



Radio Frequency Interference Monitoring System (RFIMS)

Program to Support Spectrum Sharing

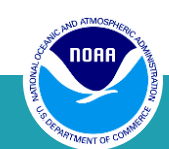
National Environmental Satellite,
Data, and Information Service

November 14, 2024

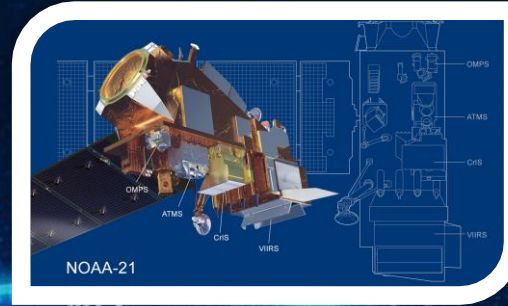
Jonathan Terrell, RFIMS Project Manager

Agenda

- Provide historical project background
- Problem Statement
- Challenge to detect, identify and notify
- Acquisition approach
- Review Concept of Operations (CONOPS)
- Operational Use Scenario
- RFIMS Enhancement
 - Artificial Intelligence (AI) & Machine Learning (ML)
- Future of RFIMS and spectrum Sharing
- Lessons learned with conclusion



Space is a busy place

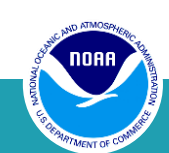


-  USA
-  FRANCE
-  NOAA
-  EUMETSAT
-  EUROPEAN COMMISSION
-  NATIONAL SPACE ORGANIZATION (NSPO)
-  EUROPEAN SPACE AGENCY
-  NASA
-  DEPARTMENT OF DEFENSE



Background

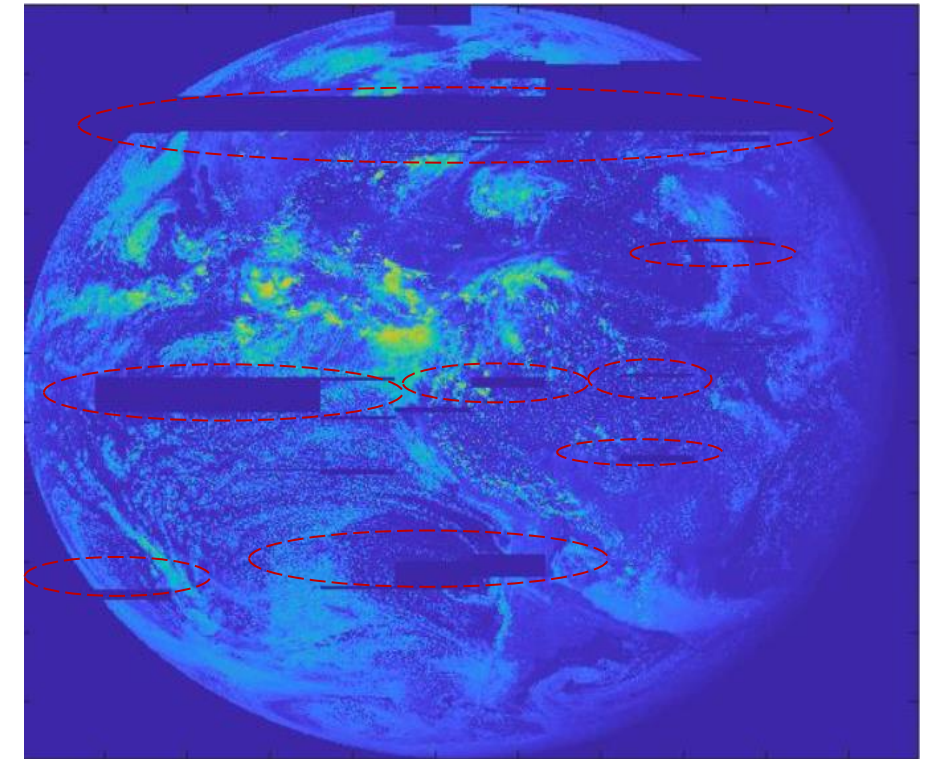
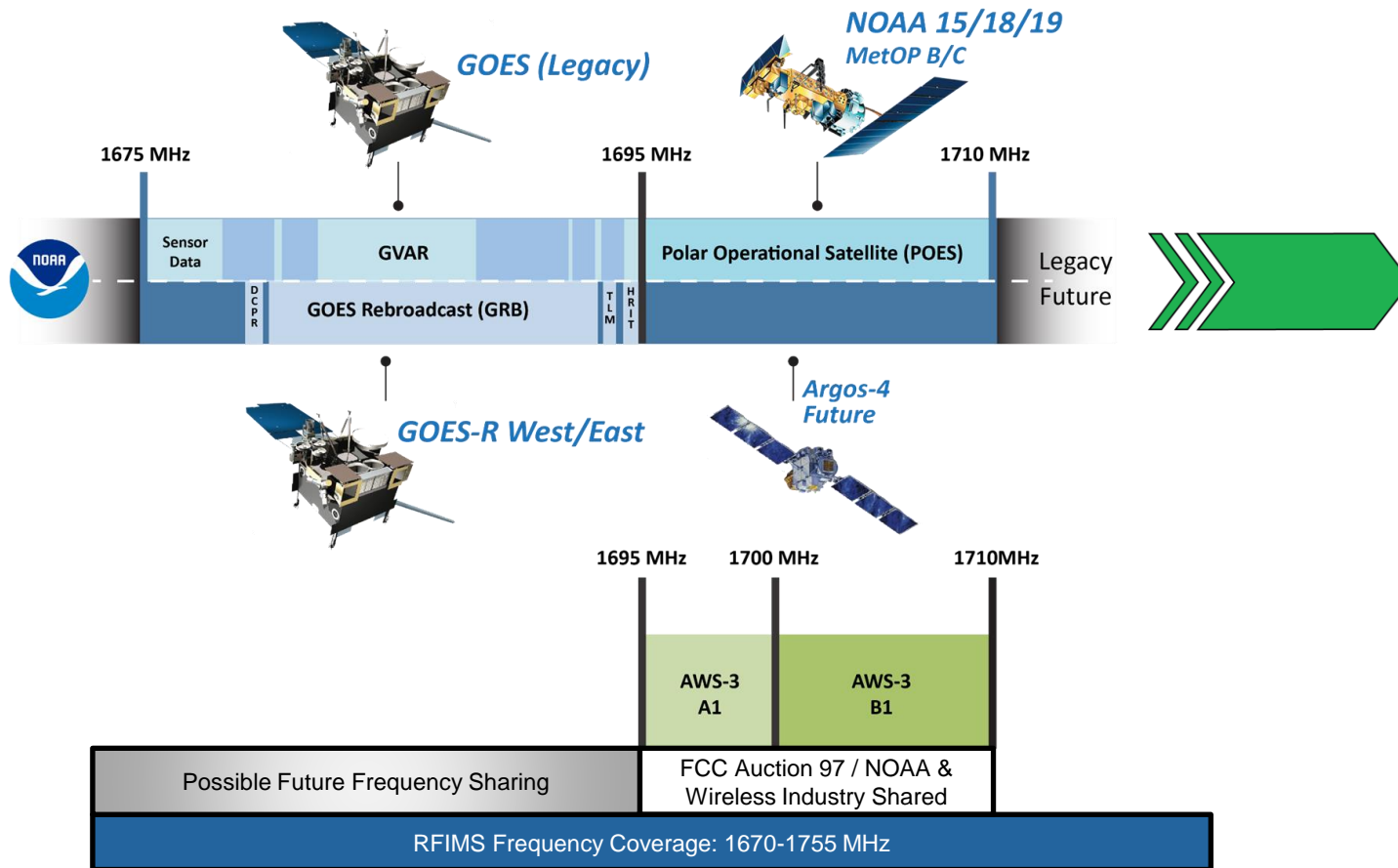
- In January 2015, the Federal Communications Commission (FCC) auctioned AWS-3 licenses requiring NOAA to share the 1695-1710 megahertz (MHz) frequency band with wireless licensees.
- This created a risk that mobile communications user equipment (UE) could interfere with meteorological reception at NOAA earth stations.
- NOAA invested to develop the RFIMS to monitor the shared and adjacent frequency bands for radio frequency interference (RFI).
- The RFIMS detects, classifies, identifies and notifies NOAA operators and wireless licensees when UEs create RFI at NOAA earth stations.



RFIMS Problem Statement

Driving Factor: Frequency band sharing between MetSat downlinks & wireless carrier uplinks

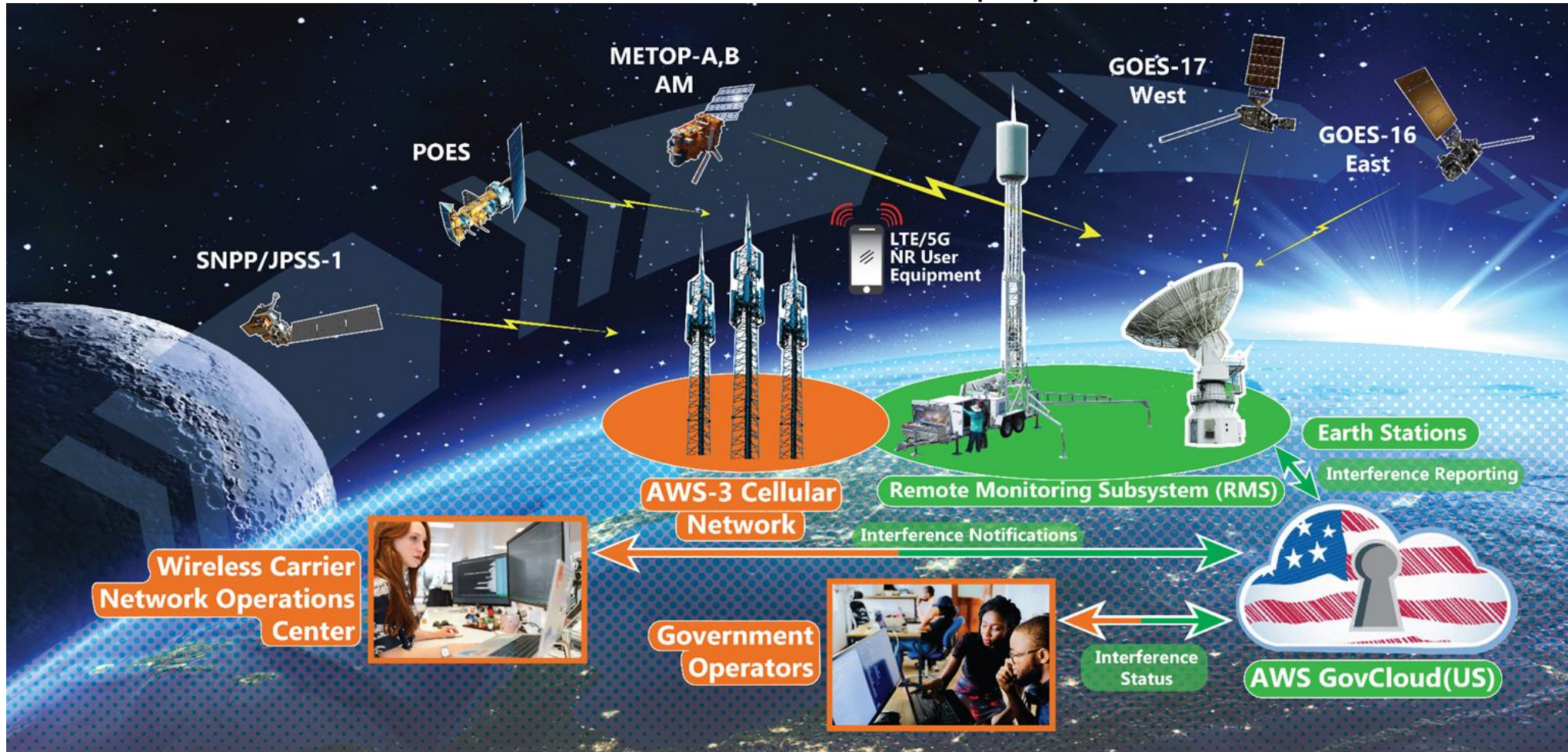
Problem Statement: UE uplink transmissions could interfere with NOAA's ability to receive MetSat downlink



RFIMS supports spectrum sharing between Government and Commercial Wireless Carriers

Sharing the Spectrum

- The Remote Monitoring Subsystem (RMS) and Centralized Monitoring Subsystem (CMS) are the RFIMS's two main subsystems.
- The CMS exists in the AWS GovCloud and RMS units are deployed at earth stations to monitor for RFI.



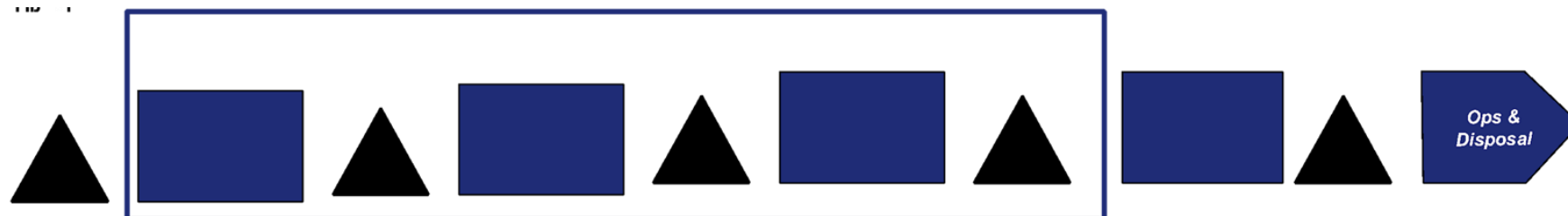
Challenge to Detect and Extract Interference Source Characteristics

- DOC Transition Plan identified 17 NOAA Federal earth stations to be protected with a interference monitoring solution
- This spectrum sharing agreement represented the first time NOAA would share frequencies with non-federal users
- No commercial off the shelf technology existed to meet the monitoring objectives and a customized development effort was required
- Detailed requirements were not available at the start of the project driving a complex acquisition strategy
- Exchange with wireless Licensees introduced new requirements throughout the project development phase



RFIMS Project Initiation

- Two-phased acquisition approach selected to minimize technical risk
 - Perform initial NRE to define system requirements
 - Conduct full and open competition to develop production system
- Interagency agreement (IAA) established with NTIA ITS and NRE contract issued to FFRDC Aerospace to study the problem of interference at the NOAA Earth Stations and provide input to requirements / objectives development for production systems
 - Established Table Mountain Test Range (TMTR) testbed to characterize likelihood and impact of interference along with effectiveness of monitoring solutions
- Discussions were held with Wireless Licensees to understand network roll-out plans

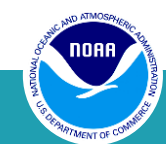


Project established utilizing tailored approach to DoC Scalable Acquisition Project Management Framework

RFIMS Production System Market Analysis

- Released two RFI's to evaluate industry capabilities and approaches, along with potential existing sourcing vehicles
 - April 2015 –Nine (9) vendor responses
 - May 2016 (including Q&A) –Twelve (12) vendor responses
- Two Industry Days held
 - One-on-one face-to-face meetings offered to each vendor to describe their capabilities, ask questions, and discuss potential solutions to meet the government's needs
 - Much of the expertise was in the intelligence community
- Vendor site visits and demonstrations were completed with L3Harris and LGS
- Effective competition was deemed to exist based on the results of market research and input from industry experts

Market research showed that there was no existing industry capability to detect, classify, identify, and notify carriers of radio frequency interference but competition for development existed



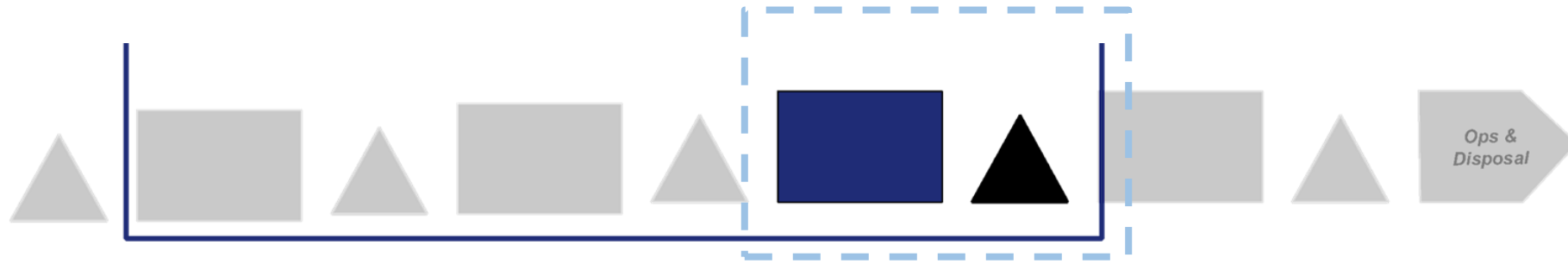
RFIMS Acquisition Strategy

- Due to the lack of existing technology and uncertainty in requirements, a full and open competition with an initial contract exploration phase was the most viable acquisition approach
- Detailed requirements were not available at the start of the project, and a Statement of Objectives (SOO) was used to outline the high-level goals, objectives, and functional requirements for the system
- An acquisition strategy using a multi-award approach was used to mitigate technical risk
 - Awarded concept exploration phase to two contractors
 - Integrated assessment was performed at the conclusion of concept exploration phase and recommendation was made to continue with both vendors into the proof-of-concept / demonstration phase
- Defined a CLIN structure utilizing options as a method to monitor the progress and control the expenditure of Government funds under a cost-reimbursement contract
- Department of Interior (DOI) leveraged NOAA-funded RFIMS development investment and contract vehicle in an assisted acquisition to procure four systems

Due to the research and development nature of the RFIMS project, a phased developmental approach was employed



Production and Deployment Phase

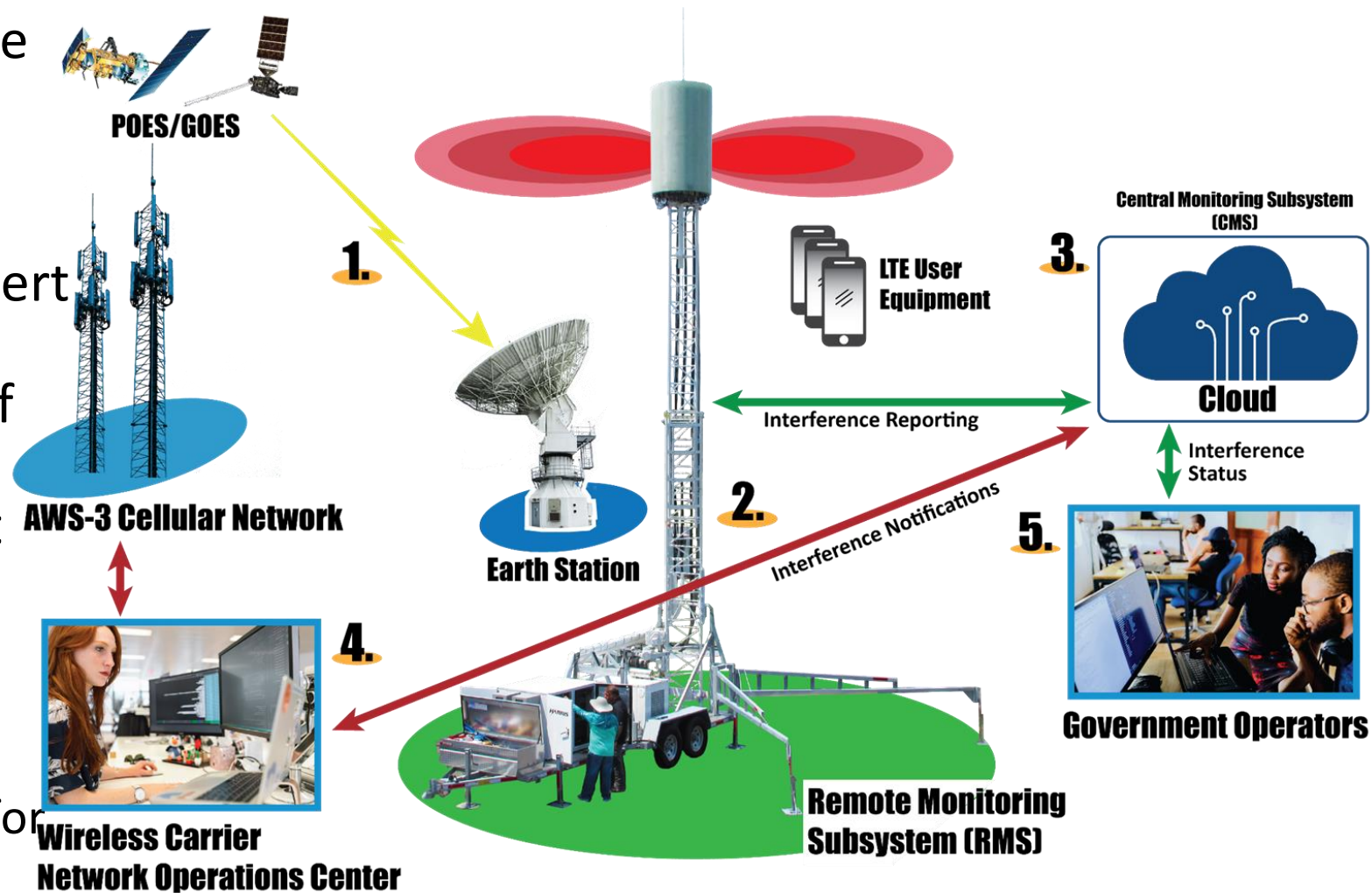


- A Test and Evaluation Master Plan (TEMP) was developed and utilized to define test objectives and criteria to be conducted at each phase of the project
- L3Harris and LGS both developed prototypes to demonstrate detection, classification, identification, and notification capability through a high-fidelity prototype in a practical RF interference environment
- An independent technical readiness level (TRL) assessment was performed by an FFRDC to verify technical maturity at the conclusion of the proof-of-concept/demonstration phase prior to exercising any production CLINs
- An integrated assessment report was produced and provided to the contracting officer based on both technical and programmatic performance criteria, down-selecting a single vendor, L3Harris, for the installation and deployment phase

RFIMS used a tailored approach with incremental production reviews for two low-rate production phases due to delays in Licensee network roll out

Final Design - Operational Use Scenario

1. Earth station receives the satellite signal.
2. RMS detects, classifies and identifies UE RFI.
3. RMS logs RFI events and sends alert messages to the CMS.
4. CMS will notify wireless carrier of RFI.
5. NOAA operators will review alert messages for certain situations.
 - RFI is not directly attributable to a wireless carrier and requires additional technical analysis.
 - NOAA technical staff retrieve data from the RMS use analytical tools for further analysis.



CMS Analysis Capability

Central Monitoring System (CMS) is cloud-based capability that consolidates RFI events from the RMS. Spectrograms, like the image on the left, allow further RFI analysis.

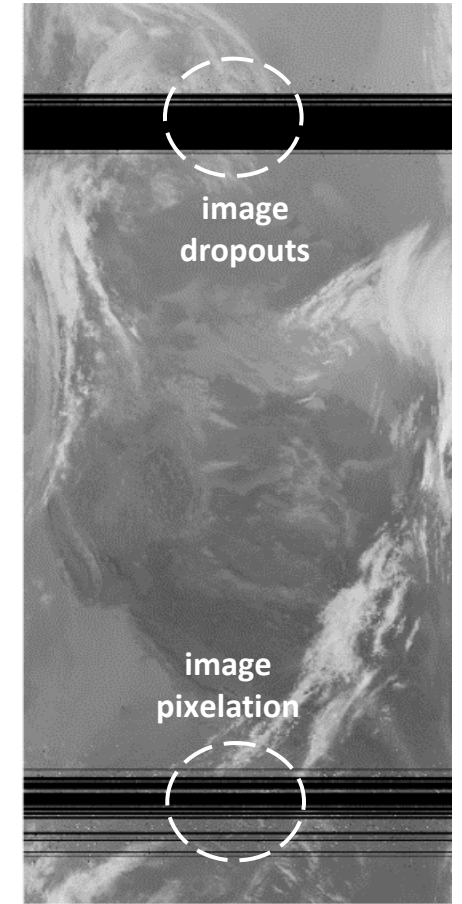
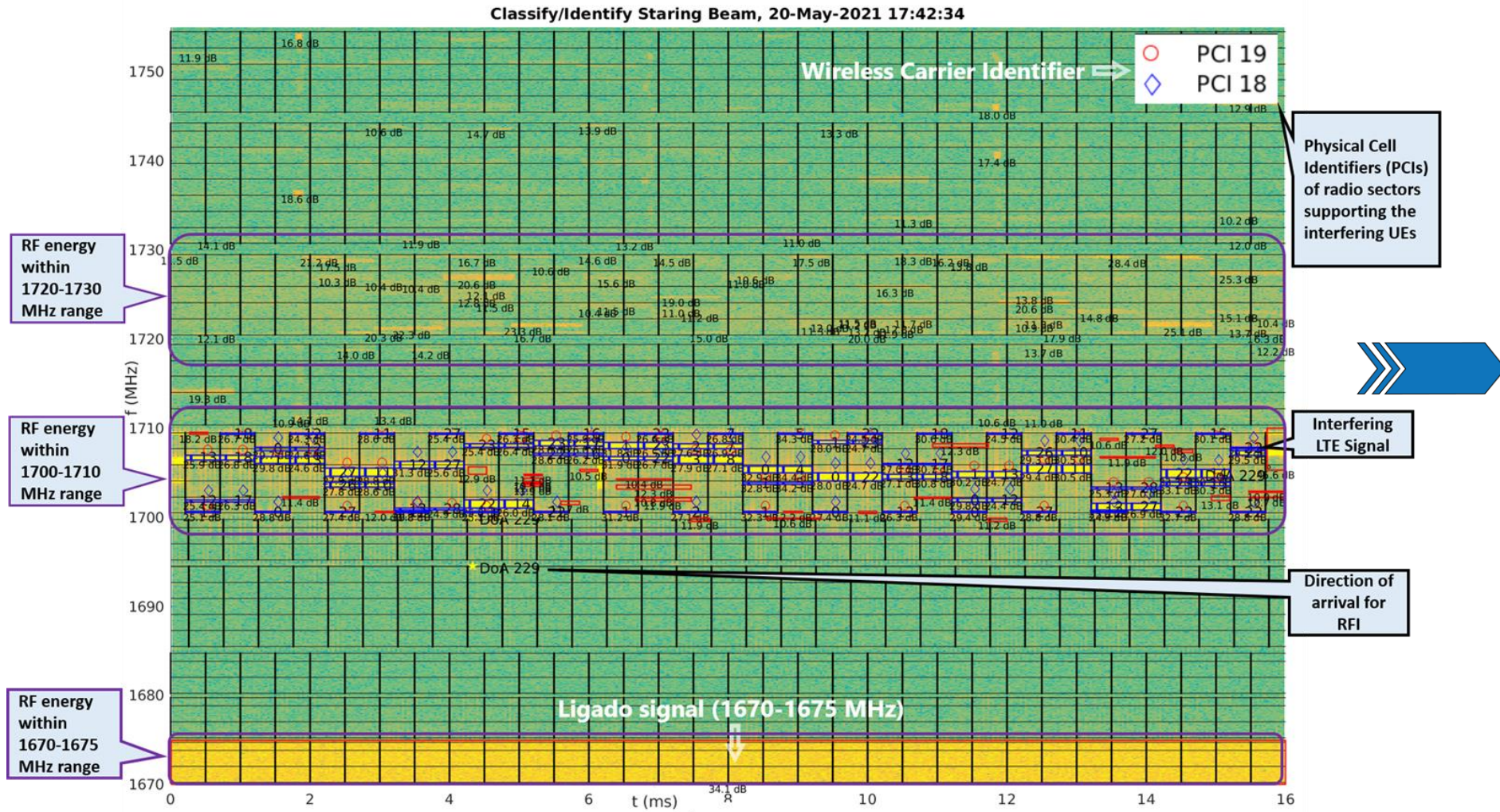


Image from polar satellite system showing RFI to reception from an emulated LTE UE signal.

- Shows physical cell identifiers for radio site sectors of UEs creating RFI to a received NOAA-19 image.
- Identifies non-LTE or non-5G RFI signals interfering with earth station reception (e.g., Ligado Networks RFI).

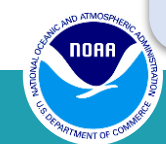


Artificial Intelligence and Machine Learning Future Enhancements



Proof of concept of external AI/ML enhancements enable closed-loop correlation between RFI events detected by RFIMS and satellite mission data degradation

| image name | error type | start pixel | end pixel | start time frame | end time frame |
|-------------------|------------|--------------|--------------|---------------------|---------------------|
| 20210520173030n01 | point | (1857, 3654) | (1857, 3654) | 2021-05-20 17:40:39 | 2021-05-20 17:40:39 |
| 20210520173030n01 | point | (1857, 3655) | (1857, 3655) | 2021-05-20 17:40:39 | 2021-05-20 17:40:39 |
| 20210520173030n01 | point | (1857, 3656) | (1857, 3656) | 2021-05-20 17:40:39 | 2021-05-20 17:40:39 |
| 20210520173030n01 | point | (1864, 3667) | (1864, 3667) | 2021-05-20 17:40:41 | 2021-05-20 17:40:41 |



RFIMS Supports the Future of Spectrum Sharing

CHALLENGES

Spectrum scarcity will result in increased sharing between federal and non-federal users

Expanding terrestrial cellular network traffic increases the risk for interference to mission data

Limitations in spectrum sharing policy and experience requires new technologies

RFIMS BENEFITS

Advances development of spectrum sharing technology and policy

- ❑ Phased array coverage, sensitive, real-time system
- ❑ RFI attribution for mitigation

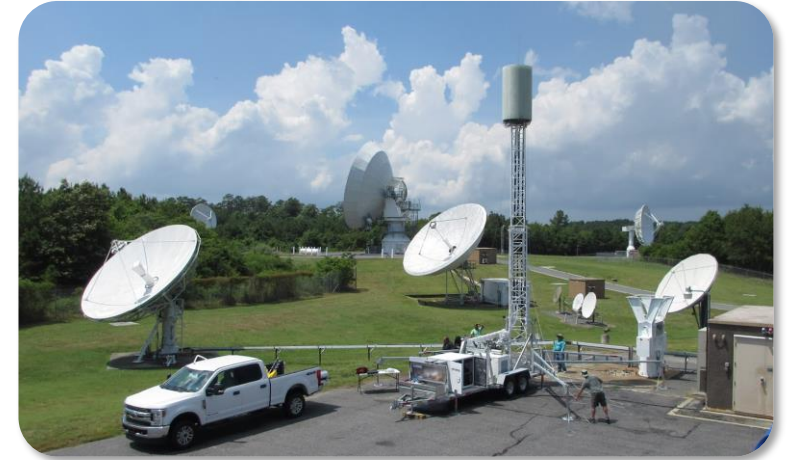
Scalable to support the future of dynamic spectrum sharing with additional interfaces to victim receivers and wireless network operations center

Spectrum Sharing Test Range and Lab, Table Mountain, CO



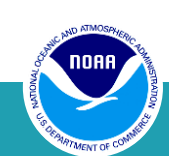
Future of RFIMS

- Limitations in spectrum sharing policy and experience and expanding terrestrial cellular network increase need for interference monitoring
- RFIMS can enable spectrum sharing policy through independent arbitration between commercial wireless users and government operators
- RFIMS is currently a stand alone, real-time system which is scalable to support the future of dynamic spectrum sharing with additional interfaces to victim receivers and wireless network operations center



Review and Lessons Learned from Procurement Approach

- During a complex development project iterative reviews are required
 - Options based procurement with integrated assessments
 - Concept exploration phase, proof-of-concept/demonstration, production
- Multi-award, competitive contracting is costly but can provide for a more robust technical solution
- Development of a technical solution ahead of the operational environment can result in requirements changes
 - Licensee network deployment timeline was delayed, and presented changing requirements (PCI requirement, LTE to 5G, PRB blanking) impacting RFIMS project costs
- Project planning phase is critical for complex development projects
 - Engaged other federal agencies and FFRDC to input to requirements



Questions



Session Evaluation

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