INtegrated Testbed Ensuring Resilient Active/Passive CoexisTence (INTERACT): End-to-End Learning-Based Interference Mitigation for Radiometers

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National Science Foundation

Award # 2332661, 2332662

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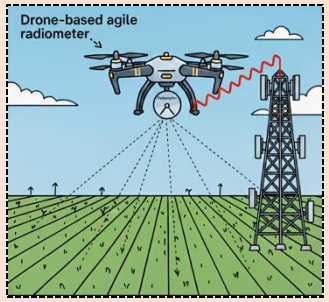
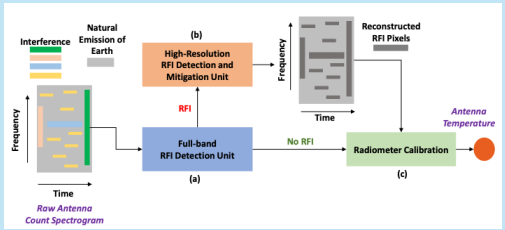
MISSISSIPPI STATE UNIVERSITY

Overall Project Objectives

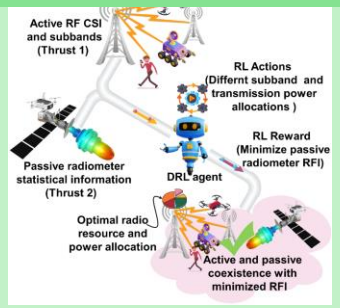
Thrust 1: Mid-band SDR-Based Agile Radiometer Development, Digital Twin and Controlled Testbed with AERPAW



Thrust 2: Joint End-To-End Frameworks for RFI Detection, Mitigation and Calibration for Radiometers



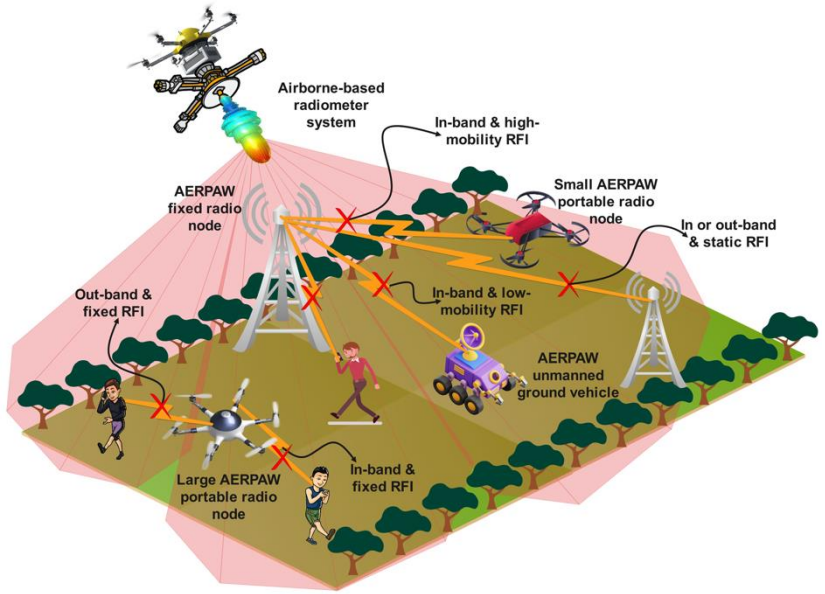
Thrust 3: Deep Reinforcement Learning-based RFI Mitigation with Feedback Between Active and Passive Systems



Two primary goals:

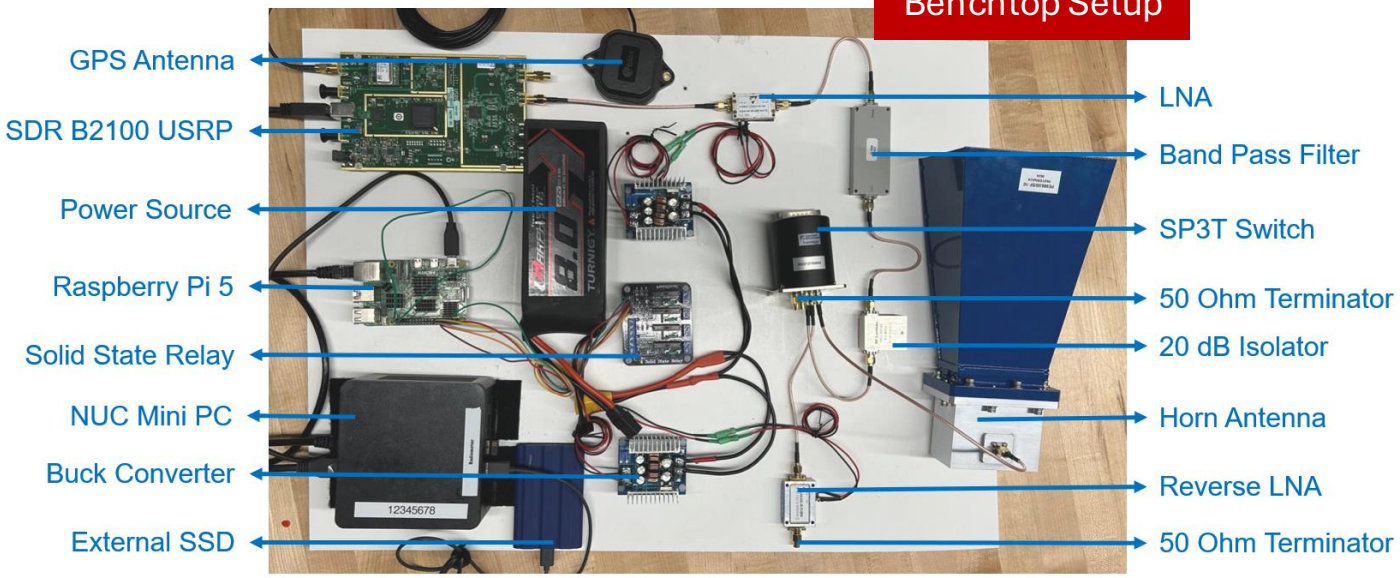
(1) Developing a publicly available dataset for RF active/passive coexistence that includes ground truth information. This will be accomplished by creating an airborne microwave passive radiometer system and implementing a range of interference scenarios using NSF-AERPAW testbed.

(2) (2) Developing data-driven, end-to-end learning-based approaches for RFI detection and mitigation.



S-Band (3.2 – 3.6 GHz) Radiometer

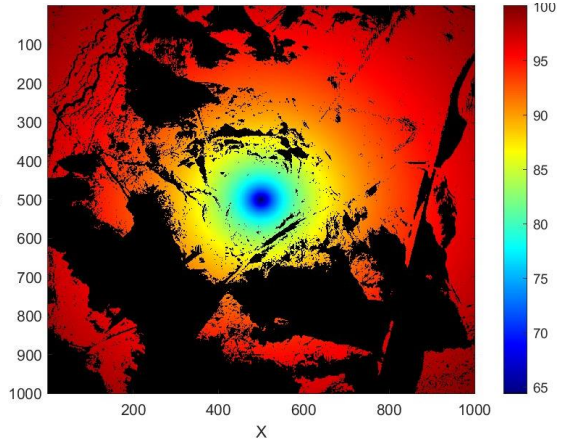
Benchtop Setup

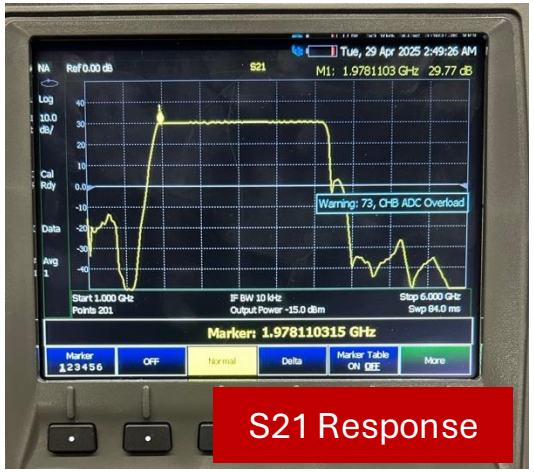


Radiometer Payload with Custom UAS

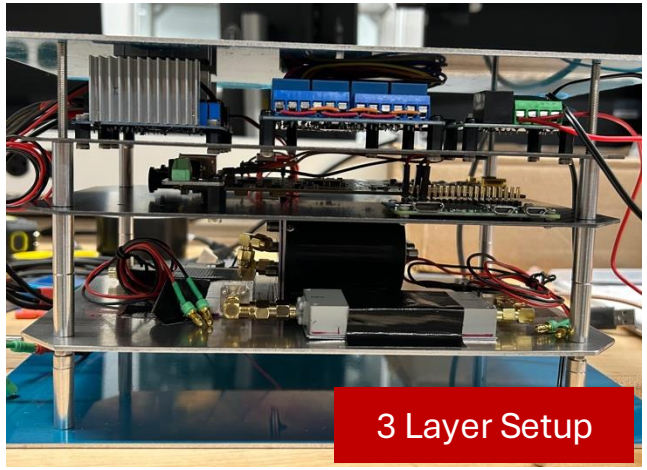
Passive Digital Twin

Free-Space Path Loss





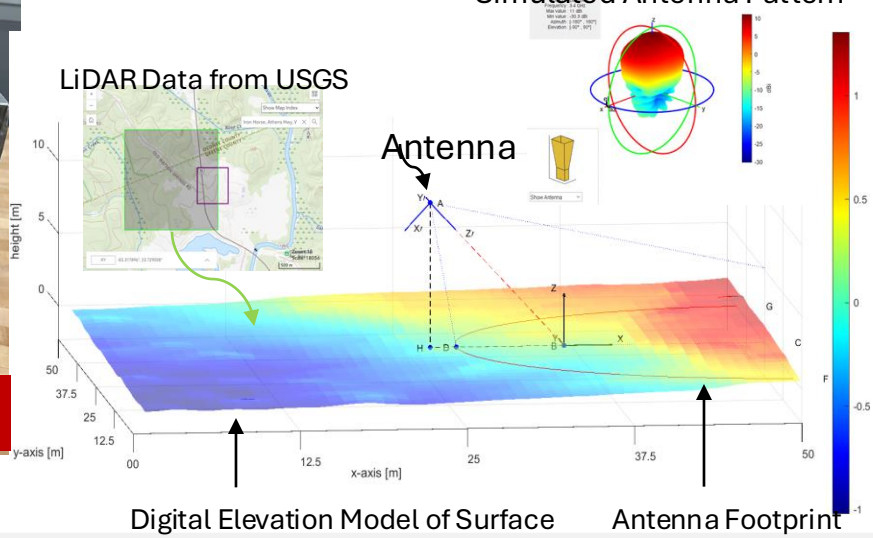
S21 Response



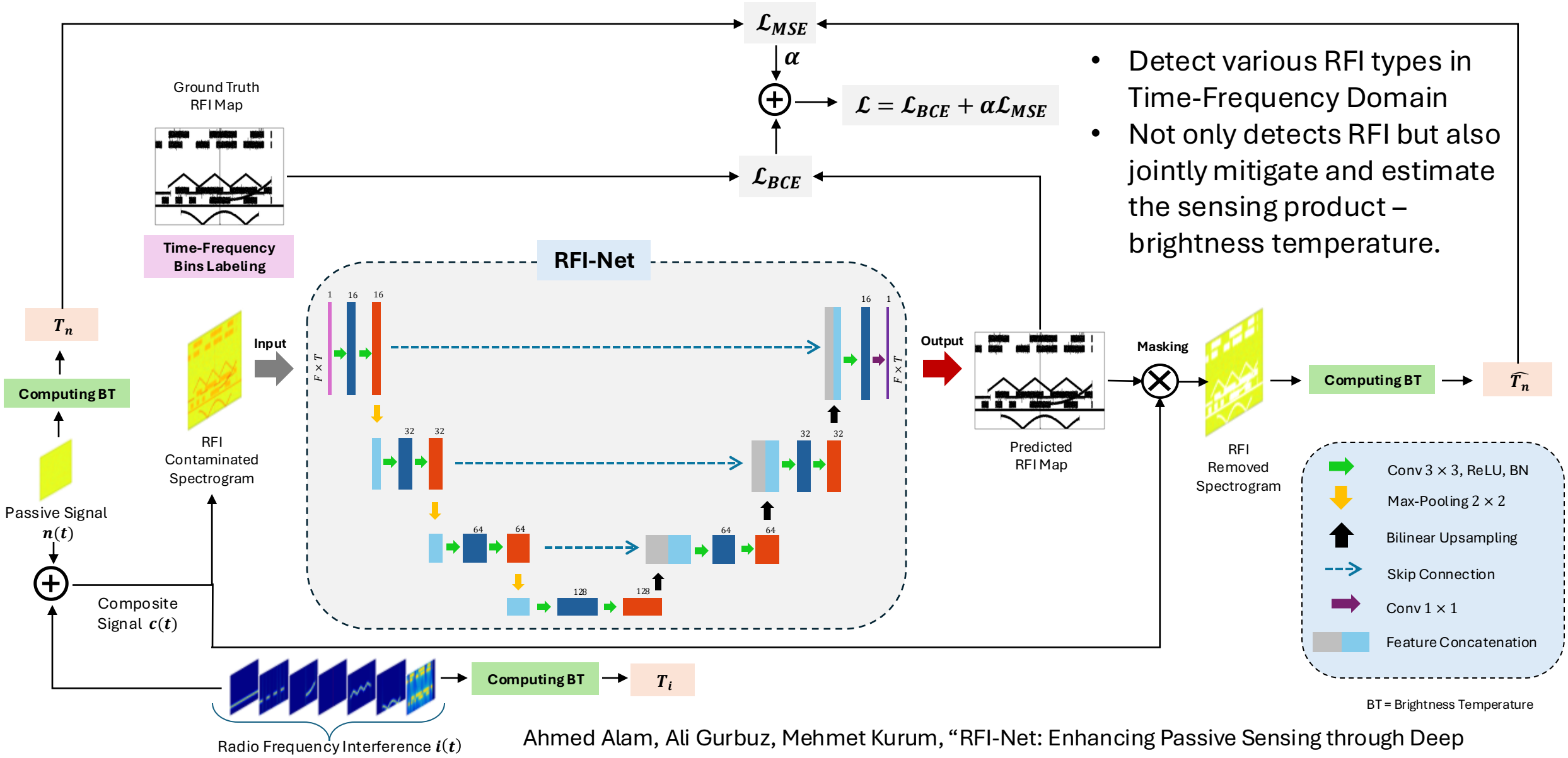
3 Layer Setup

EM Absorber Box

Simulated Antenna Pattern



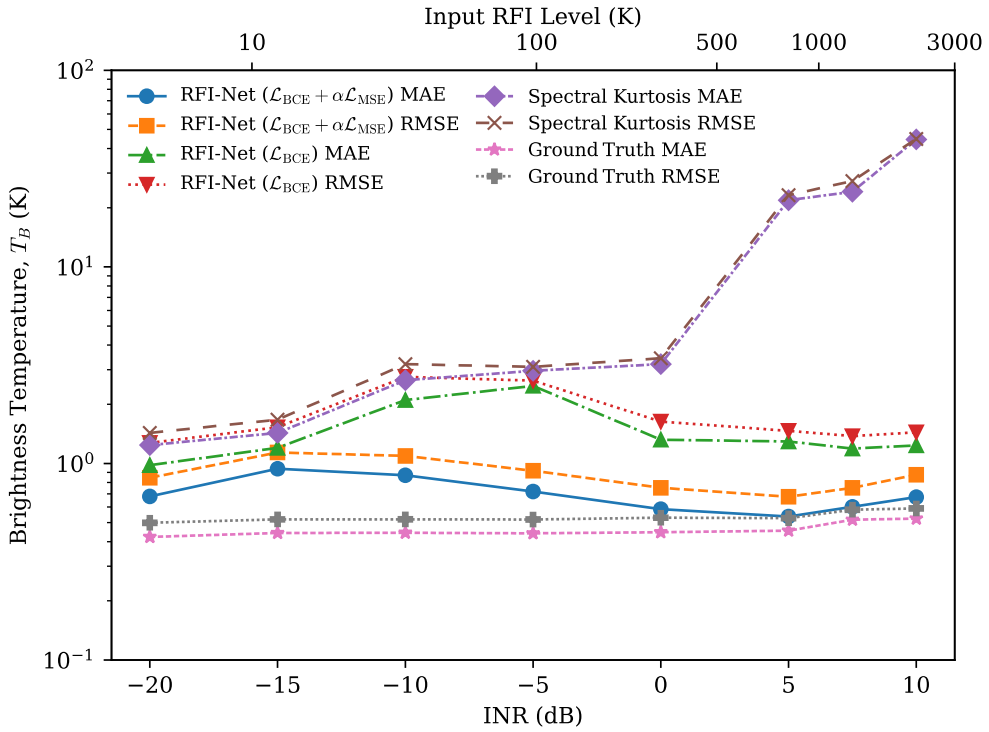
RFI-Net: RFI Detection and Mitigation



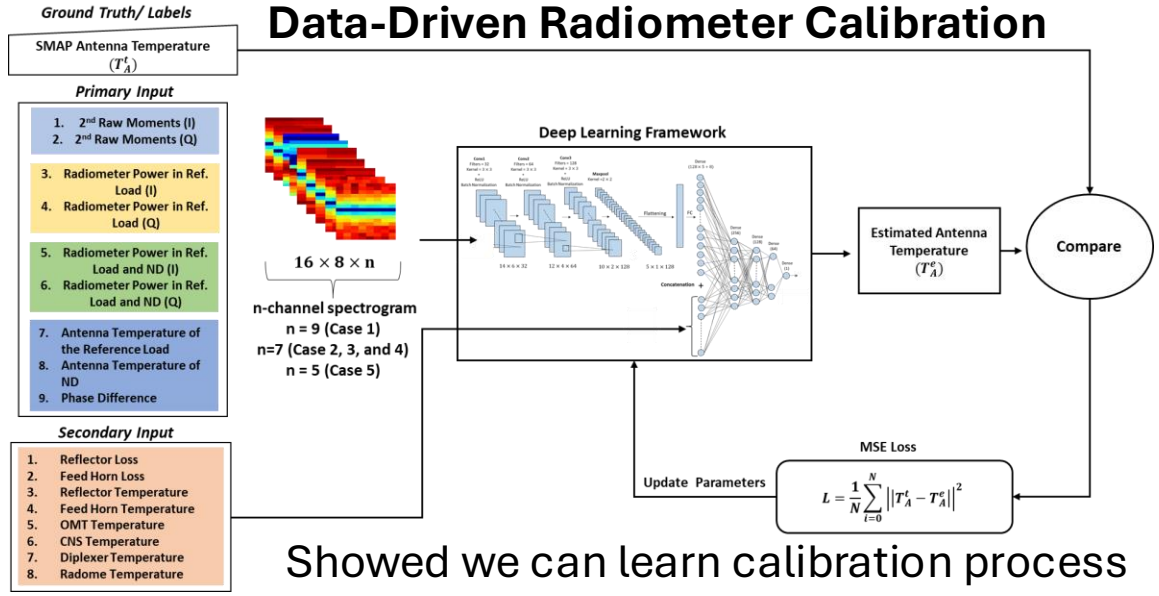
- Detect various RFI types in Time-Frequency Domain
- Not only detects RFI but also jointly mitigate and estimate the sensing product – brightness temperature.

Ahmed Alam, Ali Gurbuz, Mehmet Kurum, "RFI-Net: Enhancing Passive Sensing through Deep Learning Based Time-Frequency Domain Radio Frequency Interference Detection and Mitigation" IEEE Transactions on Geoscience and Remote Sensing, submitted , 2025

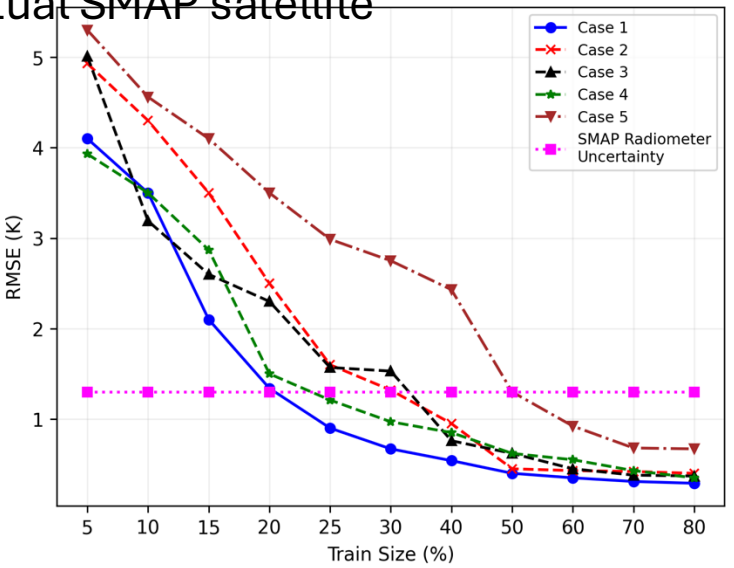
RFI-Net Performance and Radiometer Calibration



Data-Driven Radiometer Calibration

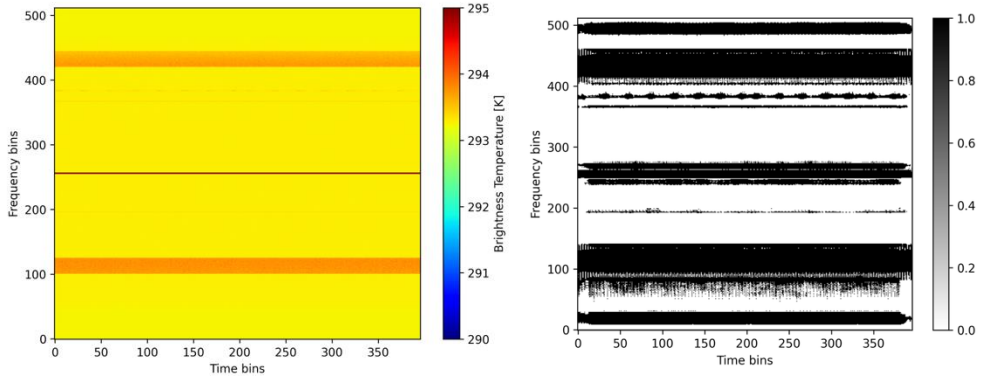


Showed we can learn calibration process of actual SMAP satellite



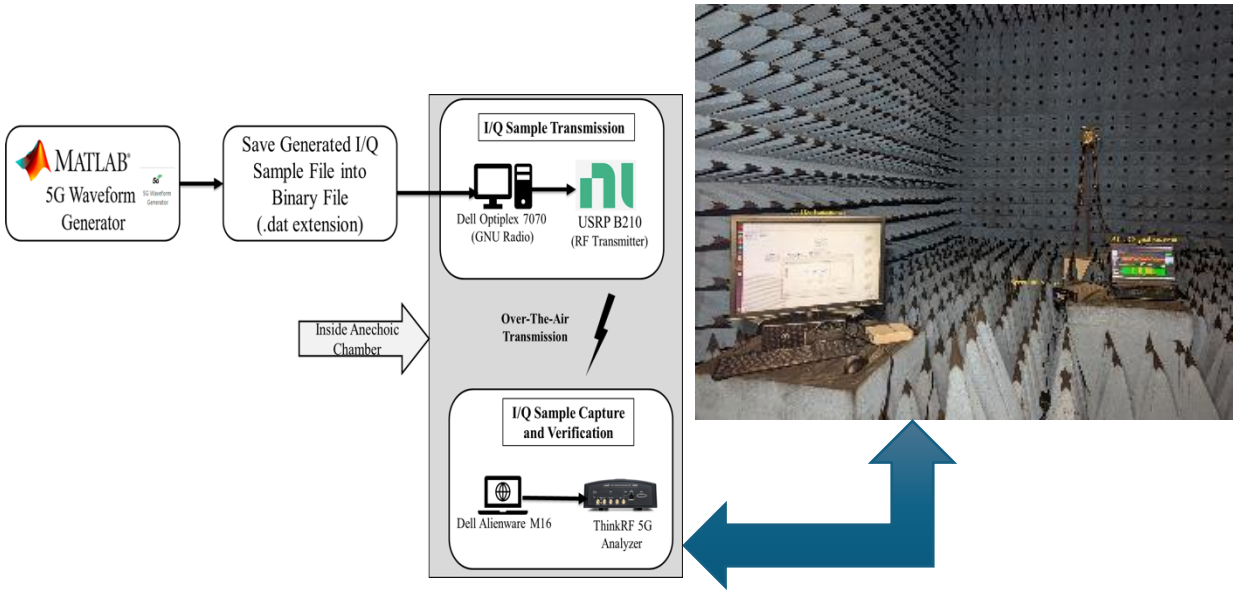
Mitigation of 5G RFI on Experimental Radiometer testbed data – Model Trained on Simulated RFI directly applied to expremintal data

RFI Absolute Error = 0.96 K



A. M. Alam, M. Kurum, M. Ogut and A. C. Gurbuz, "Microwave Radiometer Calibration Using Deep Learning With Reduced Reference Information and 2-D Spectral Features," in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, vol. 17, pp. 748-765, 2024

5G NR Transmission and Verification



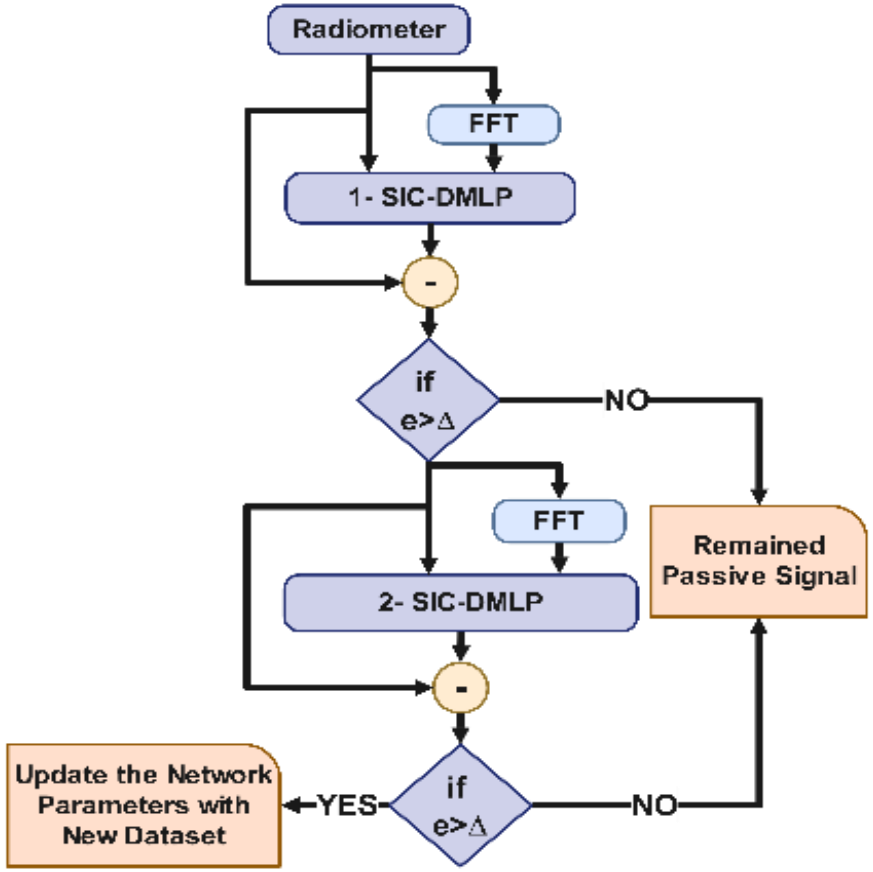
5G Signal Generation:

- Custom I-Q samples.
- Transmission via USRP B210 and GNU Radio on Dell Optiplex 7070.

Verification:

- I/Q Sample captured via 5G Real-time Spectrum Analyzer interfaced with Alienware M16 in anechoic chamber.

RL-Assisted Spectrum Reconstruction



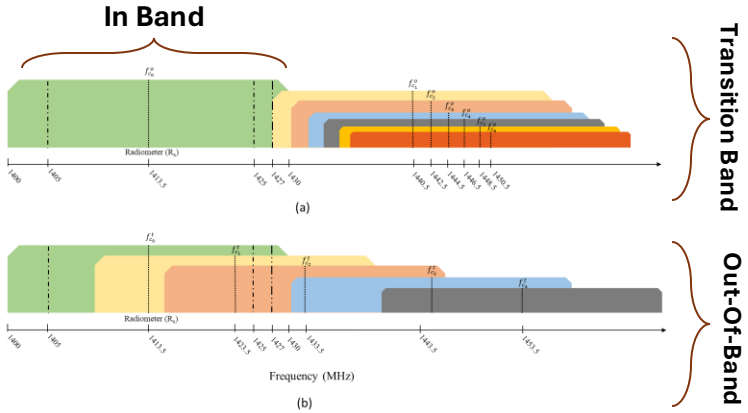
Broader Impacts

- Disseminated achieved results in conferences such as IEEE IGARSS, URSI Radio Science Meeting, IEEE DySpan
- Three PhD students are involved and contributed to active/passive spectrum coexistence area.
- One UGA and one NCSU teams contributed to AERPAW Autonomous Data Mule (AADM) Challenge. Joined 2025 CyberPowder Fellows Program
- Delivered invited lectures on spectrum recycling at the IEEE-GRSS Soil Moisture School, held at the Budapest University of Technology and Economics (BME) in Budapest, Hungary

Experimental Dataset for Active/Passive Coexistence

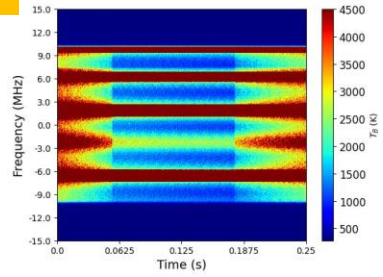
Independent Variables in Experiment Campaign:

- Transmission Bands
- Power Gains
- Modulation Techniques
- Resource Block Group Allocations
- Duty Cycles

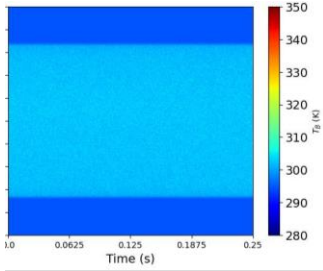


Open-Source Dataset [GitHub Link]

RFI



No RFI



Ground Truth Fully calibrated High-Resolution Spect
Brightness Temperature (T_B)

A. M. Alam et al., "A Physical Testbed and Open Dataset for Passive Sensing and Wireless Communication Spectrum Coexistence," in IEEE Access, vol. 12, pp. 131522-131540, 2024