NSF SWIFT-SAT: DASS:
Dynamically
Adjustable
Spectrum
Sharing between
Ground Communication Networks and
Earth Exploration Satellite Systems
Above 100 GHz

Institute for the Wireless Internet of Things
Northeastern University

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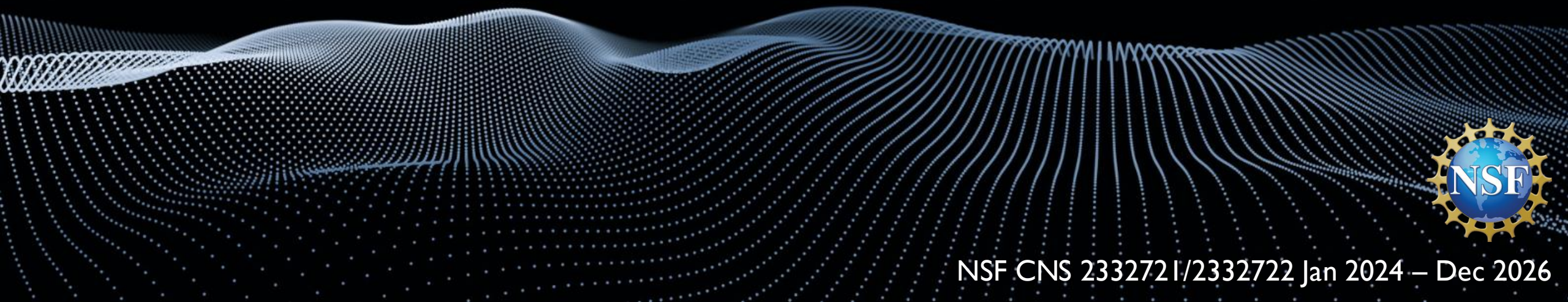

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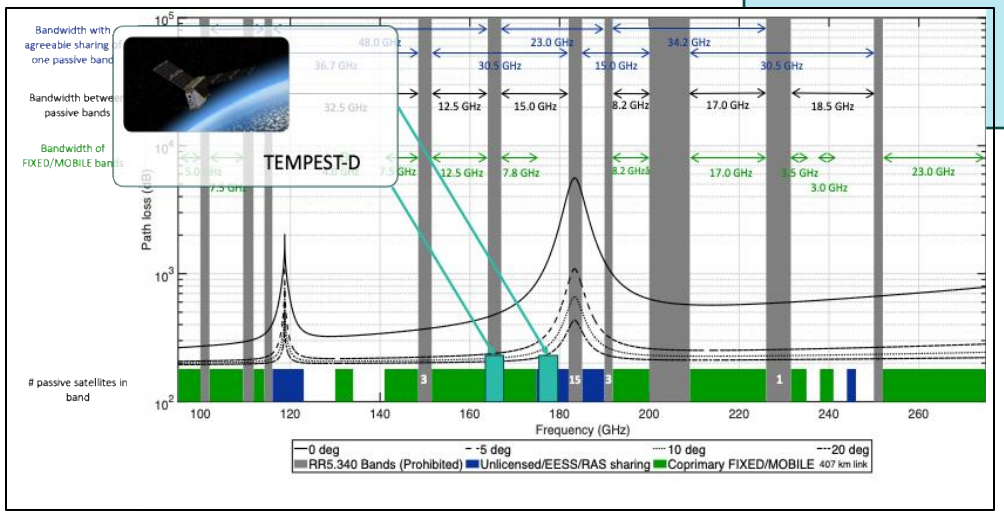
Project Goal

Transform how **terrestrial** wireless communication infrastructure and **satellite-based sensing** systems **share** the spectrum above **100 GHz**



Spectrum allocations above 100 GHz and passive sensing incumbents Polese et al, "Coexistence and Spectrum Sharing Above 100 GHz", Proceedings of the IEEE, Vol. 111, No. 8, August 2023

Team with cross-cutting expertise:

- Terahertz Communications and Networks, Spectrum Sharing, RFI Modeling
- Passing Sensing instruments from GHz to Terahertz and Observational Algorithms for the Earth's Atmosphere and Oceans

Experimental Evaluation of RFI to the Orbiting **TEMPEST-H8** Sensor

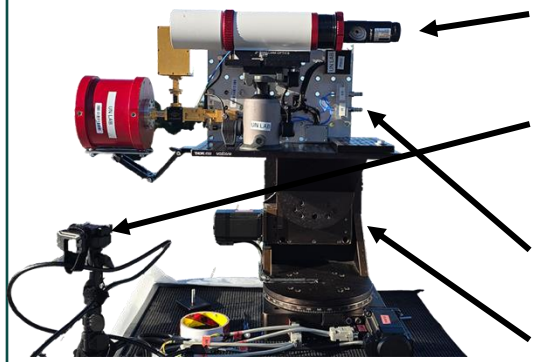
RFI Model from Large-scale Terrestrial 6G Networks and Comparison with Measurements

Interference Mitigation and **Co-Design** of Next-Generation Terrestrial and Satellite Systems

Thrust 1: Experimental RFI Evaluation

Transmit the first sub-THz signal from the ground to a LEO platform
Characterize RFI to an EESS sensor

Ground System (TX)



Optical Tracking: Williams Optics 50mm Guidescope

Calibration: Here+4 GNSS Receiver, Compass, IMU

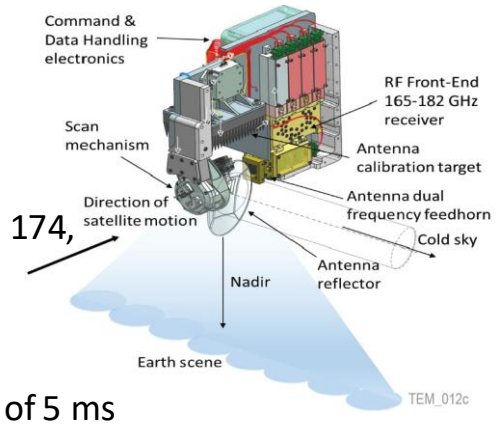
Antenna & RF Frontend: TeraNova testbed

Mount: Alt-az high-precision motorized table

Incumbent

TEMPEST-H8: Earth Remote Sensing Radiometer on the ISS

- Frequency Bands: 87, 165, 174, 178, and 181 GHz
- ±60° nadir angles
- 1550 km wide swath with radiometer sampling time of 5 ms



Challenges:

- Link budget to ensure that sensor is not damaged
- Open-loop tracking with small beamwidth (about 2 degrees) and ISS velocity (7.67 km/s)
  - No feedback on movement and/or received signal (delayed)
  - Limited tracking opportunities

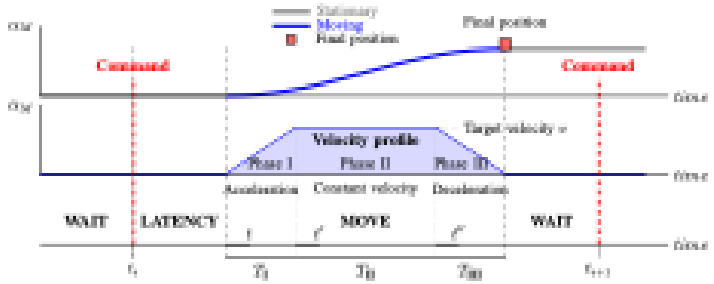
Successfully addressed ✅

- *Experimental license* - multiple iterations over 1.5 years, still not possible to perform experiments. The sensor will be removed soon

Blocker ⛔

Thrust 1: Experimental RFI Evaluation - Tracking

1 - **System modeling** to characterize tracking errors



Model:

- Limitations of the alt-az mount: latency, acceleration, sampling effects
- Imprecise positioning (compass, GPS errors)
- Narrow beam (limited margin of error)

2 - Two-step **experiment** setup

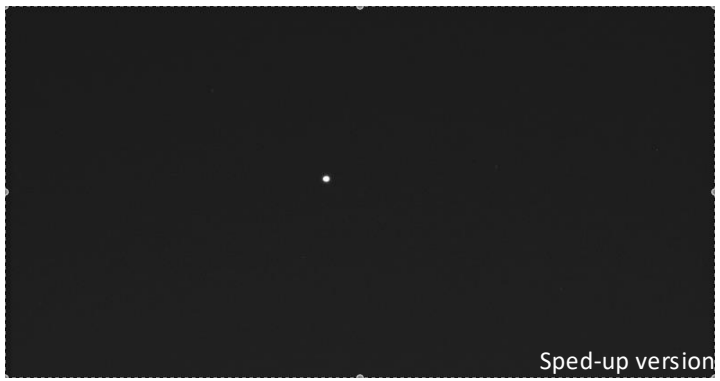
Calibration: track precise and known object (e.g., the sun/moon)

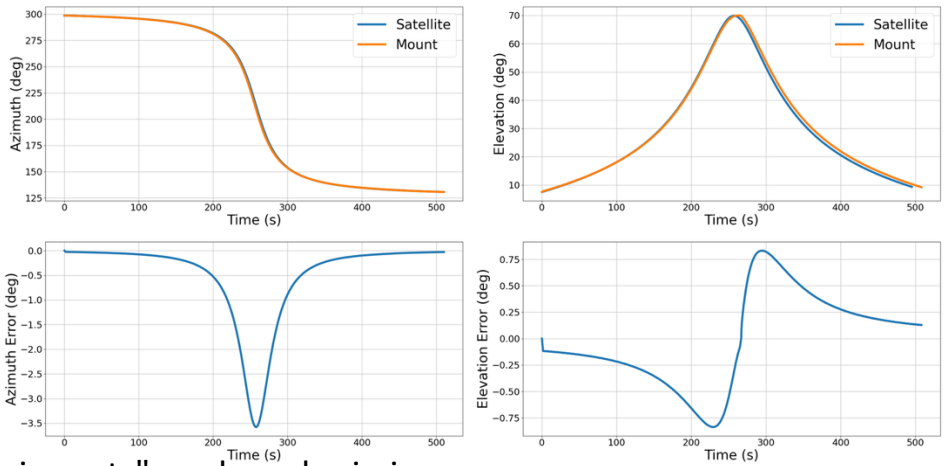
Feedback Loop Tracking

Error Correction

Experiment: track the ISS without feedback

Open Loop "Tracking"

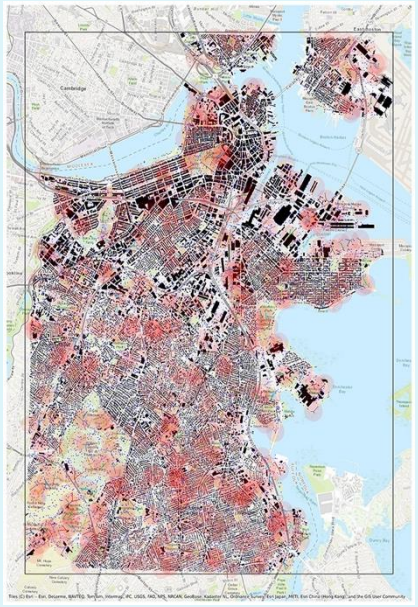




P. Brach del Prever et al., "Pointing-Error-Induced Fading in an Open-Loop THz Uplink with Hardware Impairments", under submission

Thrust 2: Large-scale RFI Modeling

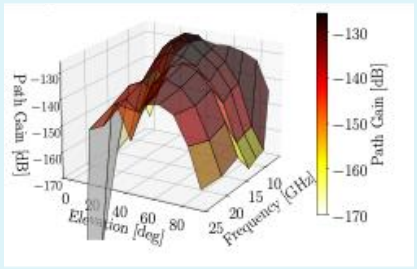
Ground-to-sat RFI

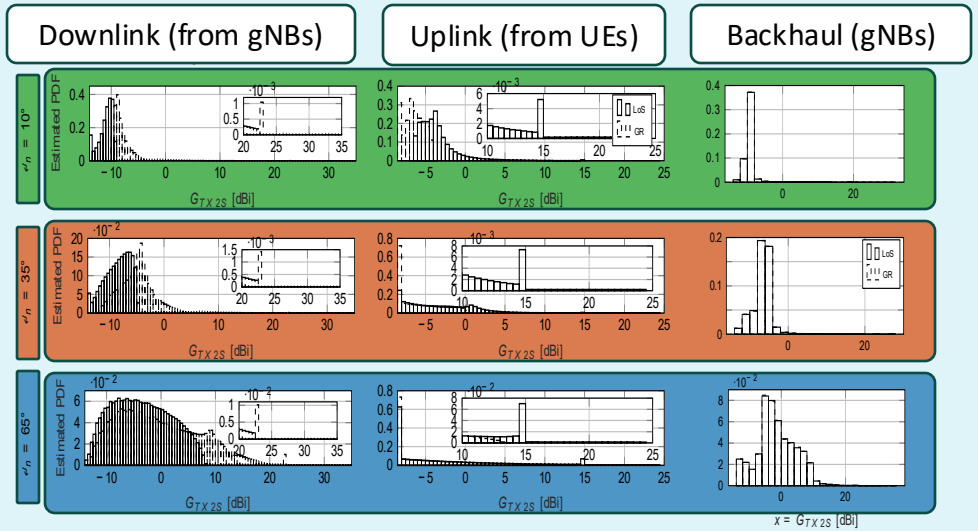


City-scale ground network modeling and RFI (above 100 GHz and in FR-3 for comparison)

Highlights:

- Impact of ground reflection alters RFI geometry
  - Interplay between main lobe steering and ground reflection
- At scale, aggregate RFI from UEs may be harmful
- Path loss, building, and atmospheric attenuation provide the most protection, especially above 100 GHz





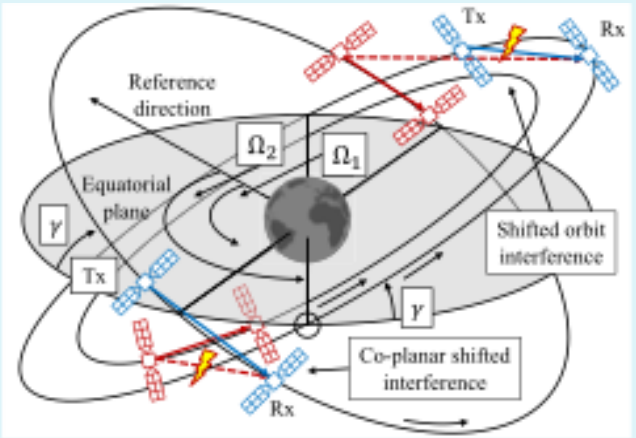
P. Testolina, M. Polese, J. M. Jornet, T. Melodia and M. Zorzi, "Modeling Interference for the Coexistence of 6G Networks and Passive Sensing Systems," in IEEE Transactions on Wireless Communications, 2024
P. Testolina, E. Beshaj, M. Polese and T. Melodia, "Spectrum Sharing Across Terrestrial and Non-Terrestrial Services in the FR3 Upper Midband," IEEE DySPAN, 2025

Cross-link sat-to-sat RFI

Mathematical framework for modeling directional interference in orbital systems

Highlights:

- Analytical model and numerical validation
- Identify regimes where RFI needs to be accounted for despite directionality



S. Aliaga Torrens, V. Petrov and J. M. Jornet, "Modeling Interference From Millimeter Wave and Terahertz Bands Cross-Links in Low Earth Orbit Satellite Networks for 6G and Beyond," IEEE JSAC, 2024

Broader Impacts

Bridging two communities	• Provide learning opportunities across different disciplines • Discuss requirements, pain points, and opportunities for co-design
Outreach	• EuCAP 2025 special session • Led spectrum summer workshop for 38 undergrads from 12 universities in 9 states
Policy	• Participation in American Meteorological Society committee on RF Allocations • Participation in ATIS NextG Alliance Spectrum working group • Feedback in FCC proceedings
Education	• Coursework on spectrum policy at Northeastern University
Future technology	• Tracking system will be used for future THz-based space science missions at Northeastern University

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