5G Non Terrestrial Networks – Overview & Test Solution

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Satellite System Characteristics

SATELLITE COMMUNICATIONS OVERVIEW

Future of SATCOM

MAIN CHANGES FOR THE NEXT 10 YEARS

- **Increasing demand for throughput**

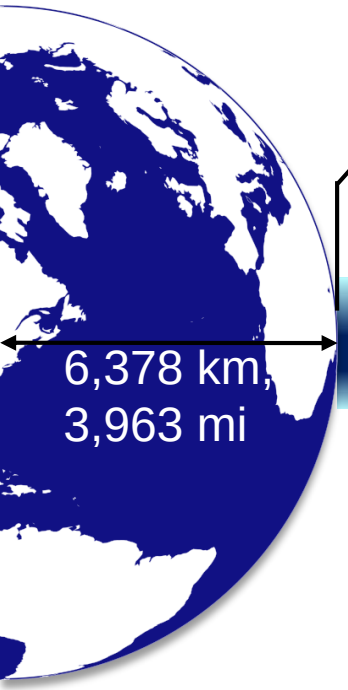
- **Wider bandwidths**
- **Higher operating frequencies**
- **Laser links**

- **Increasing number of satellites**:
  - Now: 1,800
  - 2025-2030: 18,000
  - Massive LEO

Technology on the way
- What are the applications?

Satellite Orbital Altitudes: Big Variance

HUGE LINK DISTANCES COMPARED TO CELLULAR



0 km sea level

340 km International Space Station (ISS)

700-1,700 km polar-orbiting

LEO

2,000 km / 1243.7 mi / 6.7 ms

600-800km sun-synchronous

Hubble: (HST) Space Telescope 559 km

MEO

20,350 km, 68 ms
GPS satellites
12 h orbit

GPS: 20,200 km
GLONASS: 19,100 km
Galileo: 23,222 km
Compass: 21,528 km for MEO

Compass: 35,786 km for GEO/IGSO

35,786 km, 120 ms
Geosynchronous (GEO)
Geostationary (GSO)
satellites
24h orbit

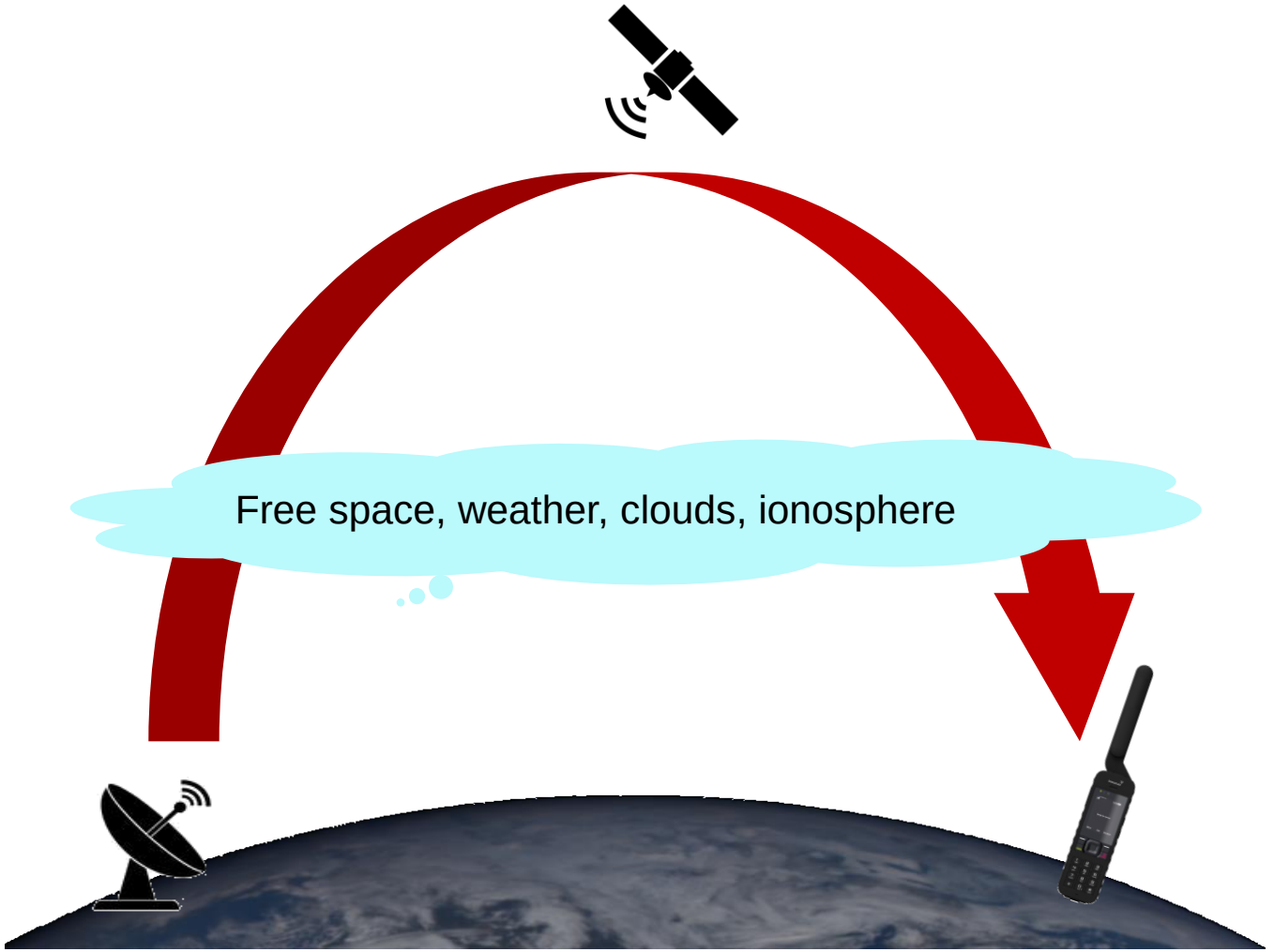
HEO

384,000km, 1,300 ms
Moon

MEO HEO

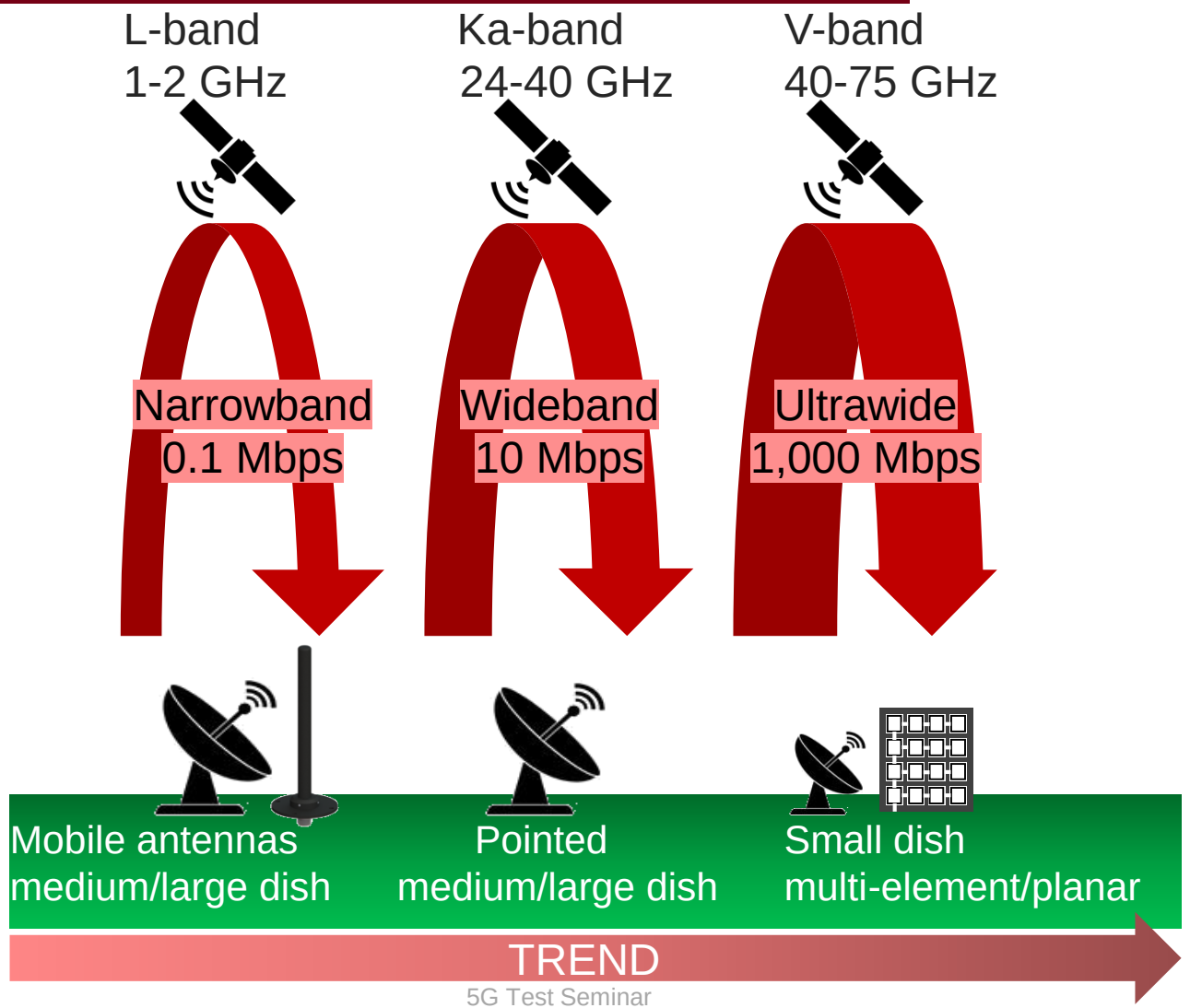
Received Power, a Problem in SATCOM

HOW TO GET ENOUGH POWER INTO THE RECEIVER?

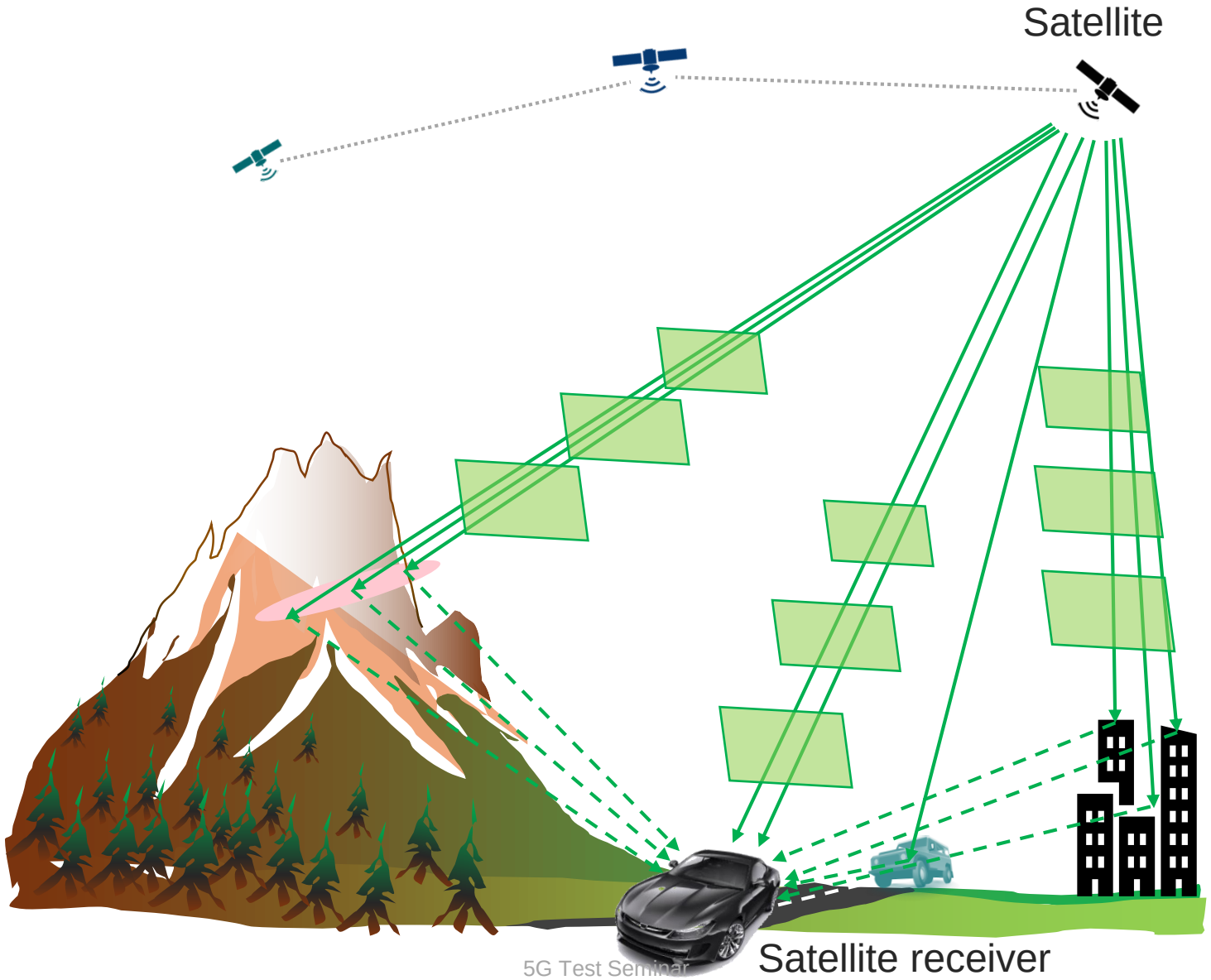


More Complex SATCOM Systems

TESTING ALSO BECOMES MORE CHALLENGING



Characteristics Compared to Telecommunications



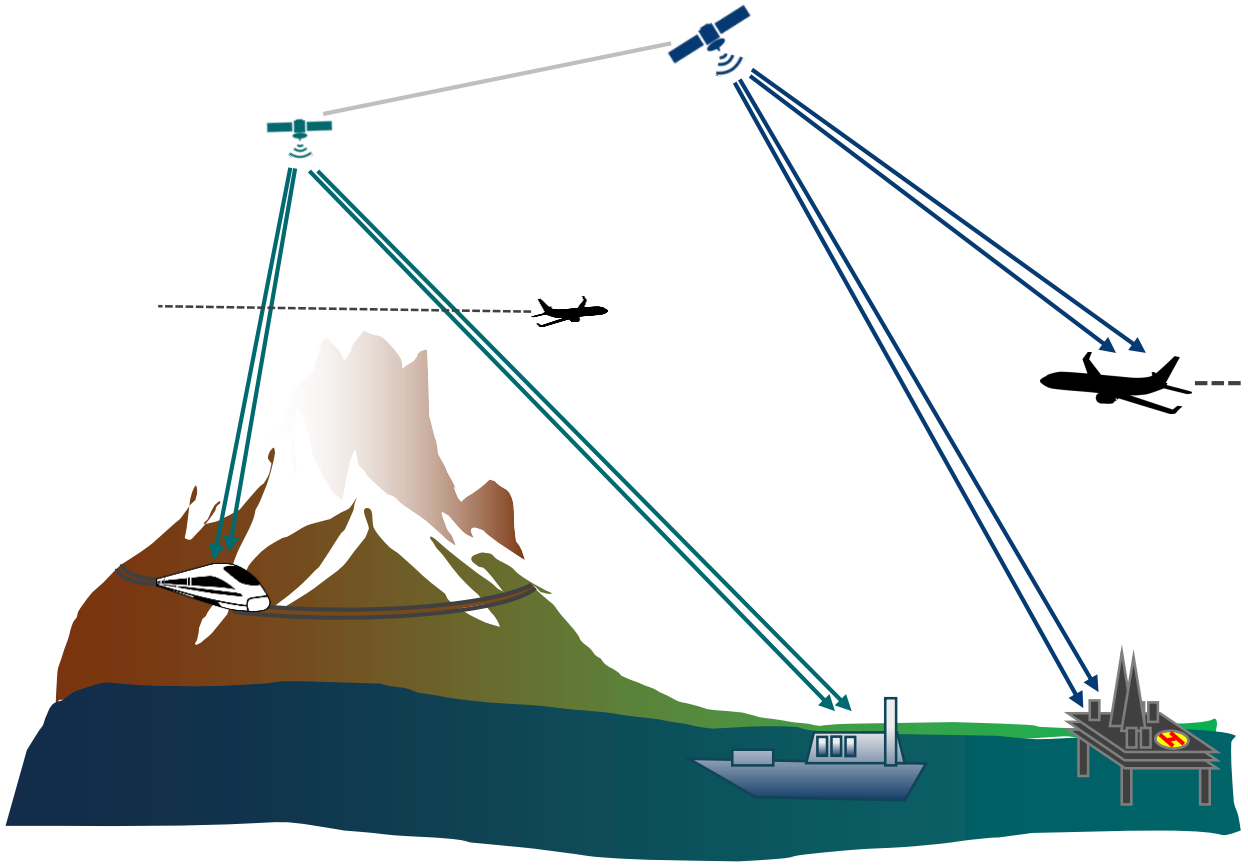
5G Non-Terrestrial Networks

BRINGING SATCOM TO THE MAINSTREAM

5G NTN – Part of 3GPP Release 17

GETTING READY FOR SATELLITE CONNECTIVITY

- Satellite communications is becoming a part of cellular networks
- Support 5G deployments by covering difficult-to-reach areas
  - Areas with no infrastructure, isolated platforms
- Provide extra reliability for M2M/IoT and connectivity for moving platforms
  - Airplanes, trains, cars
- Scale traffic, provide broadcast service, improve coverage
  - Cover the edge of networks



Isolated and moving platforms, hard-to-reach places

5G NR NTN: Main Benefits

IMPROVING CELLULAR SERVICE

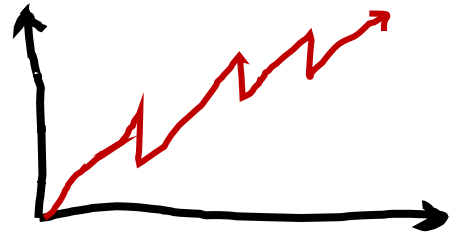
- **Achieve multi-connectivity**: customer attached to terrestrial & SATCOM (mostly indirectly)
- **Address users in underserved or isolated areas**: use SATCOM “fixed cell” (continuous SATCOM service)
- **Serve passengers in aircrafts or on high-speed trains**: use SATCOM “mobile cell” (HO)
- **Support high-availability networks** (>99.999): use SATCOM as back-up/fallback network

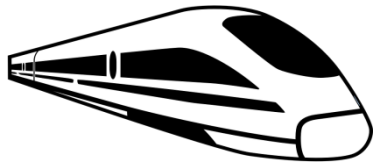
- Deploying or restoring network coverage (e.g. after disaster)
- Offloading 5G network on network edges
- IoT services for wide area with relatively high latency (e.g. energy networks, transport, agriculture)
- Need direct SATCOM link to user equipment in emergency situations

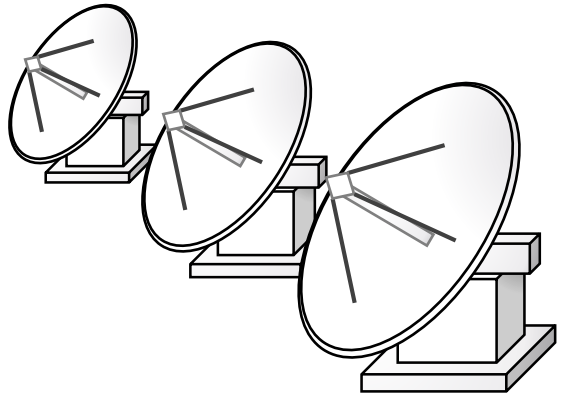
5G NR NTN: SATCOM Use Cases

DEFINING THE TEST REQUIREMENTS FOR 5G SATCOM

- Testing 5G NR NTN satellite links:
  - Channel models are described in 3GPP TR 38.811
- Use cases/scenarios
  - Cover unserved areas
  - Service for aircrafts, ships, trains, buses, etc.
  - Man-to-machine and IoT
    - Relaxed latency requirements
  - Ensure service availability
  - Enable 5G network scalability
- Concerns: will latency be an issue?
  - Generally, 5G tightens latency requirements vs. 4G
  - SATCOM is a supportive technology for terrestrial networks and special-purpose applications







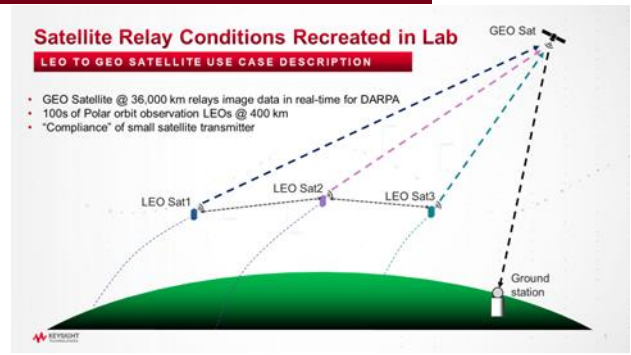
Testing Challenges

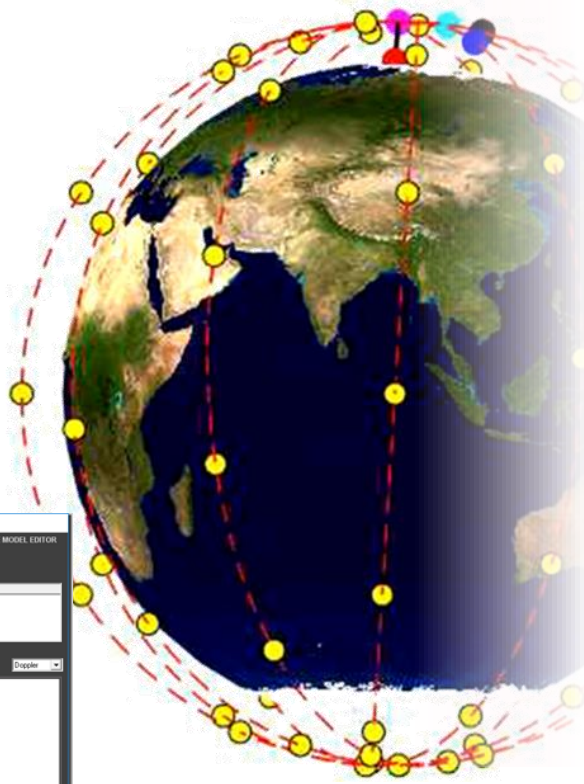
HOW TO TEST MODERN SATCOM SYSTEMS

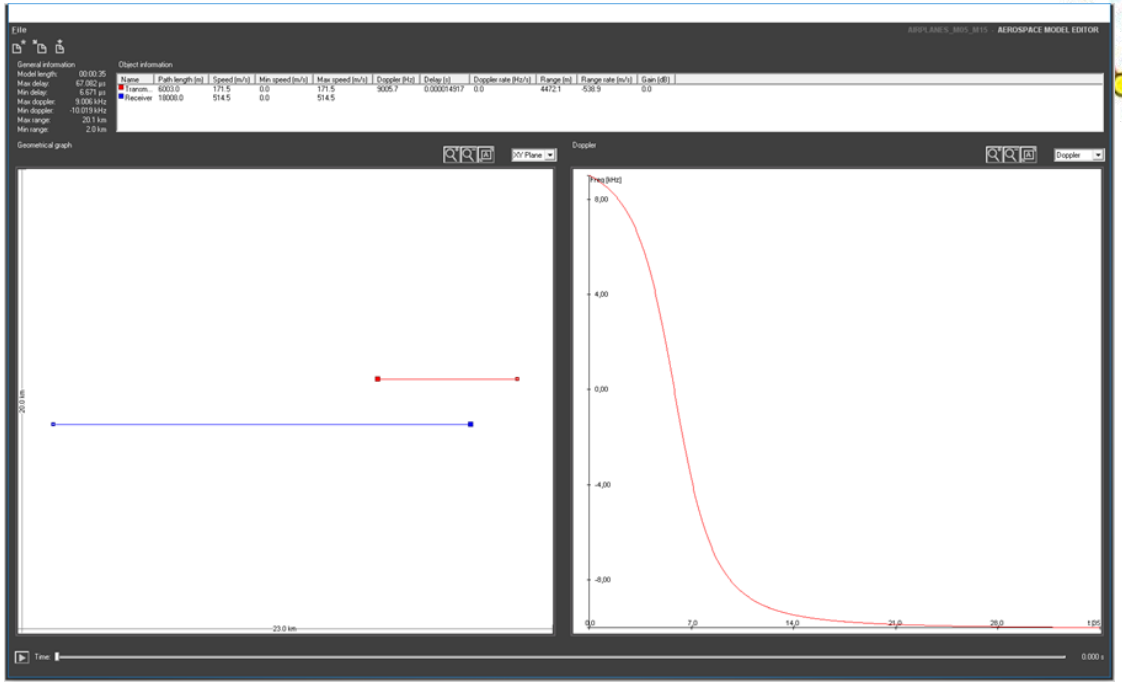
Setting Up Orbital Conditions

LONG DELAYS AND HIGH DOPPLER

- It is crucial to test satellite communication systems with realistic environmental models
- Adding buffering for delayed signals
- Simulating sliding delay for creating realistic satellite kinematics



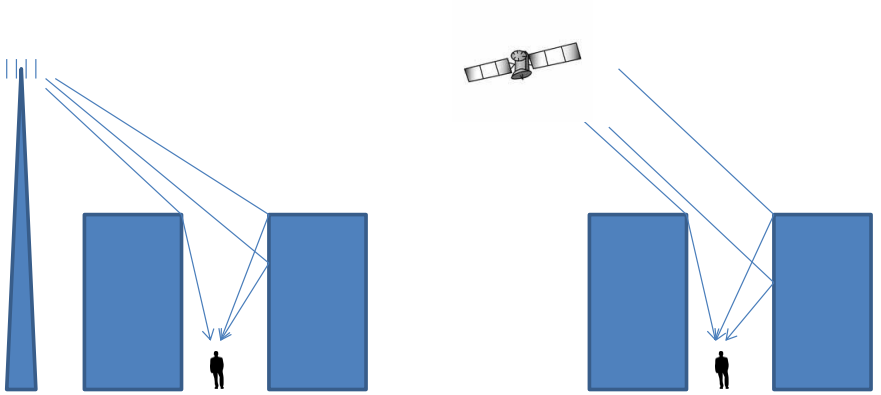




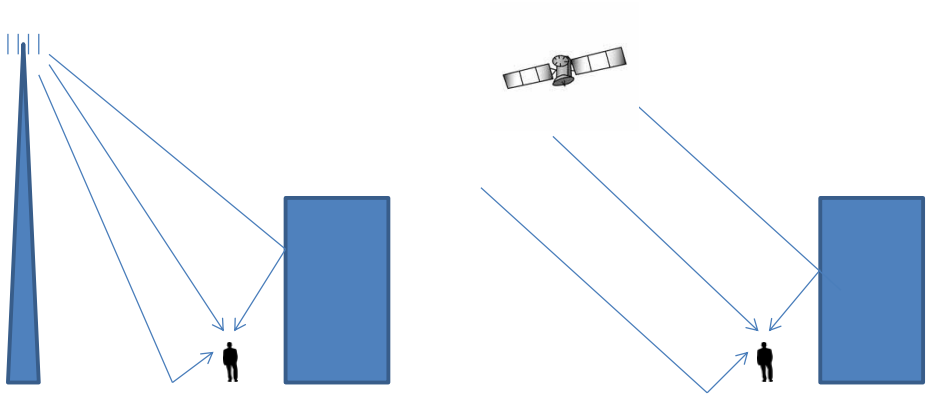
Radio Channel Propagation Modeling

WHAT IS REQUIRED TO MODEL THE SATELLITE LINK?

- Outdoor links, due to high path loss for indoors



Macro-cellular vs. satellite channel, NLOS*



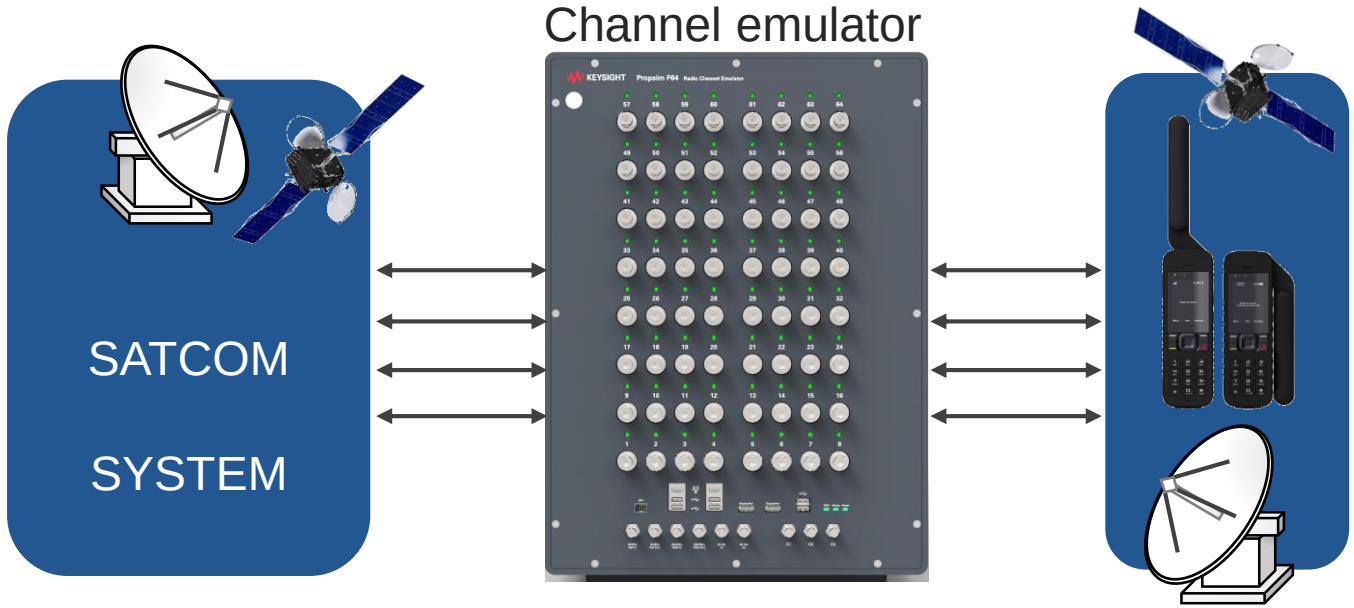
Macro-cellular vs. satellite channel, LOS*

*3GPP TR 38.811 figure 6.2-1/6.2-2

SATCOM Link Simulation in Laboratory

INTRODUCING CHANNEL EMULATION INTO TESTING

- **Single-link satellite simulation has been around for a long time**
- **New, more complex solutions**
  - Satellite mesh
  - Multiple transponders and multiple satellites
- **Channel emulator can simulate a whole network of devices**
  - Compare variants and SW versions
  - Objective comparison of different devices



Connecting multiple devices, interlinking subsystems

Using Channel Emulator for SATCOM

DEFINE SCENARIO, CREATE EMULATION

```
; Propsim Aerospace Model file, version 1.0

[Model]
SimulationCenterFrequency=11400000000 Hz
RFCenterFrequency=5700000000 Hz

[LOS]
N=0,30000414,0,0,-29902656.79 ,-125.627817
N=1,30000414,0,0,-29902656 -125.646957
N=2,30000414,0,0,-299 125.712724
N=3,30000414,0,0, 25.636887
```

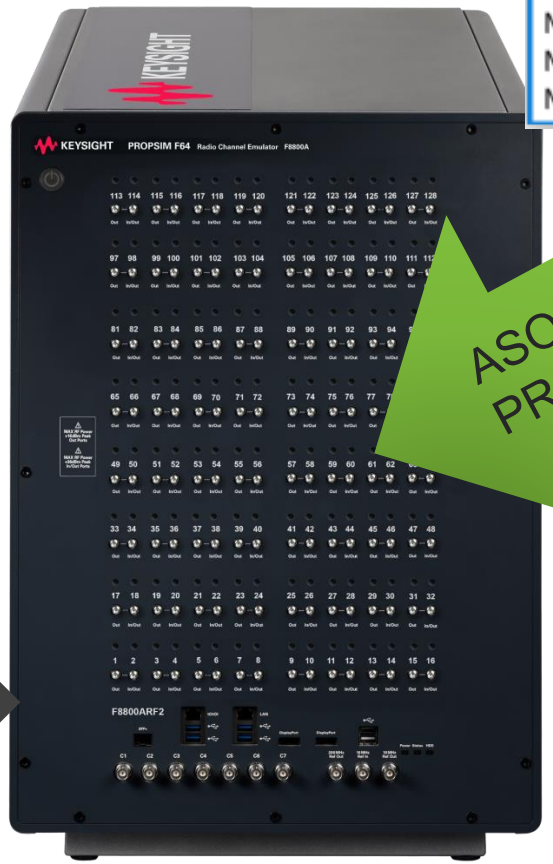
ASO channel model running in PROPSIM, created from ASO files

Apply attenuators between DUT and test environment

Satellite MODEM 1

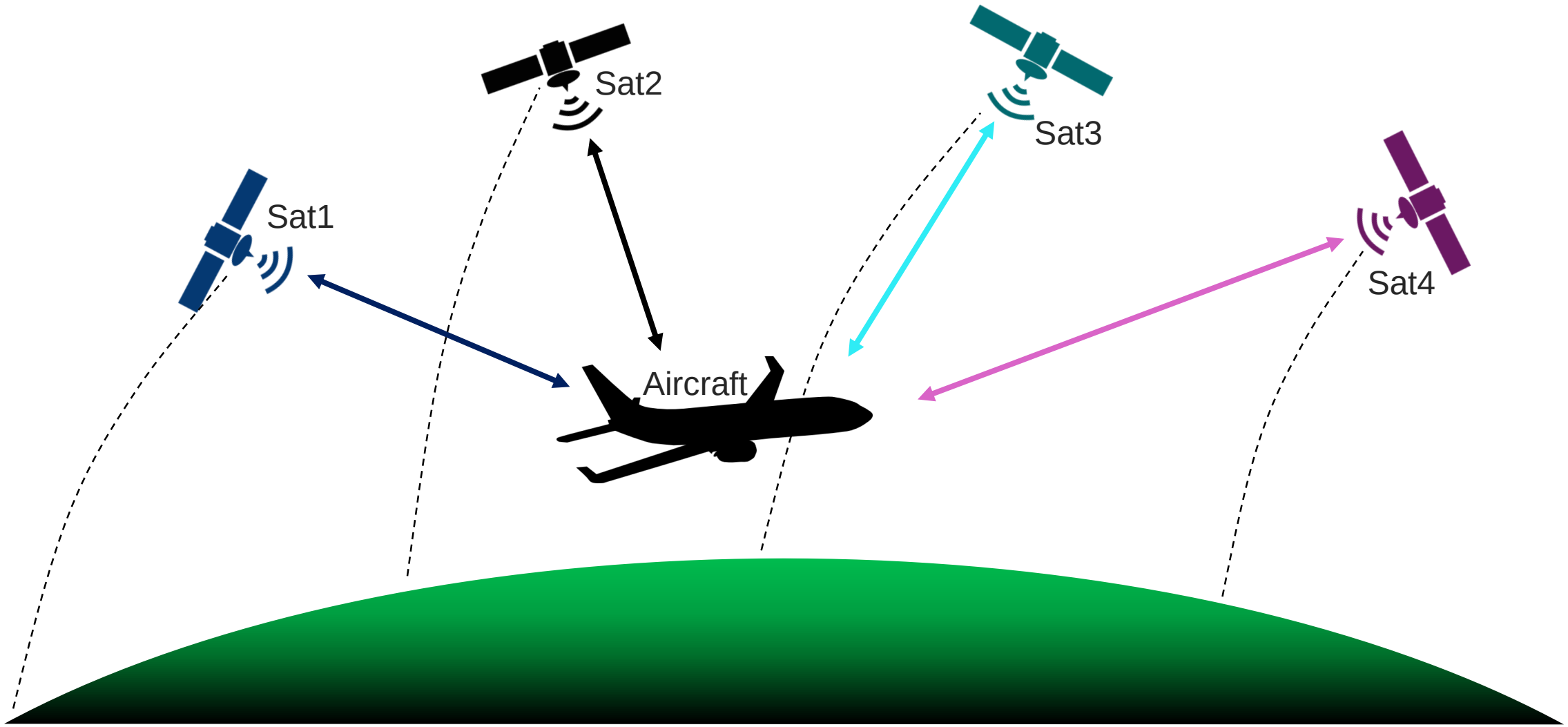
Satellite MODEM 2

CIU

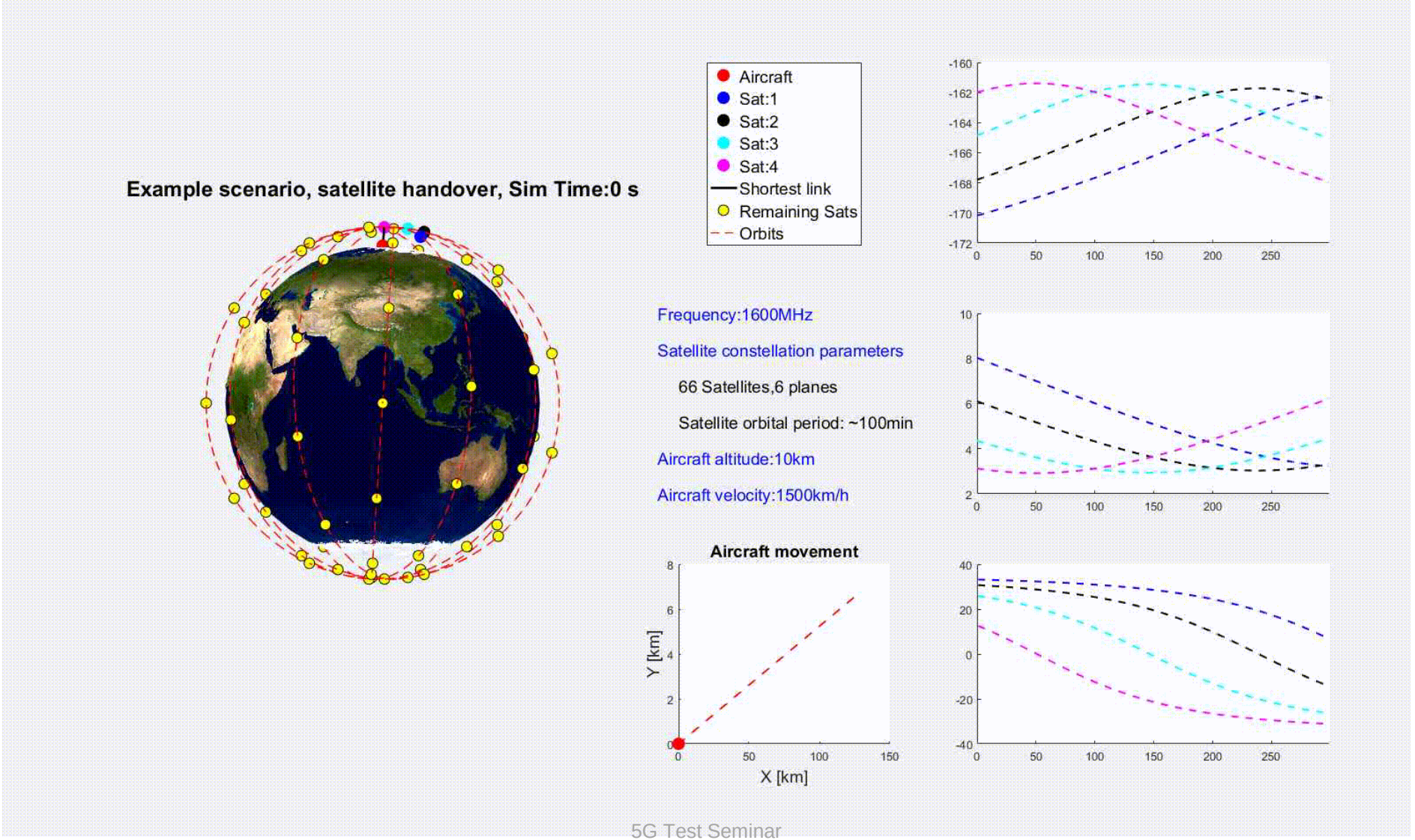


Channel emulator

Aircraft-to-Satellite Use Case

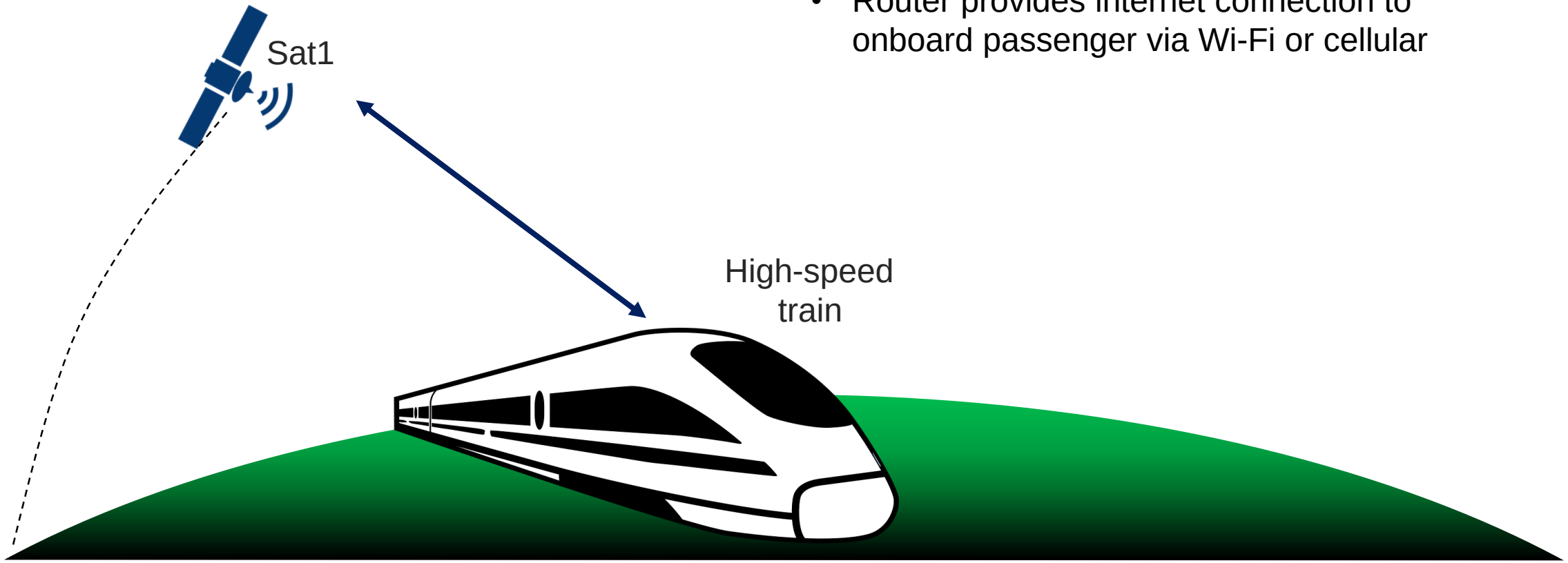


Aircraft-to-Satellite Use Case

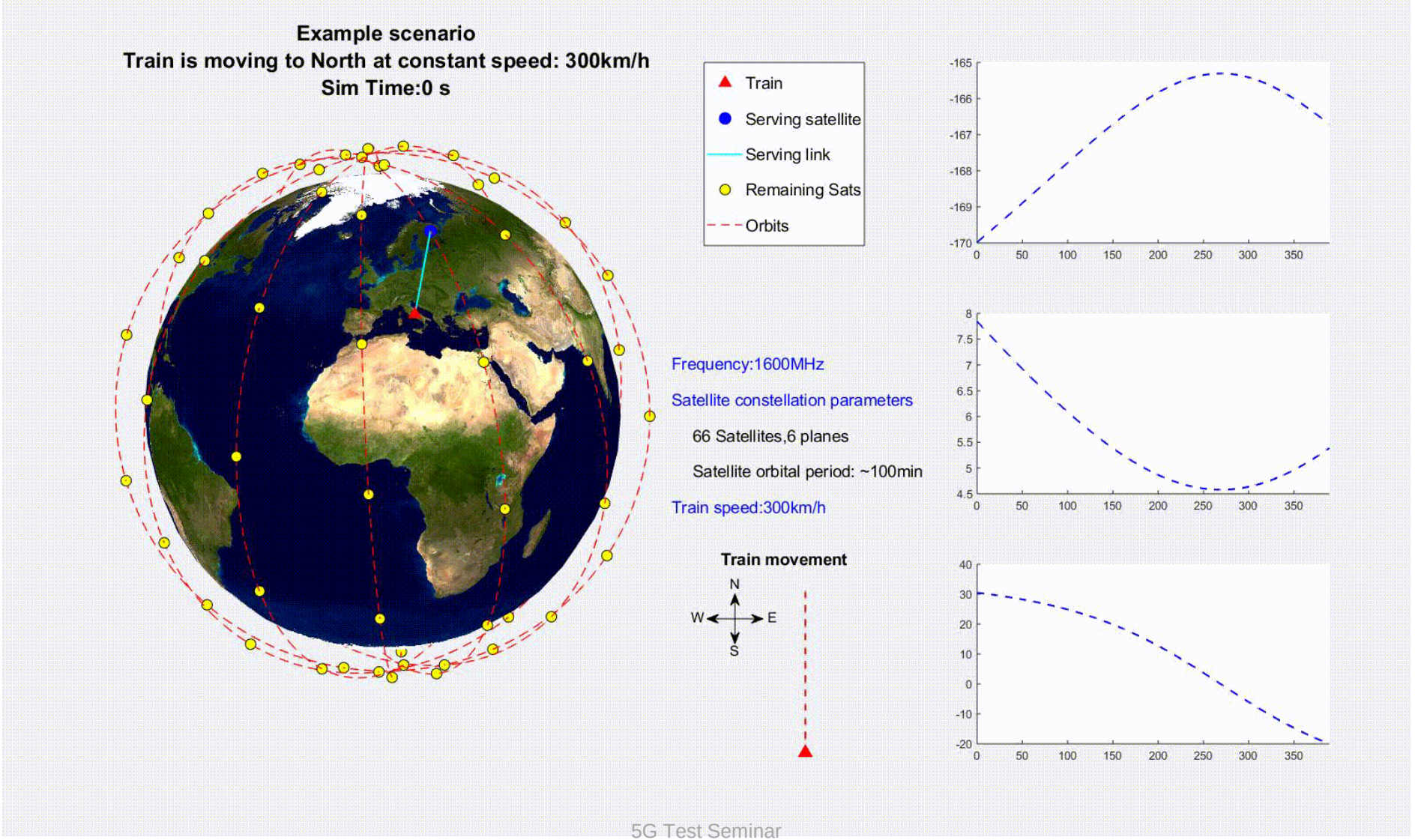


High-Speed Train SATCOM Use Case

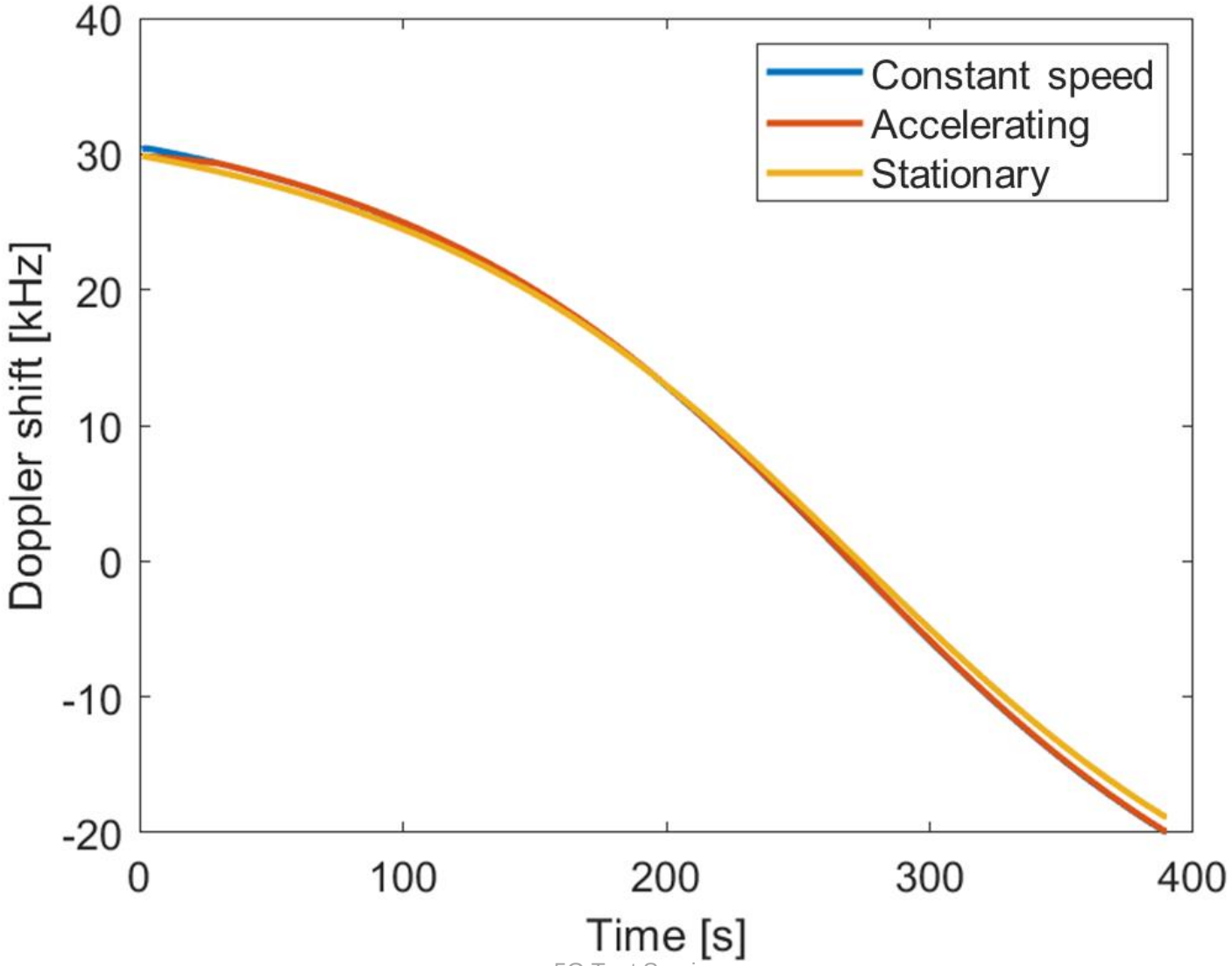
- Train traveling at 300 km/h
- Only one active satellite connection
- Router provides internet connection to onboard passenger via Wi-Fi or cellular



High-Speed Train SATCOM Use Case

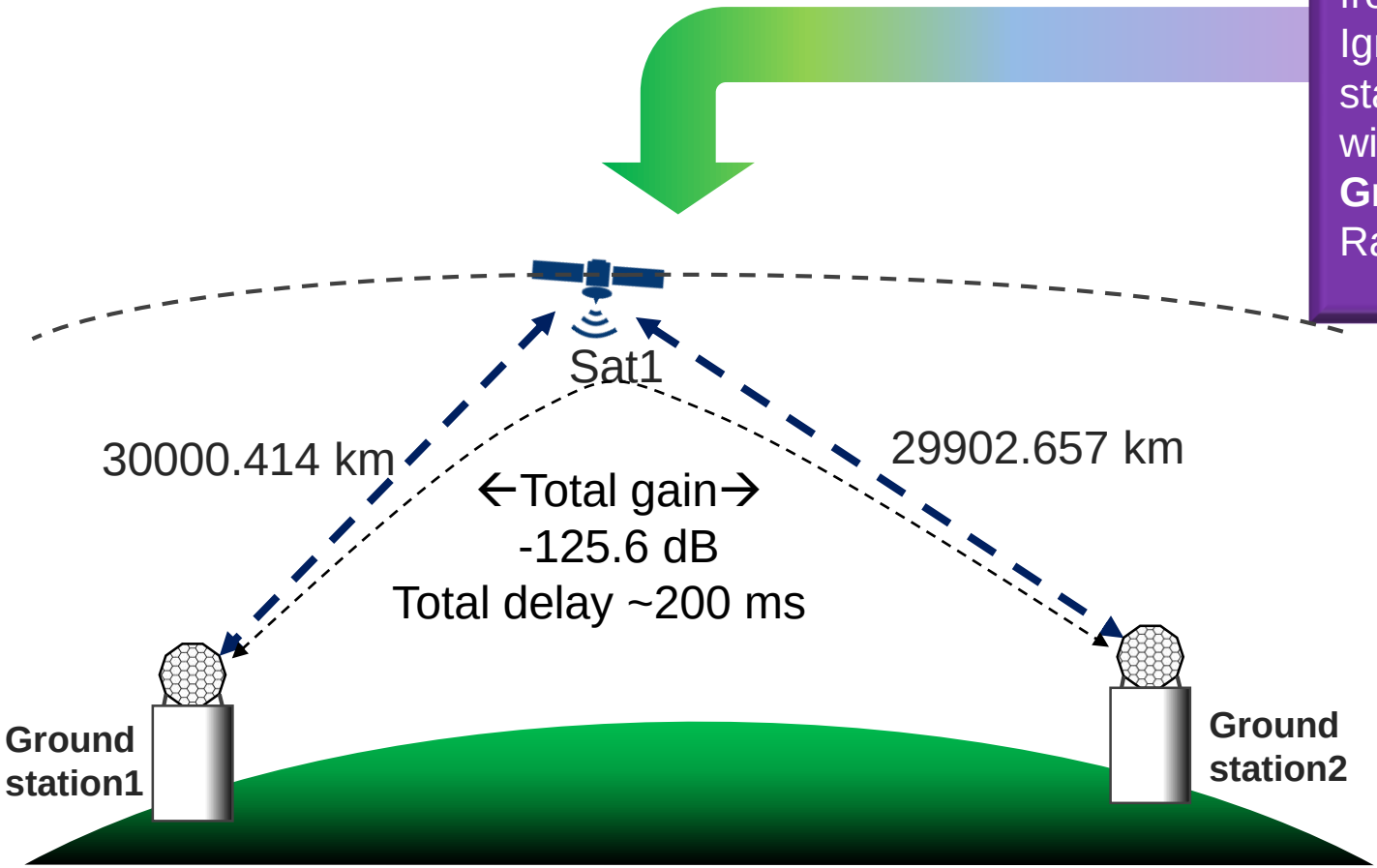


High-Speed Train SATCOM Use Case



Total Link Budget vs. Dynamic Range

Satellite modeled as part of channel characteristics
1 MEO satellite ~30 tkm from ground stations
Ignore orbit details, almost stationary within time window
Ground stations
Radio frequency 11.4 GHz



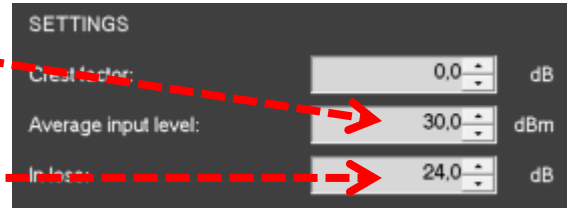
Using ASO File

GROUND-TO-GROUND: SETTING POWER VALUES

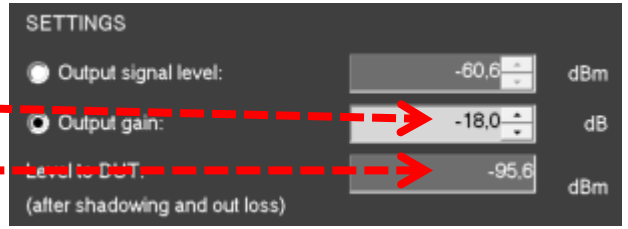
- Channel gain of 0 dBW to –125,6 dBW too large for power window of ASO models (75 dB)
  - Average input level is +30 dBm
    - Scaled emulation +60 dB from simulated values, to roughly –65.6 dB
  - Need to add attenuator before input
    - Set to –24 dB
    - Enter into PROPSIM as “in loss”
  - At these levels, PROPSIM attenuation is about –12 dB
    - “Level to DUT” in PROPSIM output
    - Added extra –18 dB as “output gain”
  - Adds up to –95.6 dBm as correct signal level for receiver under test

Result = ASO file with scaled values

Input



Output



Solutions

END-TO-END TESTING FOR SATCOM LINKS

PROPSIM Channel Emulators

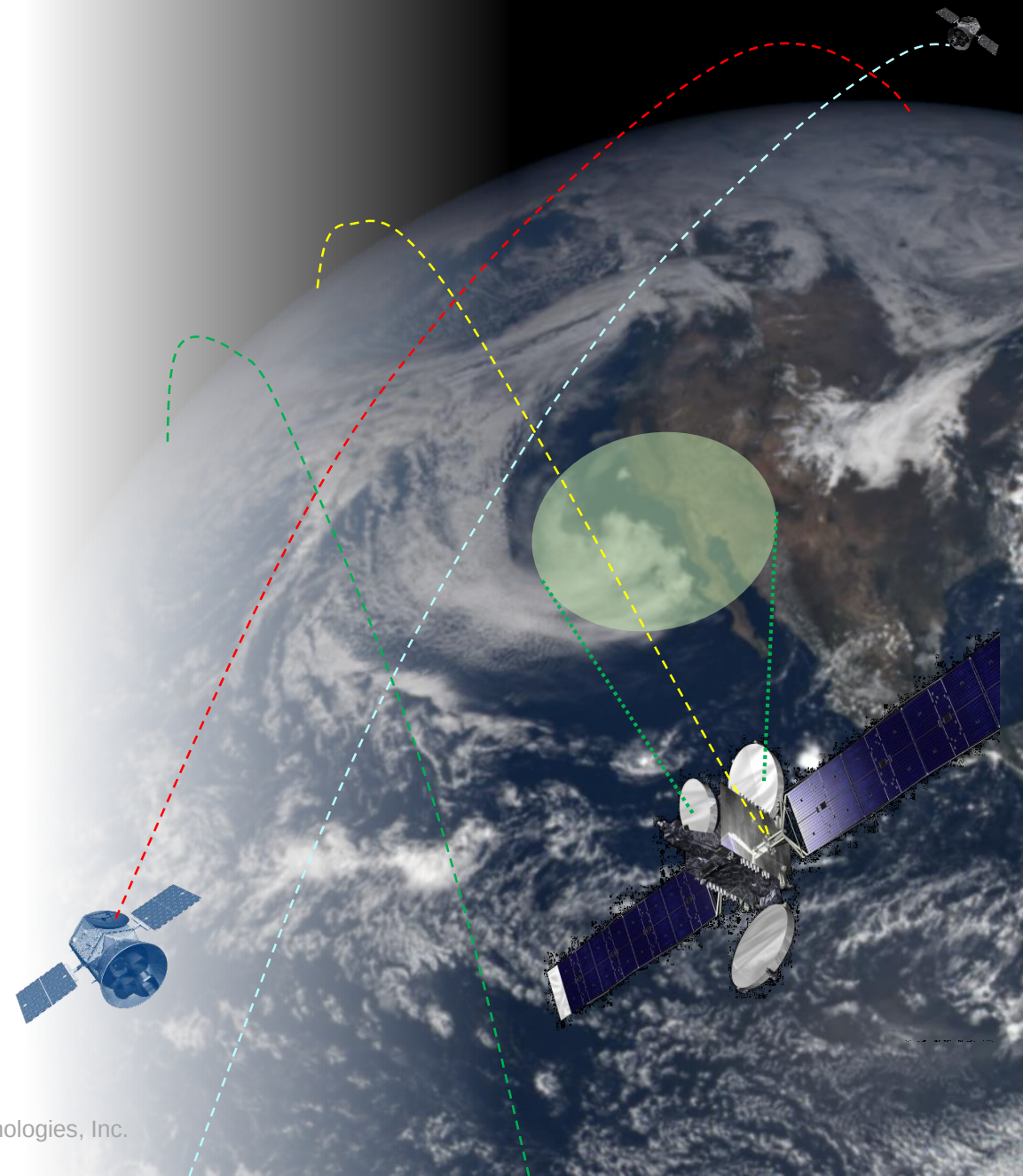
NEXT LEVEL OF TESTING

- PROPSIM F64 platform
- Up to 64TRX + 64TX ports
  - Starting from 8 channels, expanding in increments of 8 ch
- Bi-directional and unidirectional fading support
- 3 MHz…6000 MHz seamless RF range
- Up to 1,024 digital fading channels
- From 40 MHz to 1,200 MHz signal bandwidths
  - Accessible from a single port without circulators
- Up to 32 RFLOs

Aerospace Channel Emulation Engine (ACE)

TAILORED FOR AEROSPACE APPLICATIONS

- Test with up to 64 radios
- Flexible configurations
- Unrivaled performance



ASO Available 04/2020

SATCOM Testing

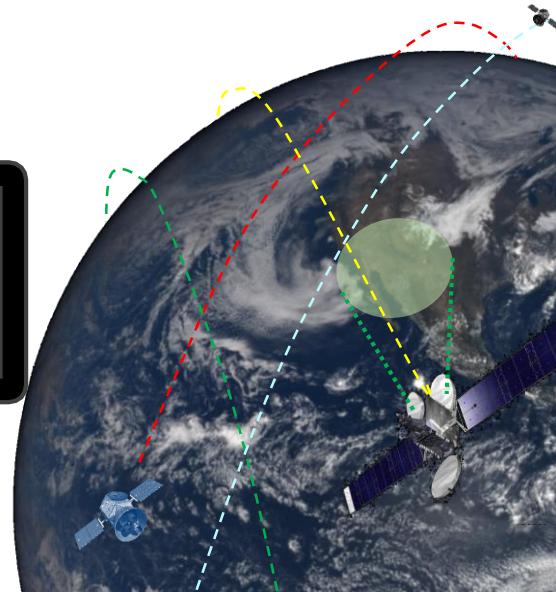
EXTENDING THE FREQUENCY RANGE

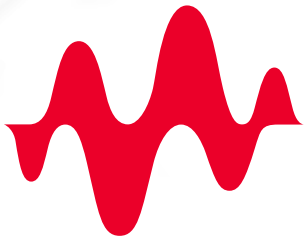
- Keysight can deliver full end-to-end satellite-testing environments
- Keysight PROPSIM channel emulators
  - Additional HW for extended frequency range
- 3rd party data import
  - Enables flexible construction of scenarios for testing real satellite radio hardware and solution/network level

24 – 45 GHz

6 – 12 GHz

3 MHz – 6 GHz





KEYSIGHT
TECHNOLOGIES