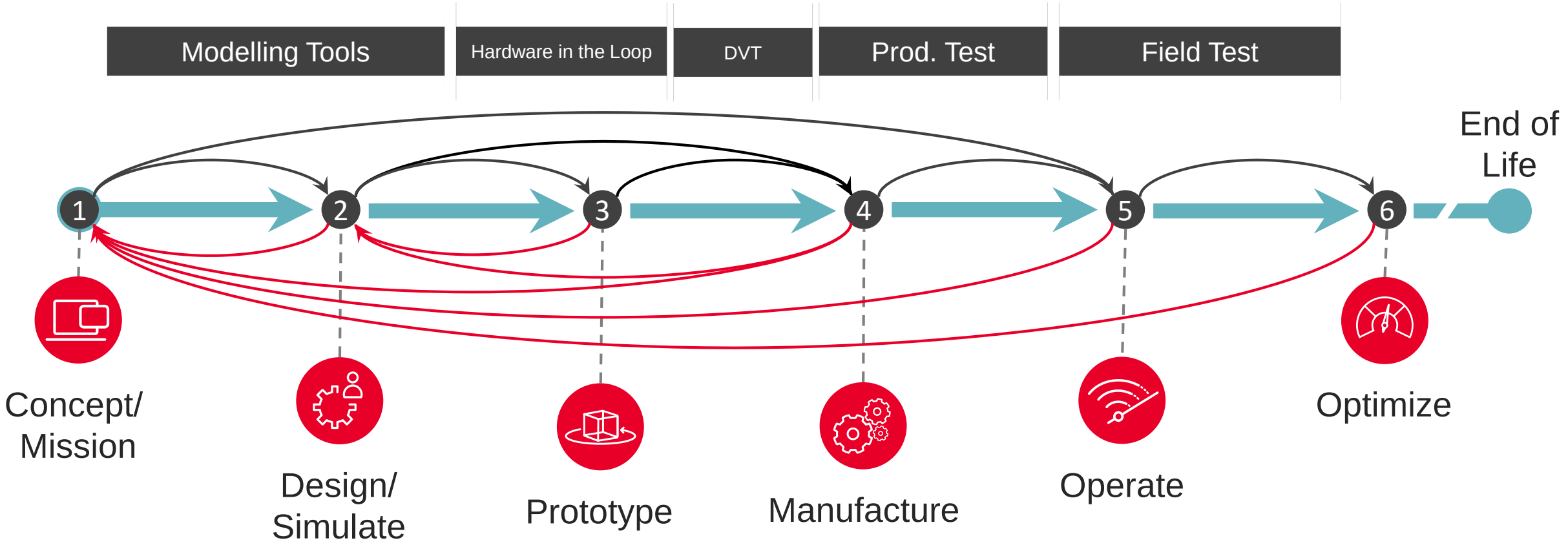
Modelling, Simulation and Emulation



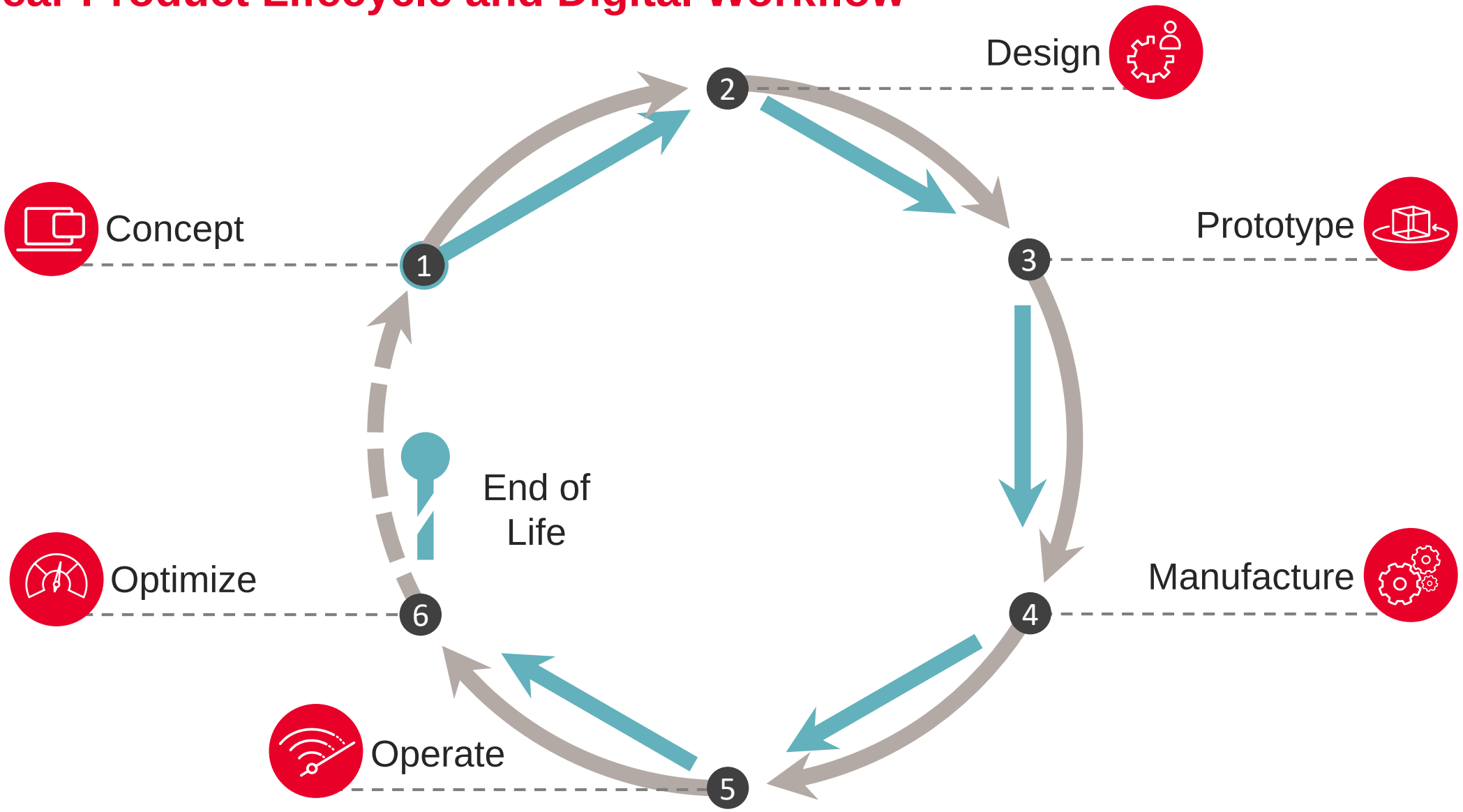
(source: Dr. Kolonay – Air Force Research Laboratory)

Linear Product Lifecycle

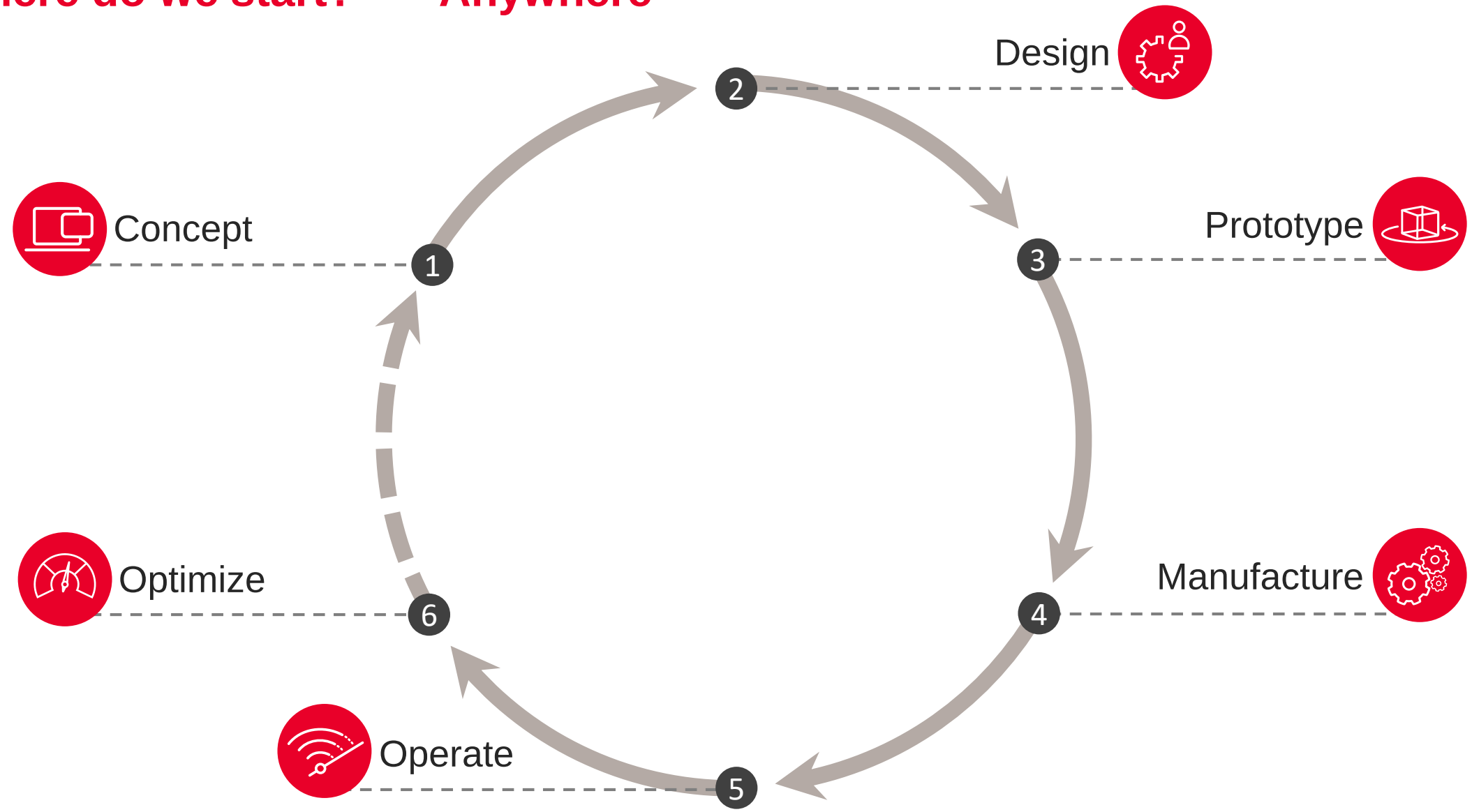
DATA SOURCES AND DATA USE



Linear Product Lifecycle and Digital Workflow



Where do we start? Anywhere



What Can We Model?

- Mechanical CAD – Size, weight, vibrational modelling.
- Orbital Kinematics – Doppler, delay and orbital physics.
- RF systems – Communication and subsystems, antennas and components.
- Power systems – solar generation, power storage and usage.
- Network operation – Data traffic, cyber attacks.
- Software interfaces – GUI test and validation.
- Much more…

- Statistical models can be used for system-level temperature, radiation and outgassing, etc. but these often require testing.

EXata Network Modeling

L1-L7 Protocols

Routing
Encryption
QoS
Latency
Multi-hop

mobility

Offensive or Unintentional Cyber
Jammers / Interference

Physical Layer modeling

Antenna characteristics
Path loss
Multipath
Fading
Weather
Foliage
Modulation
Battery depletion

ESRI Shape Files

Propsim GCM Ray Tracing in combination with Shape/Terrain files provides full Multipath characterization

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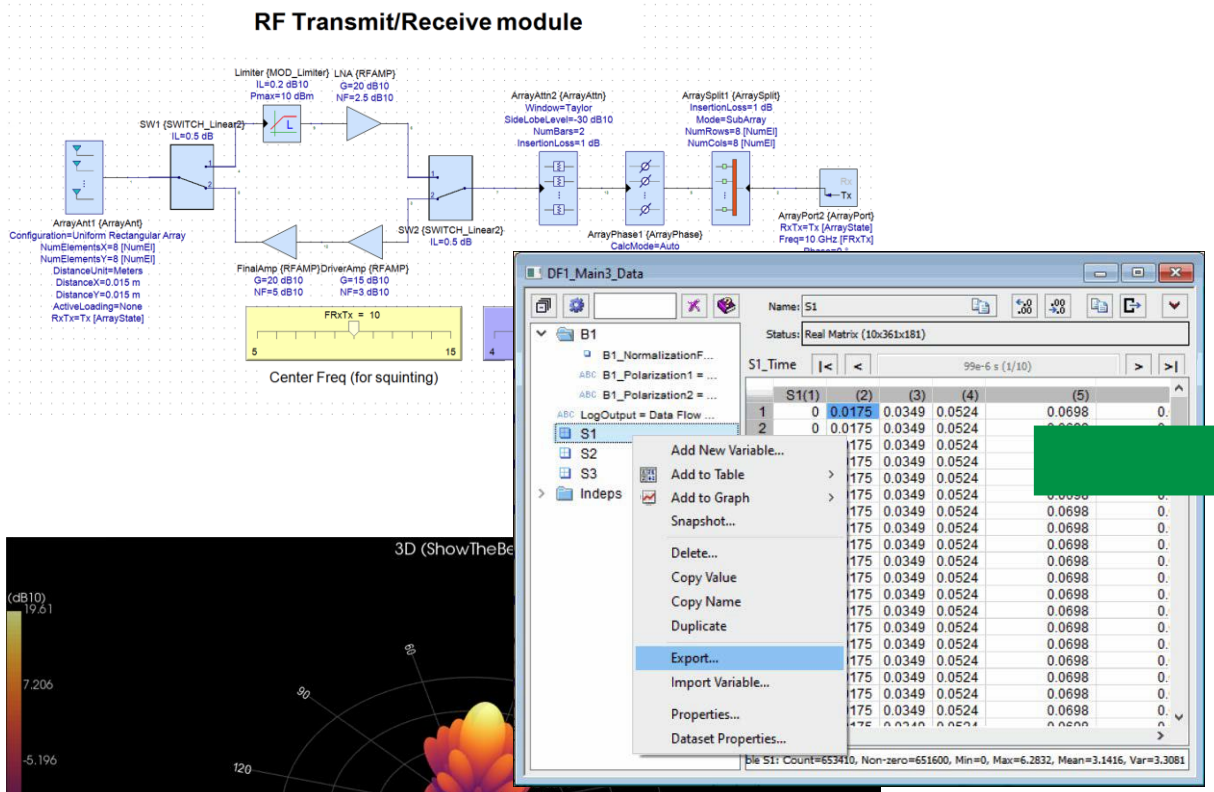
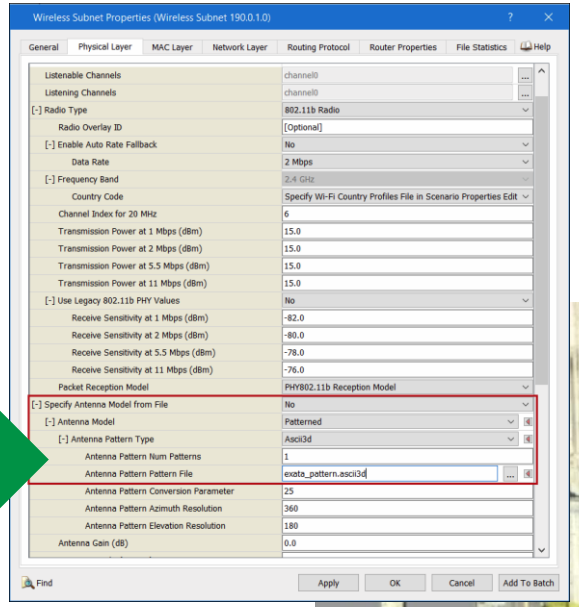
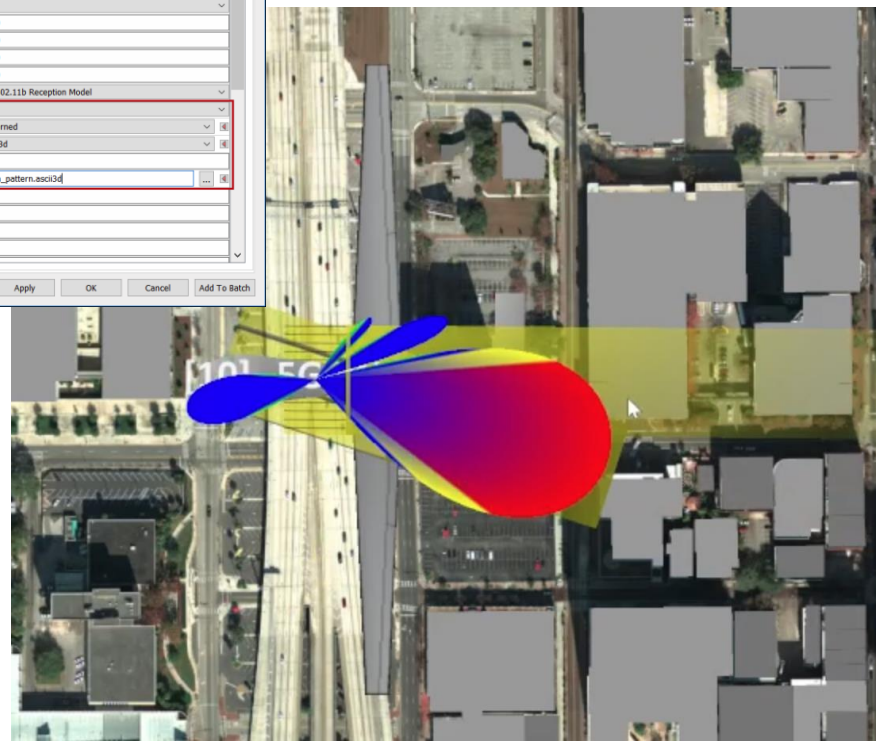
EXata-PWSD File-based Antenna Integration





PWSD Antenna Design imported to EXata

5G Network Simulation



File Edit View Tools Animation Help

Architect | Analyzer | Packet Tracer | File Editor

Lat: 36.713790 Lon: -4.474895 Alt: 0.000000 | 3D View | Saved Views | None

Emulation | Select PSI | Human in the Loop:

File System | Toolset | Visualization Controls | Runtime Analysis

Animation Speed
Slow — Fast

Animation Filters

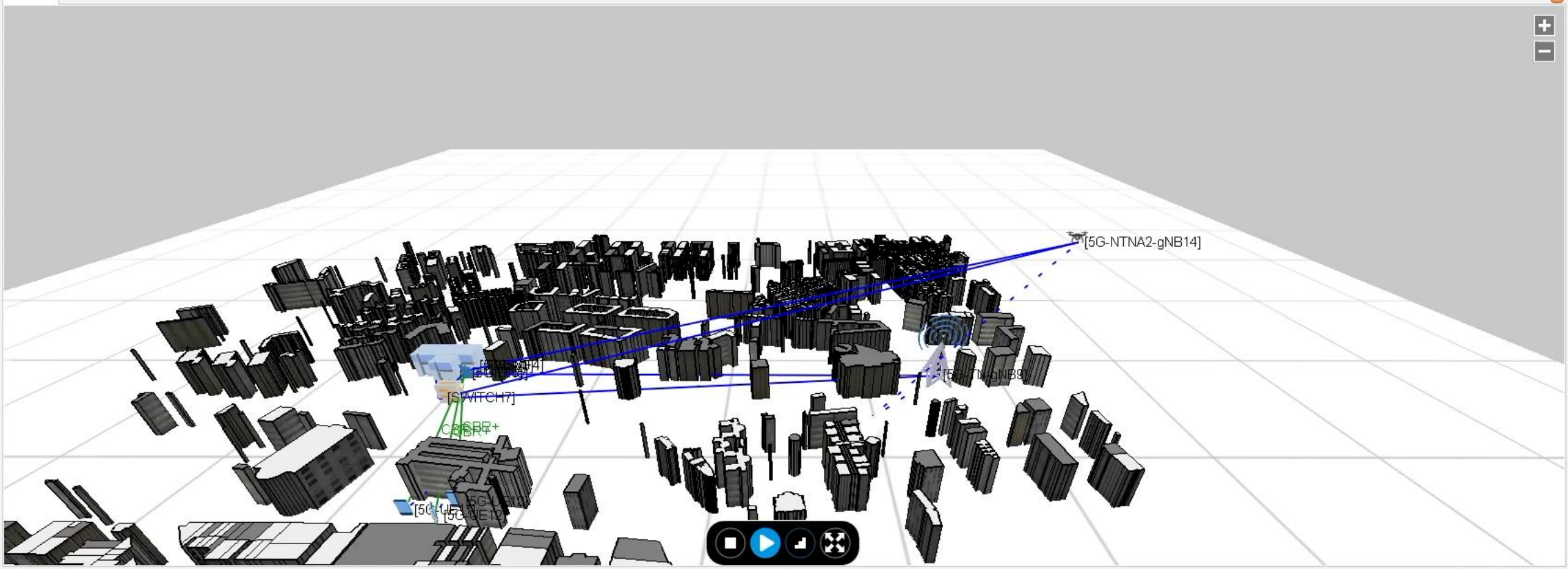
Event Filters

- All
- Node Mobility
- Broadcast Packet
- Multicast Packet
- Unicast Packet
- Packet Received
- Packet Dropped
- Packet Collision
- Packet Queuing
- Node Orientation

Layer Filters

Packet Type Filters

MAORI1



SIM 00hr : 00m : 00s 0% REAL 00hr : 00m : 00s

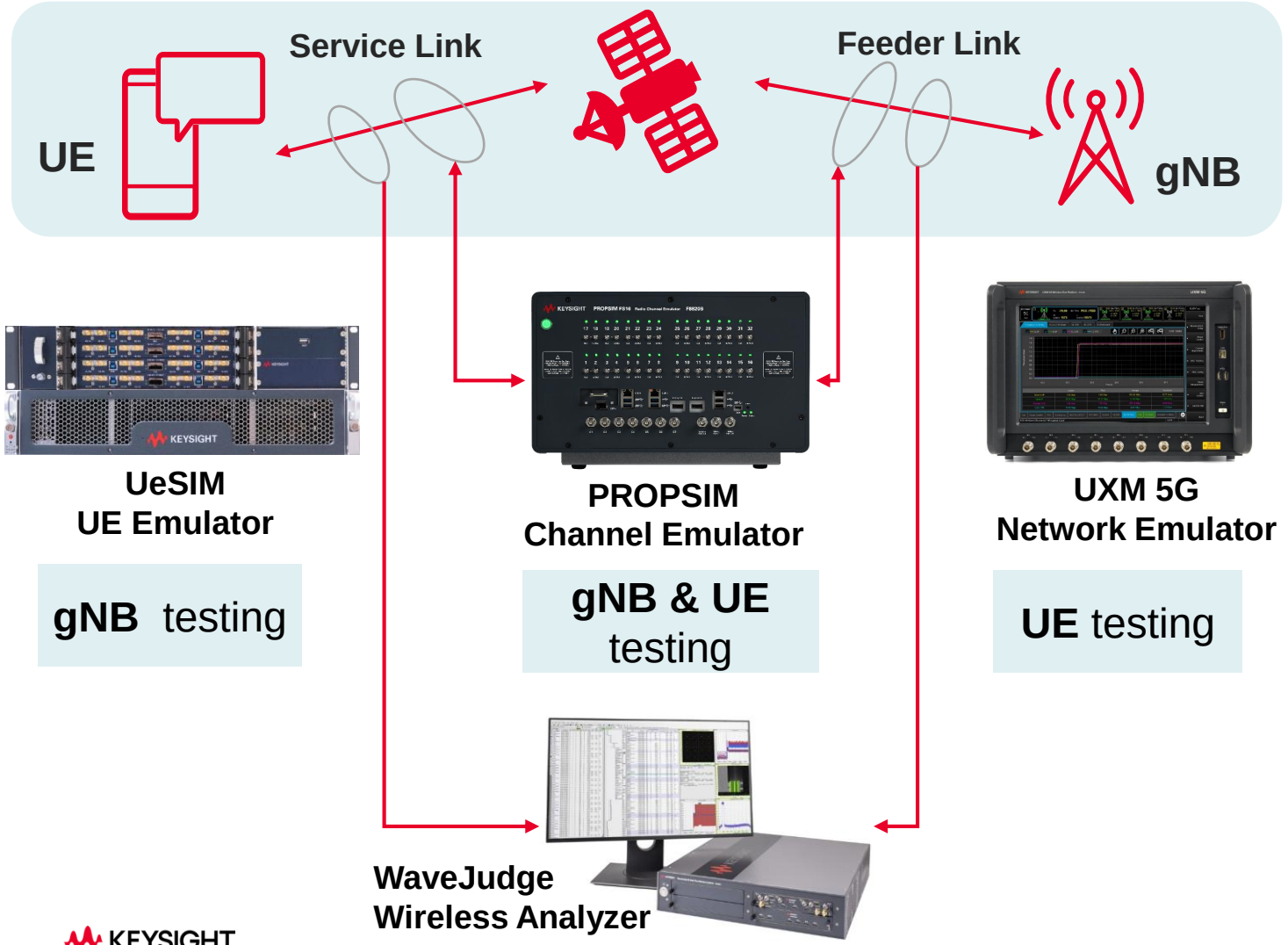
```
Partition 0, Node 2 (36.719146, -4.480989, 0.000000).
Partition 0, Node 3 (36.719146, -4.480650, 0.000000).
Partition 0, Node 4 (36.719146, -4.480311, 0.000000).
Partition 0, Node 6 (36.718804, -4.480650, 0.000000).
Partition 0, Node 5 (36.718804, -4.480311, 0.000000).
Partition 0, Node 9 (36.718741, -4.467737, 0.000000).
Partition 0, Node 14 (36.719865, -4.464257, 120.225102).
Partition 0, Node 10 (36.714792, -4.478066, 0.000000).
Partition 0, Node 11 (36.714609, -4.478929, 0.000000).
Partition 0, Node 12 (36.714487, -4.478290, 0.000000).
Starting threads for IPNE
Starting receive thread for IPNE
Initialization completed in 20.372 sec at 2024-07-17 07:57:04.595
```

Table View | Output Window | Error Log | Watch Variables | Batch Experiments

Pan your View by moving the mouse while keeping the left mouse button pressed

Emulate & Analyse Rel-17 Non-Terrestrial 5G

Complete Emulator portfolio for 5G NTN UE and Network development



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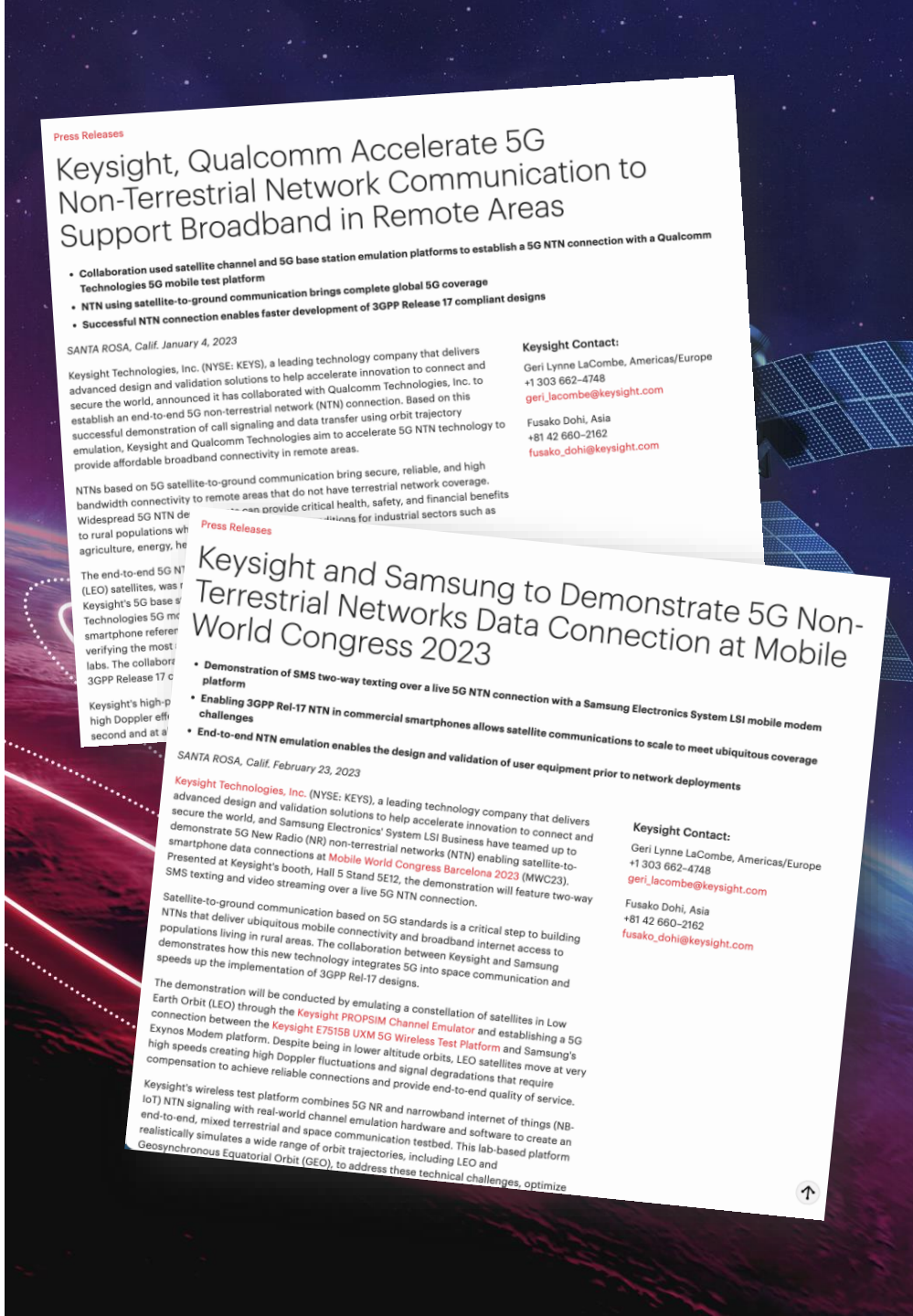

Press Releases

Keysight, Qualcomm Accelerate 5G Non-Terrestrial Network Communication to Support Broadband in Remote Areas

- **Collaboration used satellite channel and 5G base station emulation platforms to establish a 5G NTN connection with a Qualcomm Technologies 5G mobile test platform**
- **NTN using satellite-to-ground communication brings complete global 5G coverage**
- **Successful NTN connection enables faster development of 3GPP Release 17 compliant designs**

SANTA ROSA, Calif. January 4, 2023

Keysight Technologies, Inc. (NYSE: KEYS), a leading technology company that delivers advanced design and validation solutions to help accelerate innovation to connect and secure the world, announced it has collaborated with Qualcomm Technologies, Inc. to establish an end-to-end 5G non-terrestrial network (NTN) connection. Based on this successful demonstration of call signaling and data transfer using orbit trajectory emulation, Keysight and Qualcomm Technologies aim to accelerate 5G NTN technology to provide affordable broadband connectivity in remote areas.

NTNs based on 5G satellite-to-ground communication bring secure, reliable, and high bandwidth connectivity to remote areas that do not have terrestrial network coverage. Widespread 5G NTN de... to rural populations wh... agriculture, energy, he...

The end-to-end 5G NT... (LEO) satellites, was ... Keysight's 5G base s... Technologies 5G mo... smartphone referen... verifying the most ... labs. The collabora... 3GPP Release 17 c...

Keysight's high-p... high Doppler effe... second and at a...

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Press Releases

Keysight and Samsung to Demonstrate 5G Non-Terrestrial Networks Data Connection at Mobile World Congress 2023

- **Demonstration of SMS two-way texting over a live 5G NTN connection with a Samsung Electronics System LSI mobile modem platform**
- **Enabling 3GPP Rel-17 NTN in commercial smartphones allows satellite communications to scale to meet ubiquitous coverage challenges**
- **End-to-end NTN emulation enables the design and validation of user equipment prior to network deployments**

SANTA ROSA, Calif. February 23, 2023

Keysight Technologies, Inc. (NYSE: KEYS), a leading technology company that delivers advanced design and validation solutions to help accelerate innovation to connect and secure the world, and Samsung Electronics' System LSI Business have teamed up to demonstrate 5G New Radio (NR) non-terrestrial networks (NTN) enabling satellite-to-smartphone data connections at Mobile World Congress Barcelona 2023 (MWC23). Presented at Keysight's booth, Hall 5 Stand 5E12, the demonstration will feature two-way SMS texting and video streaming over a live 5G NTN connection.

Satellite-to-ground communication based on 5G standards is a critical step to building NTNs that deliver ubiquitous mobile connectivity and broadband internet access to populations living in rural areas. The collaboration between Keysight and Samsung demonstrates how this new technology integrates 5G into space communication and speeds up the implementation of 3GPP Rel-17 designs.

The demonstration will be conducted by emulating a constellation of satellites in Low Earth Orbit (LEO) through the Keysight PROPSIM Channel Emulator and establishing a 5G connection between the Keysight E7515B UXM 5G Wireless Test Platform and Samsung's Exynos Modem platform. Despite being in lower altitude orbits, LEO satellites move at very high speeds creating high Doppler fluctuations and signal degradations that require compensation to achieve reliable connections and provide end-to-end quality of service.

Keysight's wireless test platform combines 5G NR and narrowband internet of things (NB-IoT) NTN signaling with real-world channel emulation hardware and software to create an end-to-end, mixed terrestrial and space communication testbed. This lab-based platform realistically simulates a wide range of orbit trajectories, including LEO and Geosynchronous Equatorial Orbit (GEO), to address these technical challenges, optimize

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Hardware Components for NTN Test Bed Emulation

Higher SNR evaluation – Dynamic Range Extended with WaveJudge Hardware/Software

UXM5G PRO E7515P
Wireless Test Platform

- Frequency coverage to 15 GHz
- 5G NTN and NR emulation up to 8CC DL 4CC UL 2x2
- Multiple band combinations supported
- Multiple AOA tests
- RF parametric tests
- Protocol verification and testing
- Suite of application tests

Keysight Propsim F8820B
Channel Link Emulator

- Frequency coverage from 30 MHz to 17 GHz
- 16 phase and time coherent channels
- Up to 1600 MHz channel BW
- Emulates LOS satellite channel and terrestrial fast fading
- Up to 1.5 MHz doppler
- Up to 1200 mS delay

Keysight P8800S UeSIM
UE(s) Emulator

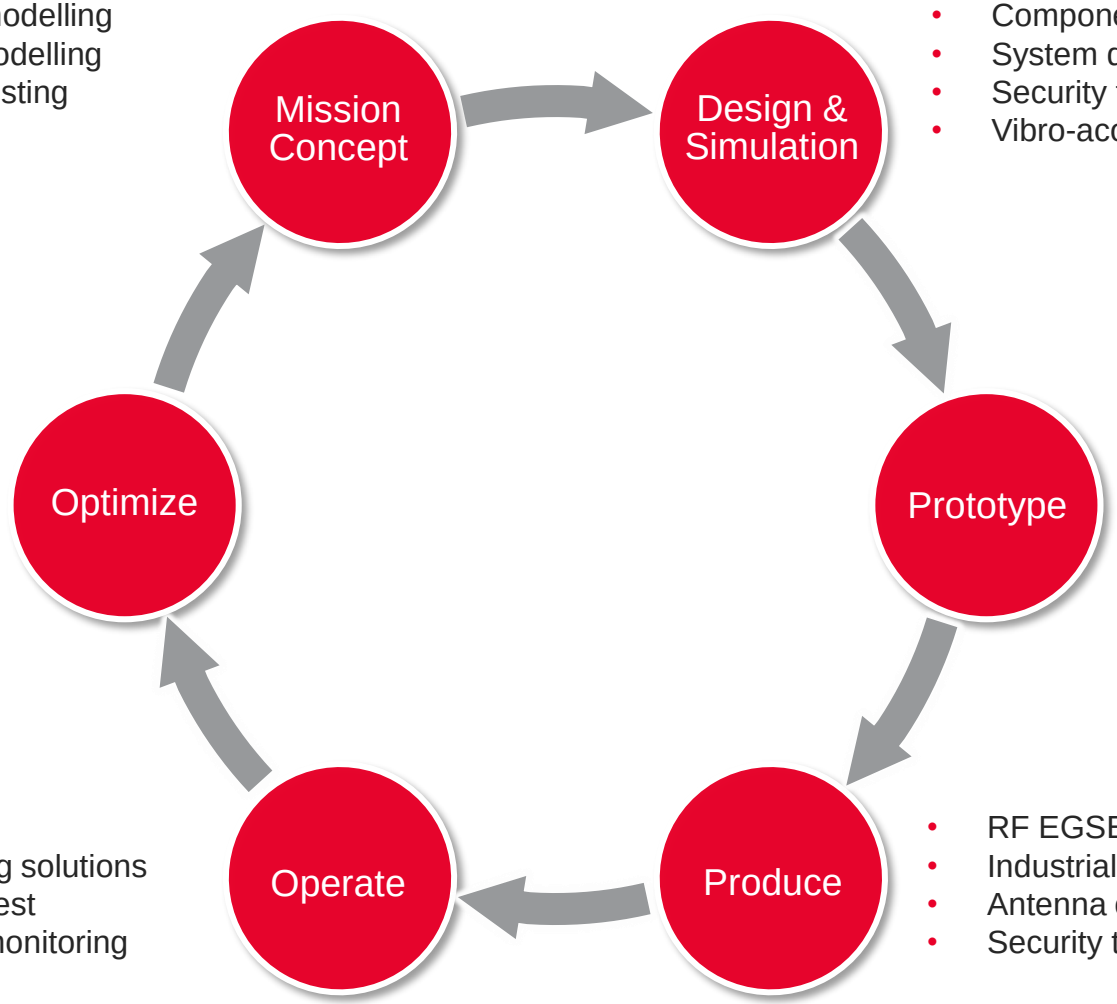
- Load testing for 5G NR
- Full protocol stack assessment from L1 to L7
- Layer by layer functional testing up to thousands of UES
- Real smartphone applications and traffic profile simulation
- Service quality validation with subscriber modeling

Keysight WaveJudge5900
Full Protocol Stack Decoder

- Unique solution for passive signal capture and analysis
- 5G NR real-time decoding
- Decode full protocol stack from RF, O-RAN Fronthaul or from complex IQ data captured in hardware.
- **Protocols include: 3GPP 5G NR Releases 15 to 17, including 5G NR NTN, RedCap, and V2X, 3GPP LTE Releases 9 to 16, IEEE Wi-Fi 802.11ax and 802.11be**
- SSD storage for long IQ captures to troubleshoot intermittent issues
- Advanced triggers, stack breakpoints.

Tools that support the workflow

- Network modelling
- System modelling
- Security testing



- Component design
- System design
- Security testing
- Vibro-acoustic modeling

- Component and system test with HiL
- Software interface testing
- Payload and Power test systems
- Security testing
- Application-specific verification (5G, Radar)

- RF EGSE and Power SCOE
- Industrial Automation
- Antenna calibration systems
- Security testing

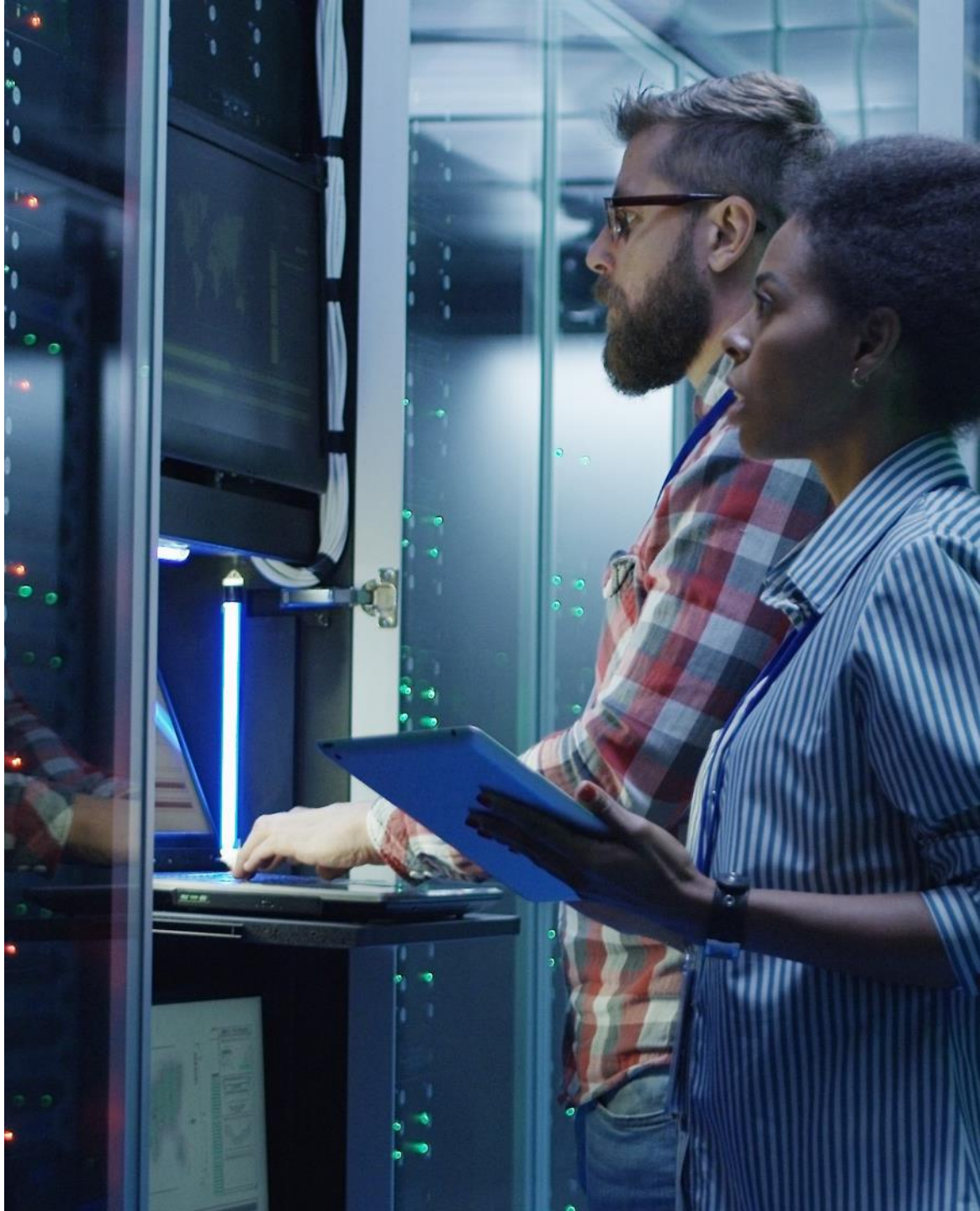
- Validation tools
- Signal monitoring solutions
- Ground station test
- Network traffic monitoring
- Security testing

- Process and test analysis
- Network modelling and test
- Security testing

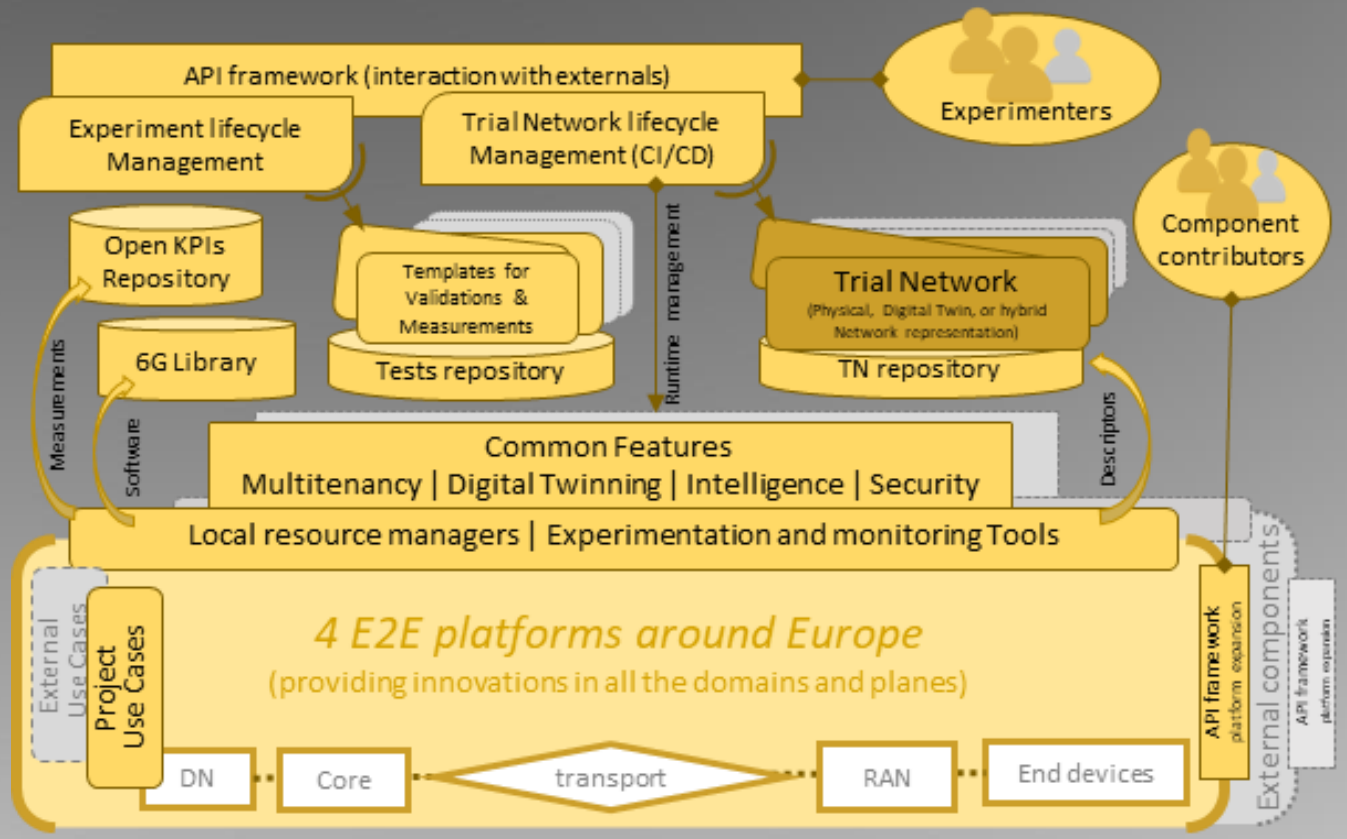
Conclusions

Beating the Goldrush

- The race to operational constellations is accelerating
- Investment in early modelling can be used to “Shift Left”, improve decision making process to reduce overall costs and operational risks.
- More tools are available to simulate complex systems than ever before.
- Emulation covers physics, to payloads to entire networks.



6G-SANDBOX Concept



(6G-SANDBOX) TRIAL NETWORK: fully configurable, manageable and controllable network which *combines digital and physical nodes* and provides services for 6G *technology validation* and 6G *KPI measurements*

- the experimenter can manage the lifecycle of the experiment and the trial network
- the open calls target both experimenters and component contributors

KEYSIGHT

Thank you