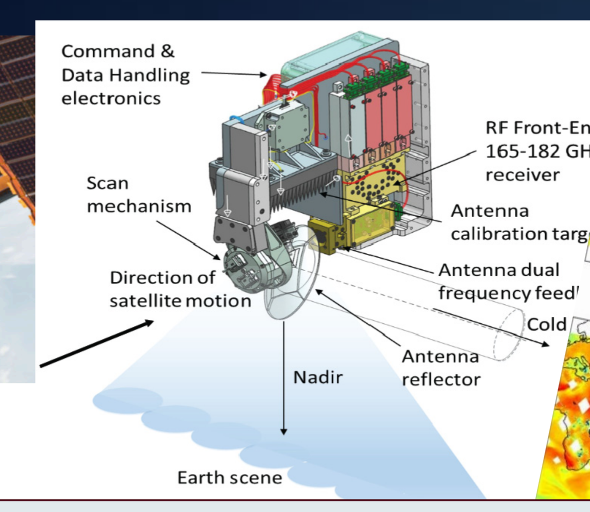
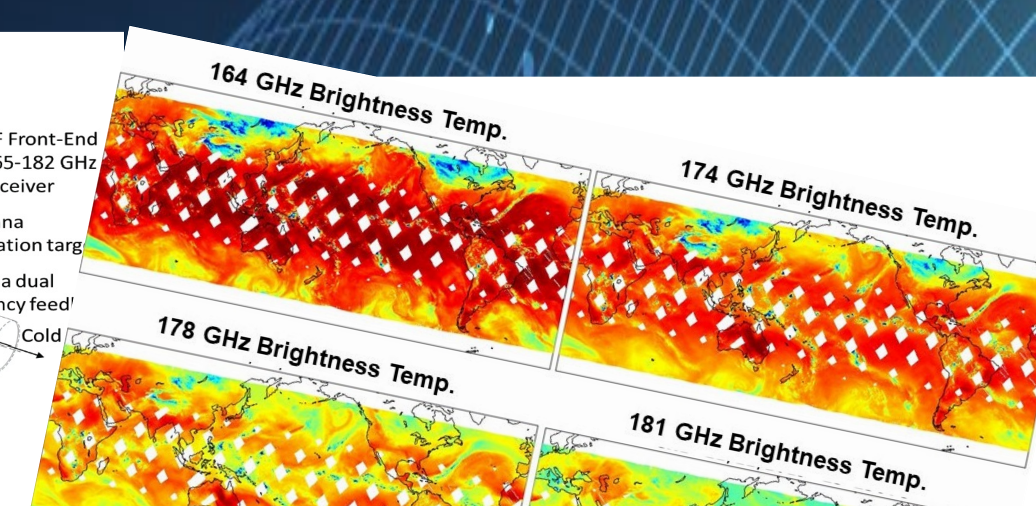
NSF CNS 2332721/2332722 Jan 2024 – Dec 2026

Institute for the Wireless Internet of Things at Northeastern University

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

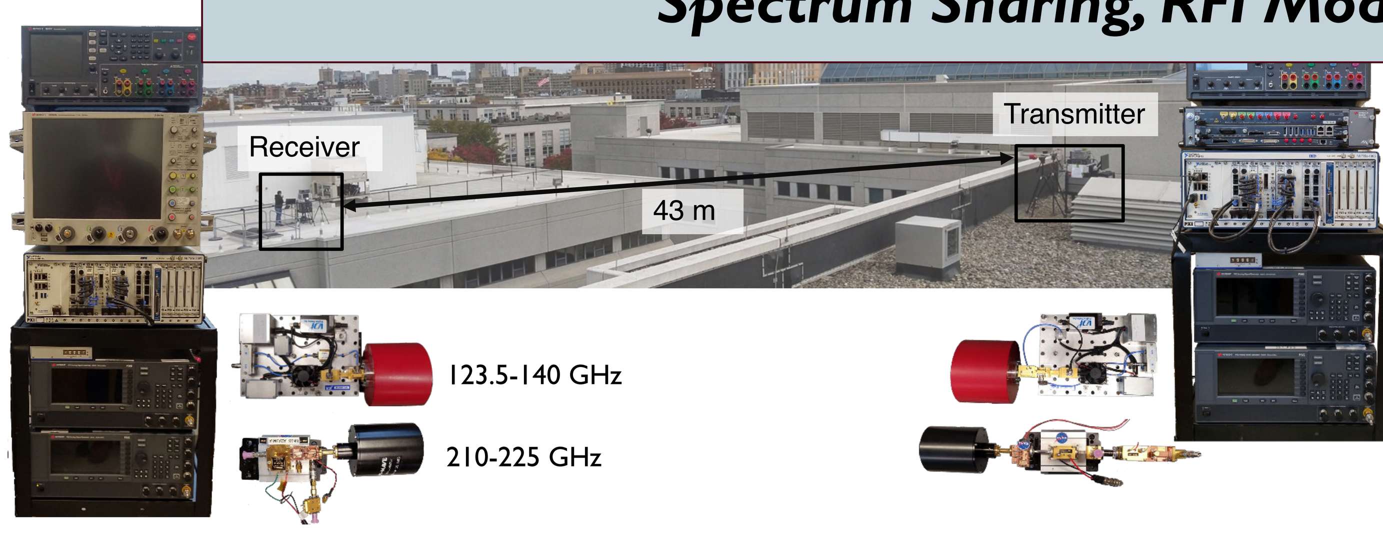


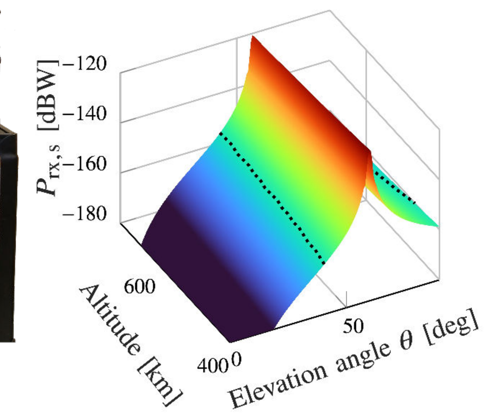


Northeastern University

Josep M. Jornet, Michele Polese, Tommaso Melodia, Michael Marcus, Vitaly Petrov, Paolo Testolina, Ahmad Masihi, and Sergey Petrushkevich

Terahertz Communications and Networks, Spectrum Sharing, RFI Modeling

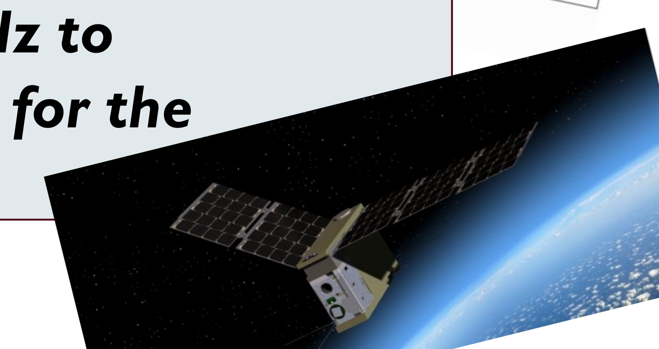




Colorado State University

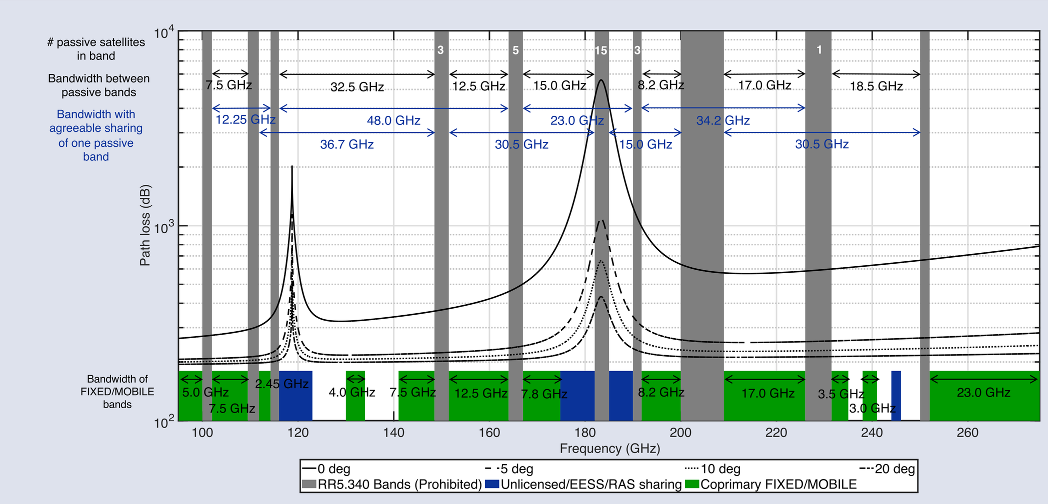
Steven C. Reising and Chandrasekar Radhakrishnan

Passing Sensing instruments from GHz to Terahertz and Observational Algorithms for the Earth's Atmosphere and Oceans



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

Michele Polese, Xavier Cantos-Roman, Arjun Singh, Michael J Marcus, Thomas J Maccarone, Tommaso Melodia, Josep M Jornet, "Coexistence and Spectrum Sharing Above 100 GHz", Proceedings of the IEEE, Vol. 111, No. 8, August 2023

Project Thrusts

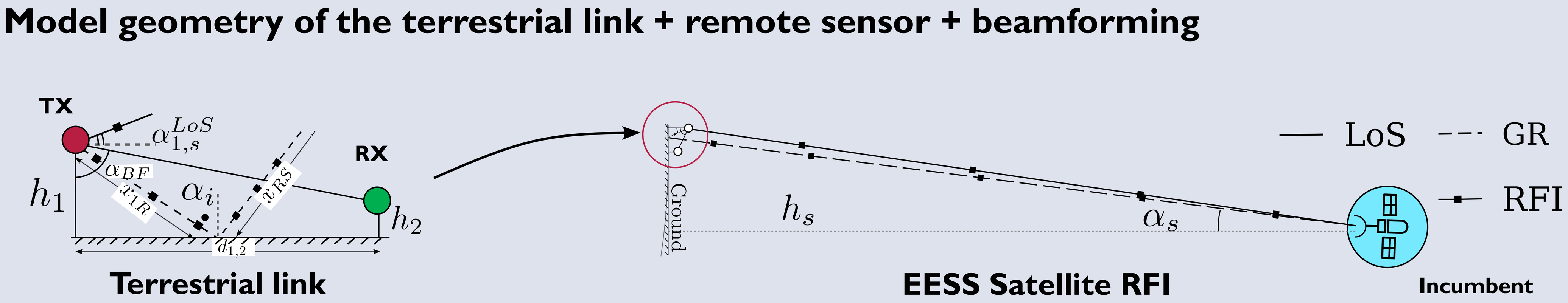
- **Experimental** Evaluation of RFI to the Orbiting **TEMPEST-H8** Sensor
- **RFI Model** from Large-scale Terrestrial 6G Networks and Comparison with Measurements
- **Interference Mitigation** and **Co-Design** of Next-Generation Terrestrial and Satellite Systems

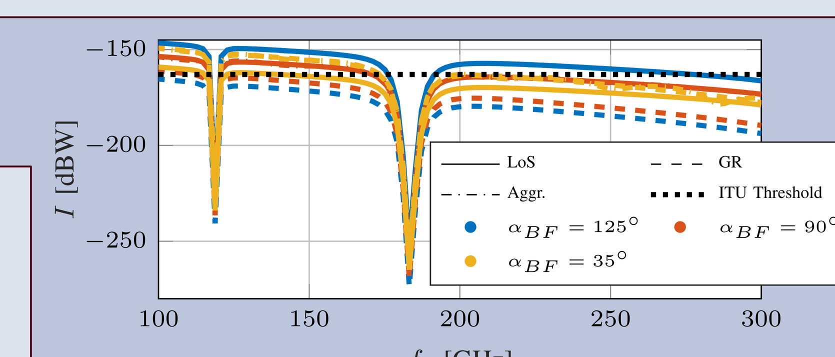
Large Scale RFI Modeling

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, early access

Single-Link Analysis: capture system dynamics in an intuitive framework

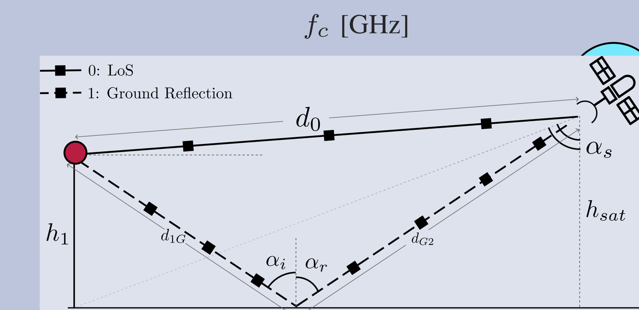
Model geometry of the terrestrial link + remote sensor + beamforming





The Role of Frequency

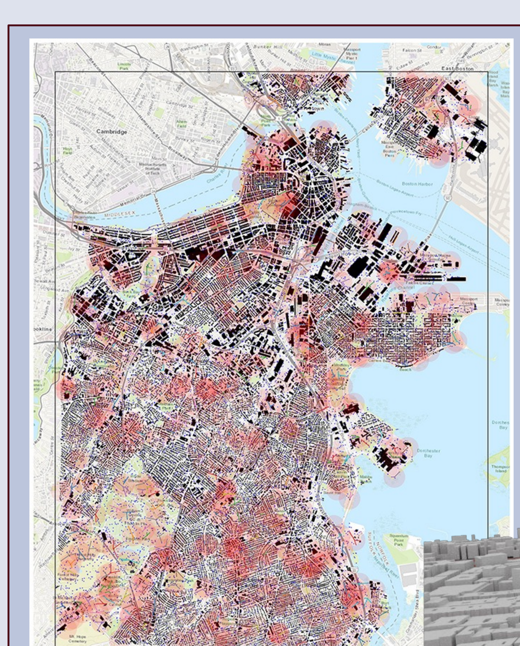
- Atmospheric absorption peaks dominate in some bands
- Difference between free-space and ground reflection around 15 dB



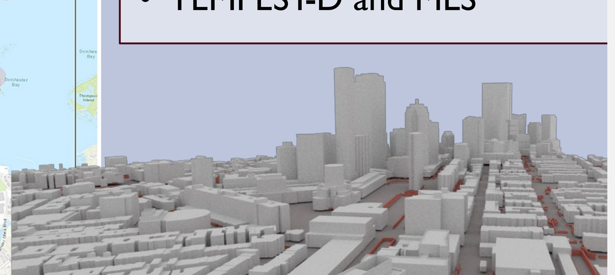
The Role of Beamforming

- The **ground reflection** can be **stronger** than **LoS** if the ground TX beamforming amplifies it, compensating for the reflection loss

City-scale RFI simulations: capture the contributions of thousands of devices



- Data from OpenStreetMap and Boston Planning & Development Agency
- PPP or small cells in real-world positions
- Beamforming and channel models based on ITU specs
- TEMPEST-D and MLS



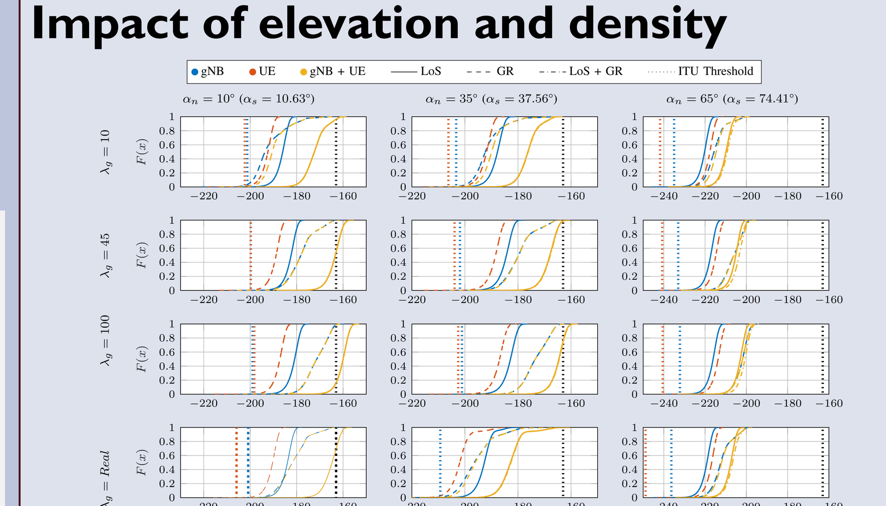
	gNB (Urban/Backhaul)	**UE** (Urban)
P_{TX} [dBm]	10/30	10
G_{MAX} [dB]	35	24.5
θ_{HB} [deg]	3	10
N^{SEC}	3	1
Height [m]	$\{3, 5, 8, 10, 15\}$	$\mathcal{U}([1.6, 1.8])$

TABLE I: Network parameters for the simulation campaign.

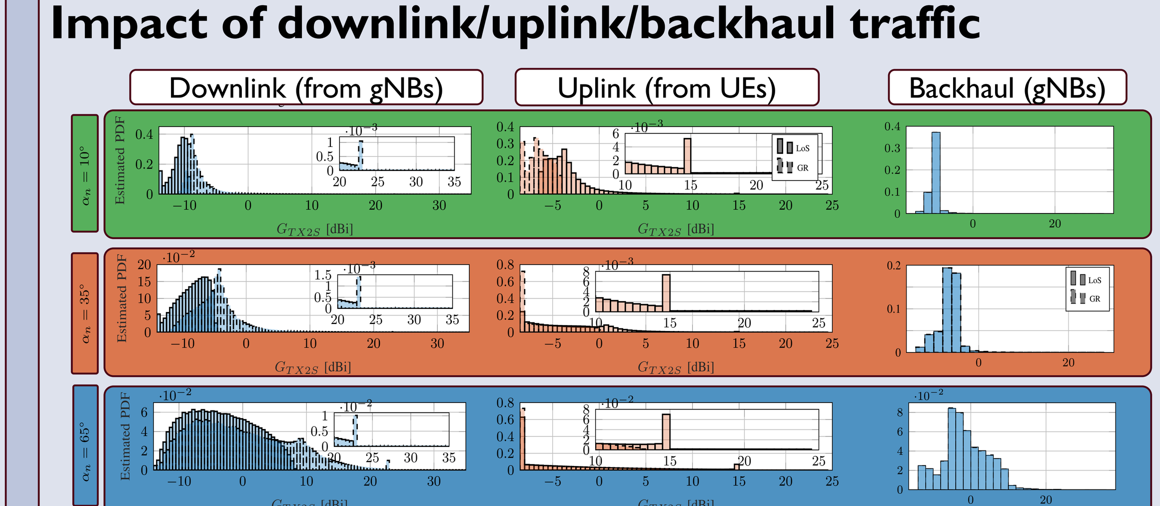
	TEMPEST [8]	Aura MLS [9]
θ_{HB} [deg]	1.68/1.72	0.066 [38]
f_c [GHz]	164/178	240
Altitude [km]	400	705
Scan Mode	Conical	Limb
I_{th} [dBW] [37]	−163	−194

TABLE II: Specifications of the considered satellites.

Impact of elevation and density



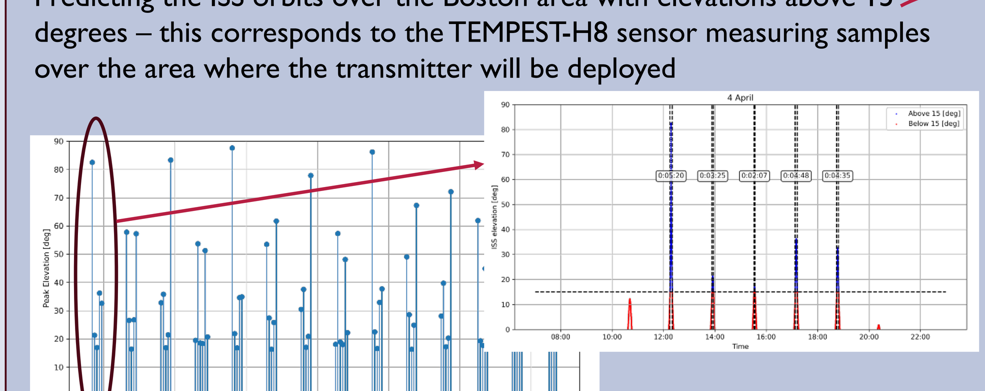
Impact of downlink/uplink/backhaul traffic



Experiment Setup: RFI Characterization at 165 GHz

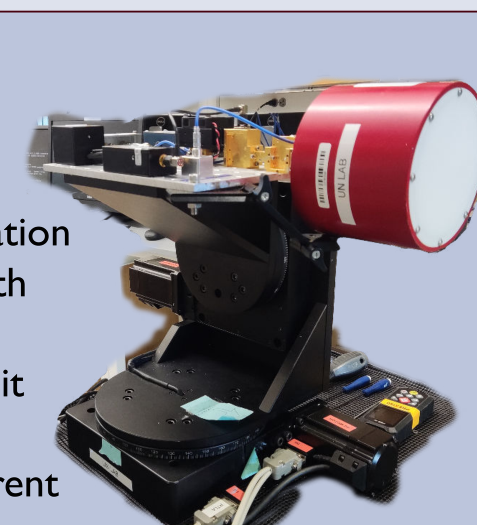
Tracking the TEMPEST-H8 Sensor on the ISS

Predicting the ISS orbits over the Boston area with elevations above 15 degrees – this corresponds to the TEMPEST-H8 sensor measuring samples over the area where the transmitter will be deployed



TeraNova platform automation

- Rotating plane in azimuth and elevation
- APIs that match ISS orbit
- Different backend waveforms to test different RFI profiles

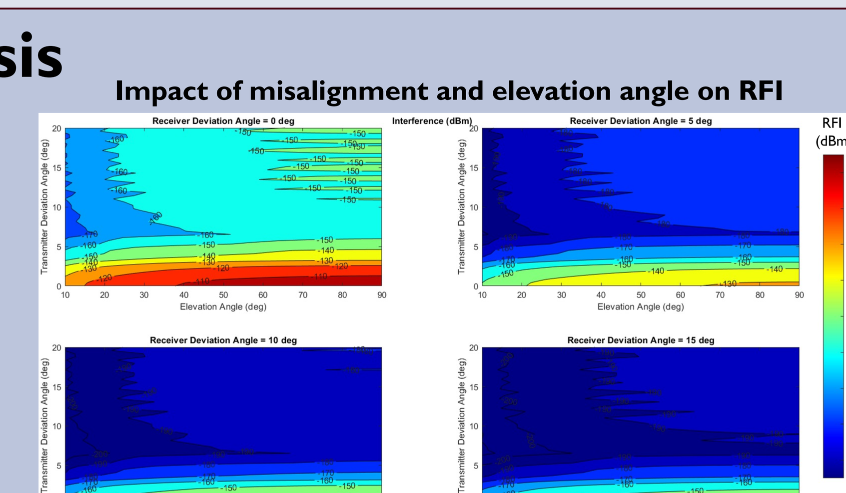


Link Budget Analysis

Profile received power at EESS sensor (a.k.a. RFI)

- Understand TX power and TX antenna gain configuration
- Profile loss due to misalignment during tracking
- Avoid damaging the sensor by remaining within safe operating conditions

Impact of misalignment and elevation angle on RFI



TX pattern based on antenna manufacturer datasheet

Info: m.polese@northeastern.edu