RFIMS update for G-DCS TWG

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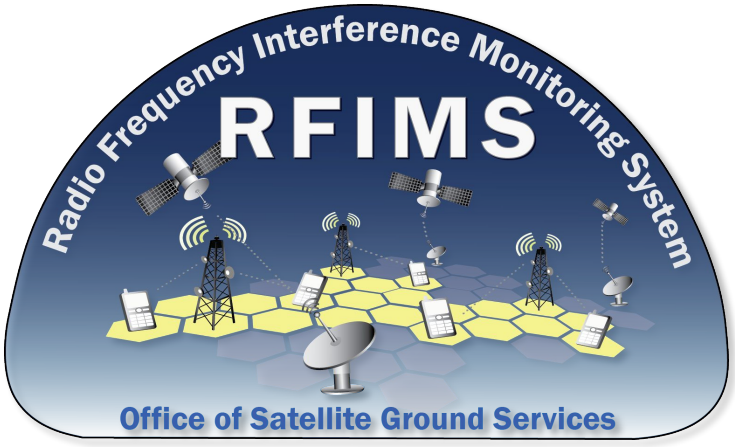
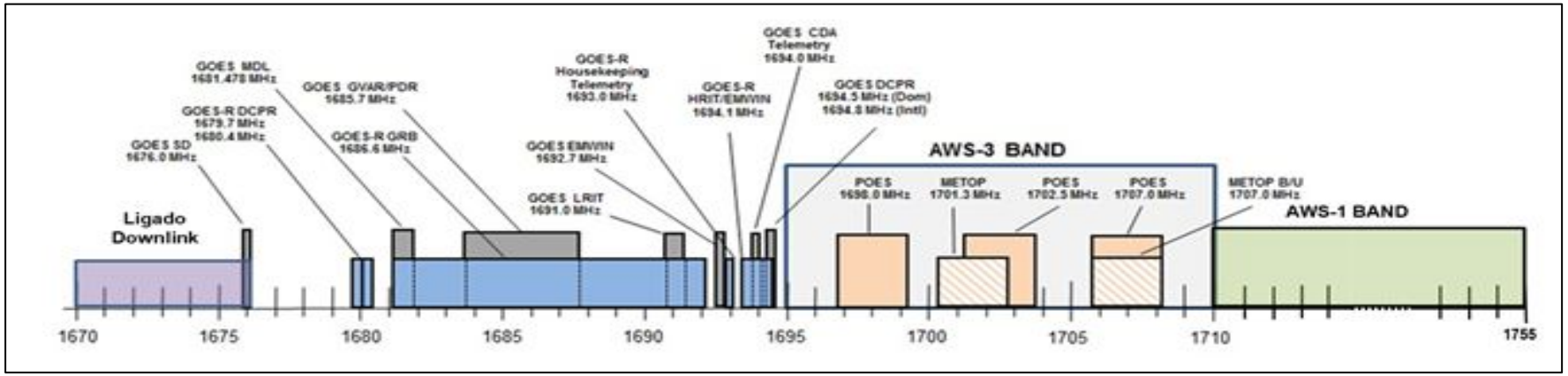


History

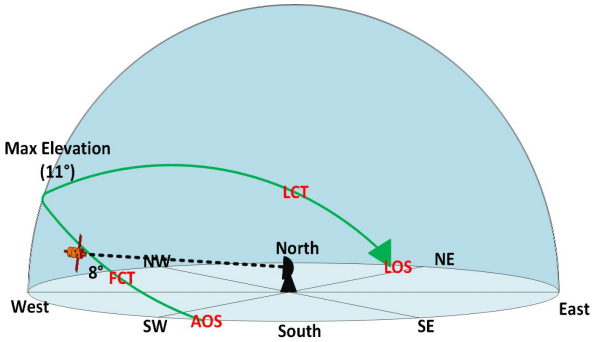
- FCC AWS-3 auction in Jan 2015 auctioned licenses to commercial LTE wireless carriers to operate in the 1695-1710 MHz band.
- In this band and its adjacent bands National Oceanic and Atmospheric Administration (NOAA) operates its downlink of weather satellites.
- The polar orbiting satellites, which include Polar-orbiting Operational Environmental Satellites (POES) and Meteorological Operational (Metop) satellites, are in highly inclined low earth orbits (LEO), or “polar” orbits.
- The Geostationary Operational Environmental Satellite (GOES) is in a geostationary earth orbit (GEO). At 35,000 Km above earth’s surface.

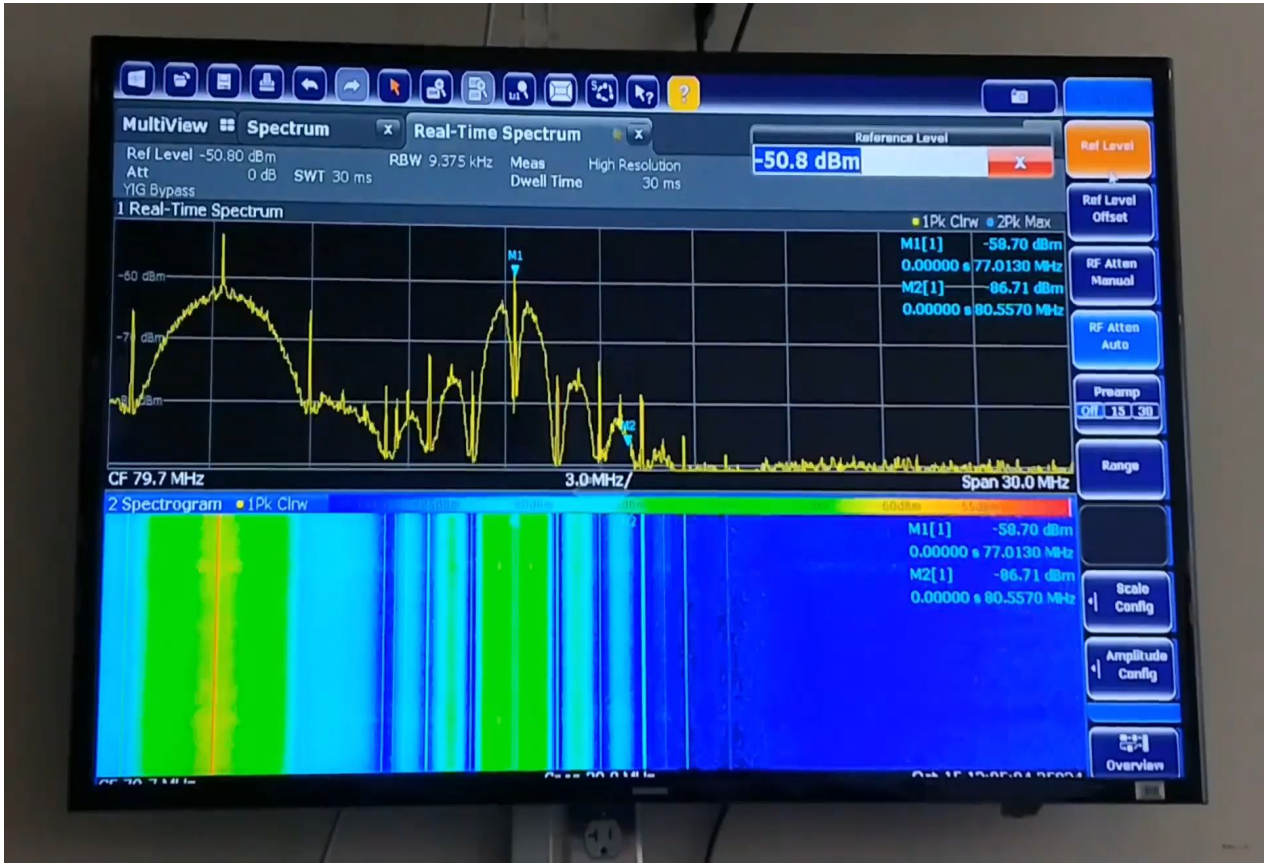
NOAA's L-band RF Environment



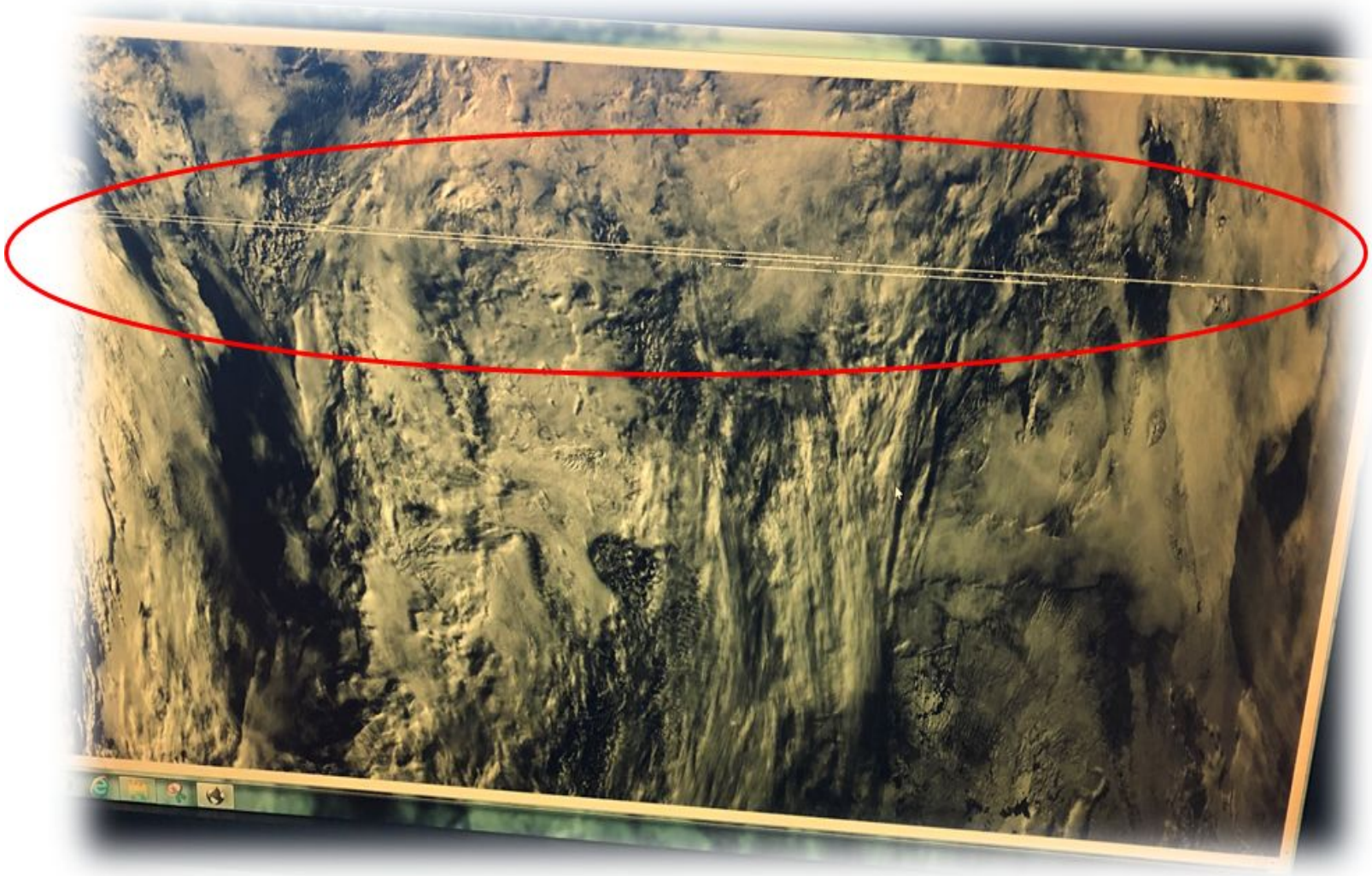
- The operational L-band RF environment at NOAA's ground stations are very crowded and it is going to be more utilized in near future.
- RFIMS will monitor for both in-band and out of band interference events.
- Therefore, RFIMS monitors all of 1670-1755 MHz.

RFI Seen at NOAA's Ground Station





Effect of RFI on NOAA's mission



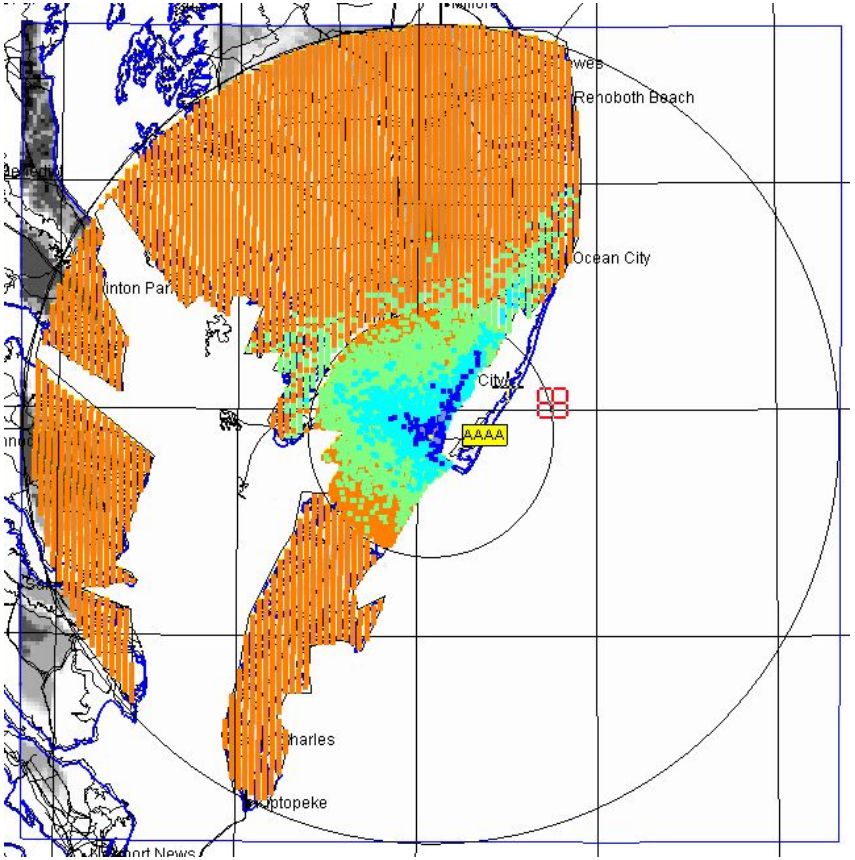
NOAA weather satellite ground stations and protection zones

- NOAA operates several satellite ground stations and each ground station is operated by different agencies under NOAA"
  - Oceanic and Atmospheric Research (OAR)
  - National Weather Services (NWS)
  - National Environmental Satellite, Data, and Information Service (NESDIS).
- Different stations support different missions and the type equipment used in different stations are diverse. Some stations such as Wallops Island and Fairbanks are operated by staff continuously for 365 days in a year. Some stations are in very remote areas and are not fully staffed.
- The antennas in these stations have different sizes and characteristics.

Ground Station	Mission	Protection Zone	Radius (km)
Fairbanks, AK	POES/GOES	Fairbanks	20
Anchorage, AK	POES	Elmendorf AFB	98
Barrow, AK	POES	Barrow	35
Monterey, CA	POES	Monterey	76
Boulder, CO	GOES	Boulder	2
Miami, FL(OAR)	POES	Miami	51
Miami, FL(NHC)	GOES		
Barrigada, GU	POES	Andersen AFB	42
Ford Island, HI	POES	Hickam AFB	28
Suitland, MD	GOES/POES	Suitland, Washington, DC	98
Greenbelt, MD	GOES		
Bay St. Louis, MS	POES	Stennis Space Center	57
Kansas City, MO	GOES	Kansas City	40
Norman, OK	GOES	Norman	3
Guaynabo, PR	GOES	Guaynabo	48
Wallops Island, VA	POES/GOES	Wallops Island	30
Fairmont, WV	GOES	Fairmont	4

Sample Protection Zone

- Example of a Protection Zone
  - Wallops Island, VA
  - 30 Km Zone
- Once LTE-carriers have been issued licenses from the FCC
  - Must have build-out plans inside the Protection Zone approved through the Coordination Portal (website)
    - Outside the Protection Zone do not require coordination via the Portal
- Assumptions for monitoring system
  - Interference could come from anywhere, inside or outside the Protection Zone
  - Spurious interferers (non-LTE)

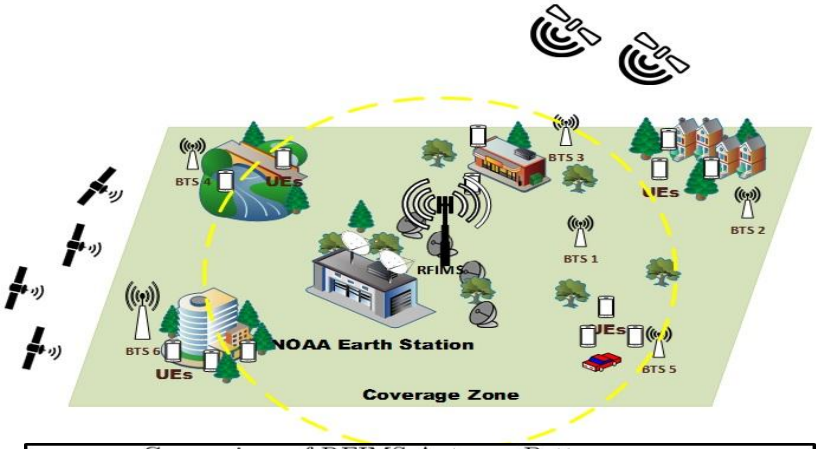


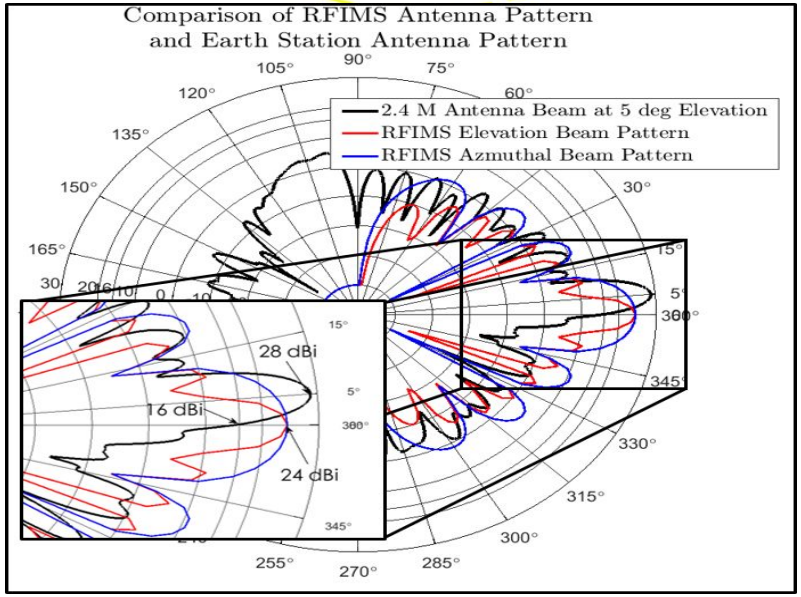
RFIMS Functional Requirements

- To protect earth station communications from LTE interference, NOAA is executing a project to implement a Radio Frequency Interference Monitoring System (RFIMS) across NOAA's Federal earth stations. The monitoring system functions are:
  - **Detect -** The system will detect, in real-time, interference "events" at levels at or above -10 dB Interference-to-Noise Ratio (INR) during NOAA's earth station downlink reception.
  - **Classify** - The system will classify, in real-time, the nature of RF interference. Where "classify" is the *discrimination* between 1695 – 1710 MHz LTE UE uplink signals and all other radio frequency interference (RFI) such as background impulsive noise and out-of-band emissions from other RF sources.
  - **Identify -** If the system determines the RFI is related to 1695 – 1710 MHz LTE UE uplink signal interference, then the system will identify the source(s) of interference in real-time
  - **Notify -** The system will notify NOAA operators, and the wireless carriers responsible for the interference

RFIMS Design: Detecting Interference

- The RFIMS is deployed at the earth station and scans a coverage area using a cylindrical phased array antenna.
- This system is heavily dependent on the capability of the antenna.
- To sensitivity requirement, a cylindrical antenna was developed with 24.4 dBi of gain and a 1-dB beamwidth of 3.
- To detect a signal, the system requires 1 dB of SNR.
- This system only monitors 1675-1755 MHz.





RFIMS Design: Classifying and Identifying Interference

- After the detection, it will attempt to do classification and identification. It will need a 10 dB SNR to perform these functions.
- The system will use digital beamforming using individual columns on the detected signal to increase the SNR.
- Identification happens at two levels: one level is the direction of received signal and the other by extracting LTE protocol characteristics of the received uplink signal.
- This system could be built either on a fixed or transportable platform.

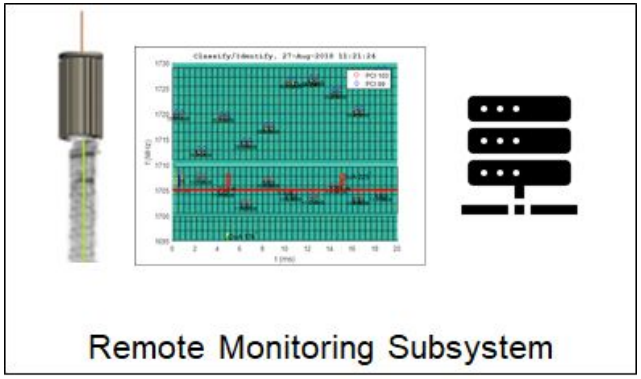
RFIMS Transportable Platform

RFIMS Operational Concept- RFI Event

Signal at the receiver ≥ -10 dB INR

RFIMS Operational Concept- RFI Event

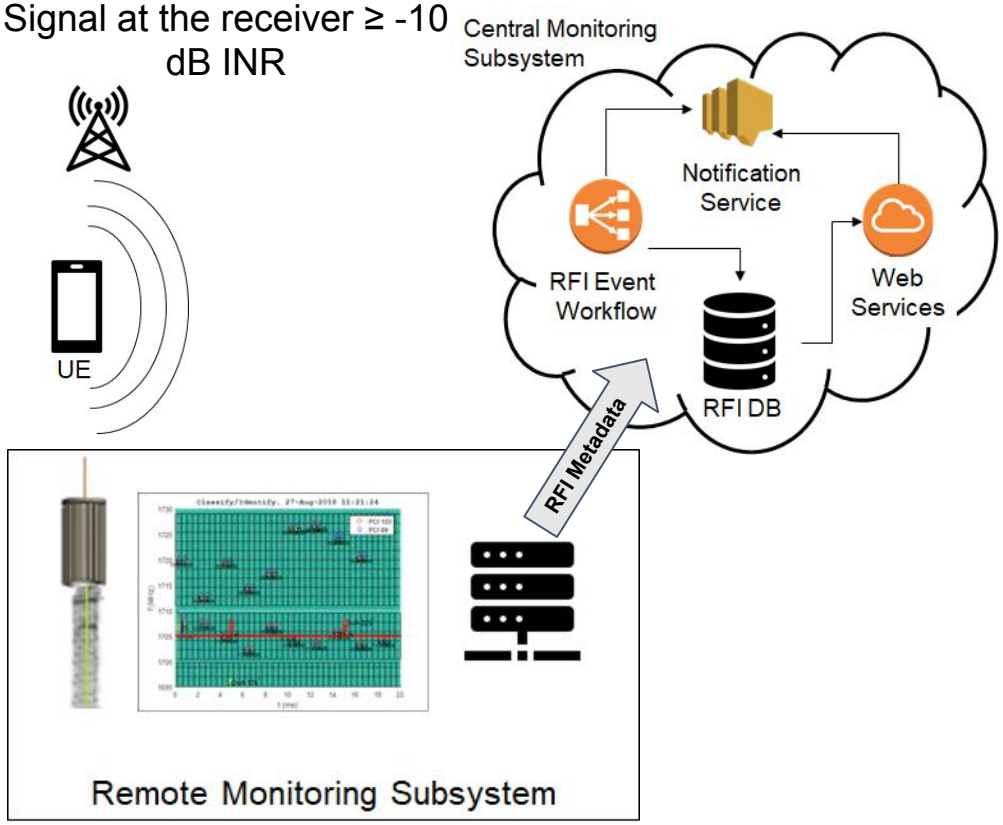
Signal at the receiver ≥ -10 dB INR



Detect ≥ -10 dB INR

RFIMS Operational Concept- RFI Event

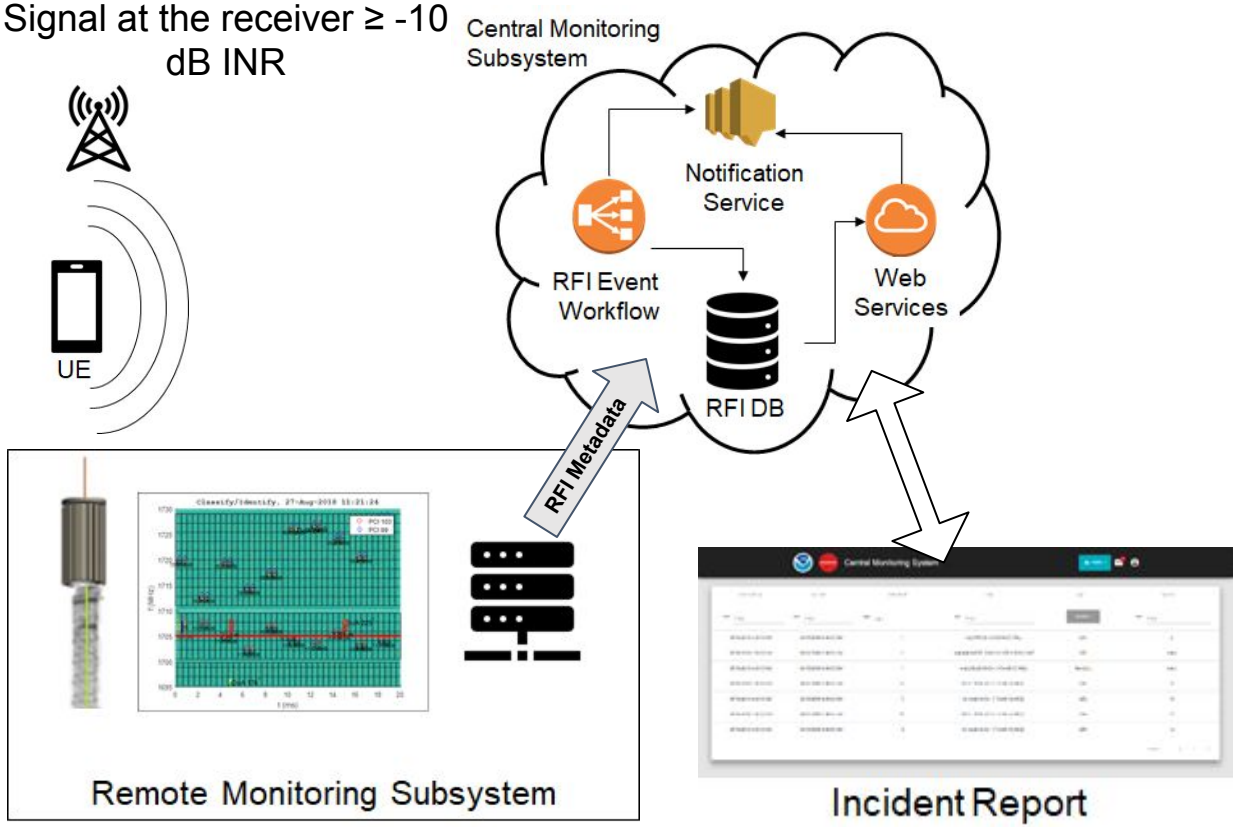
Signal at the receiver ≥ -10 dB INR



Classify LTE or Non-LTE

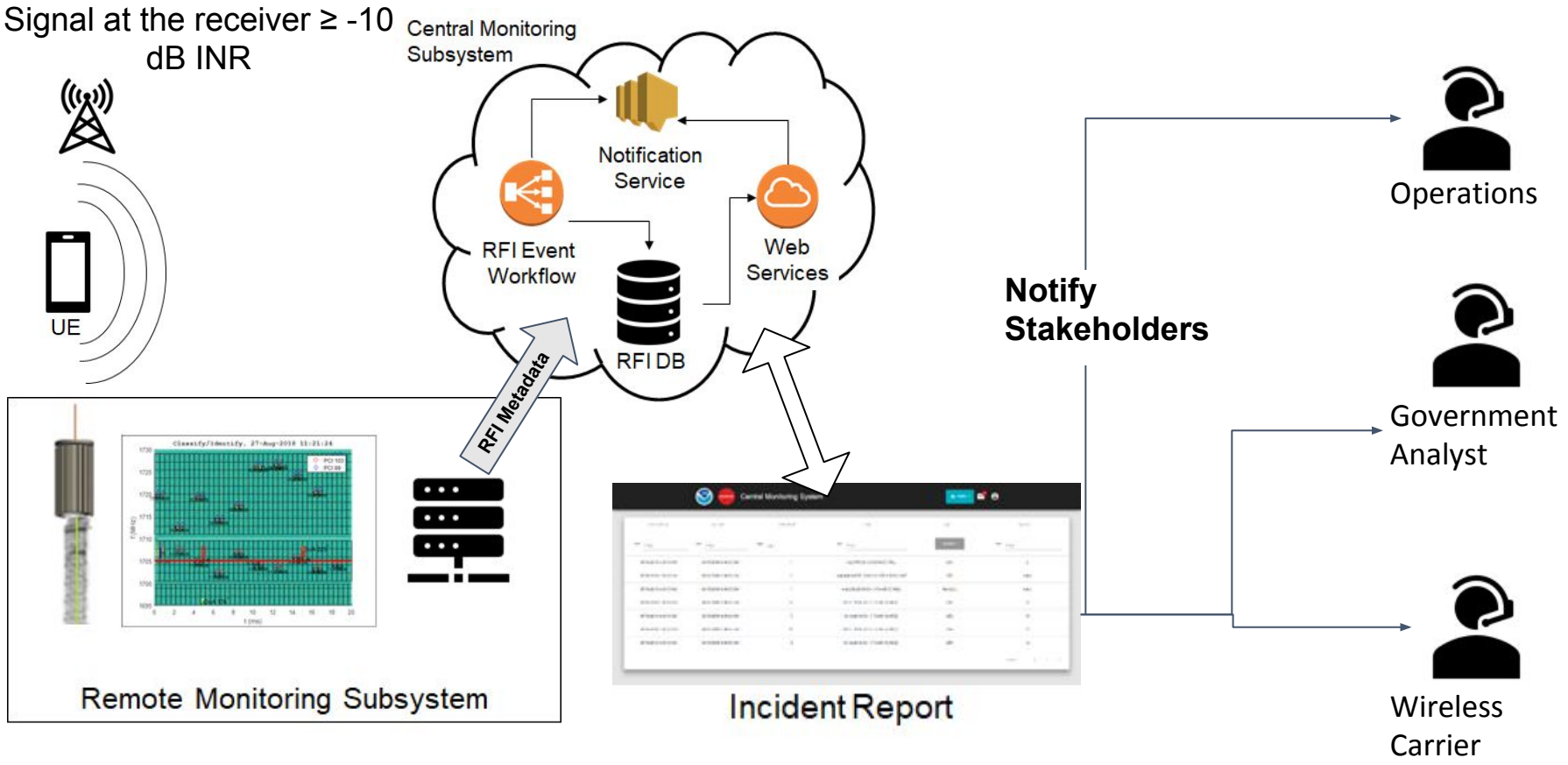
RFIMS Operational Concept- RFI Event

Signal at the receiver ≥ -10 dB INR

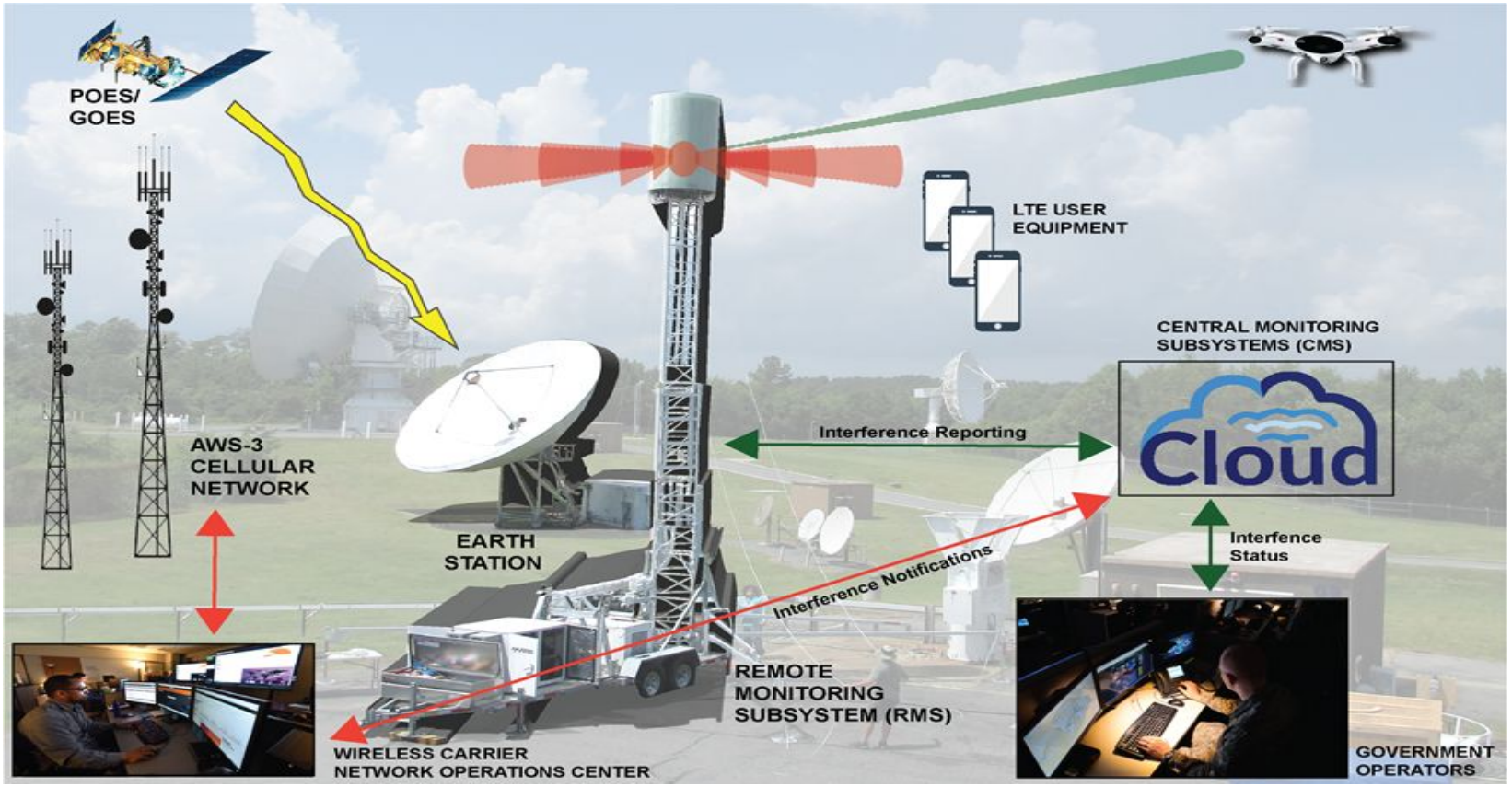


Identify LTE Tower and Sector

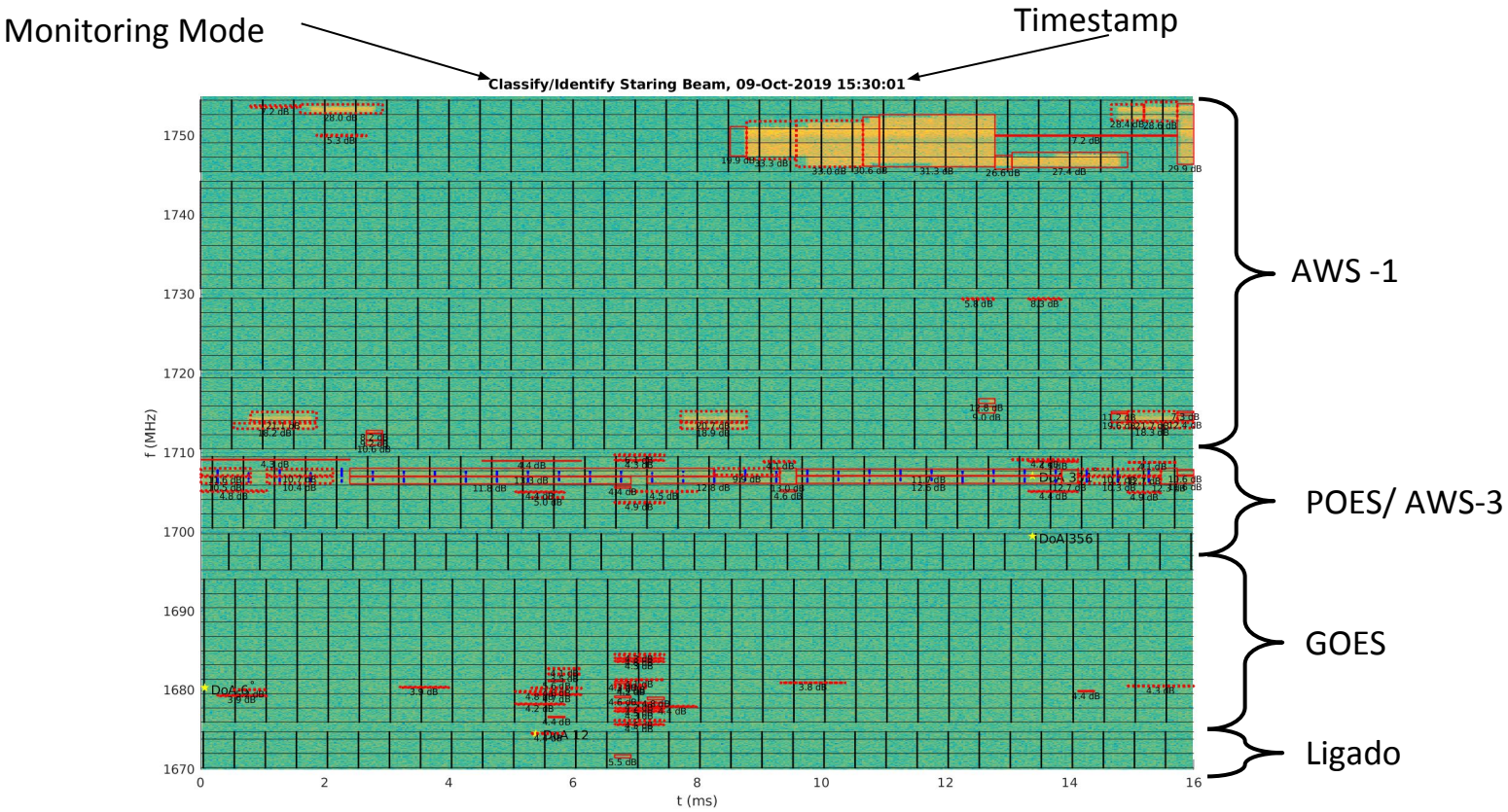
RFIMS Operational Concept- RFI Event



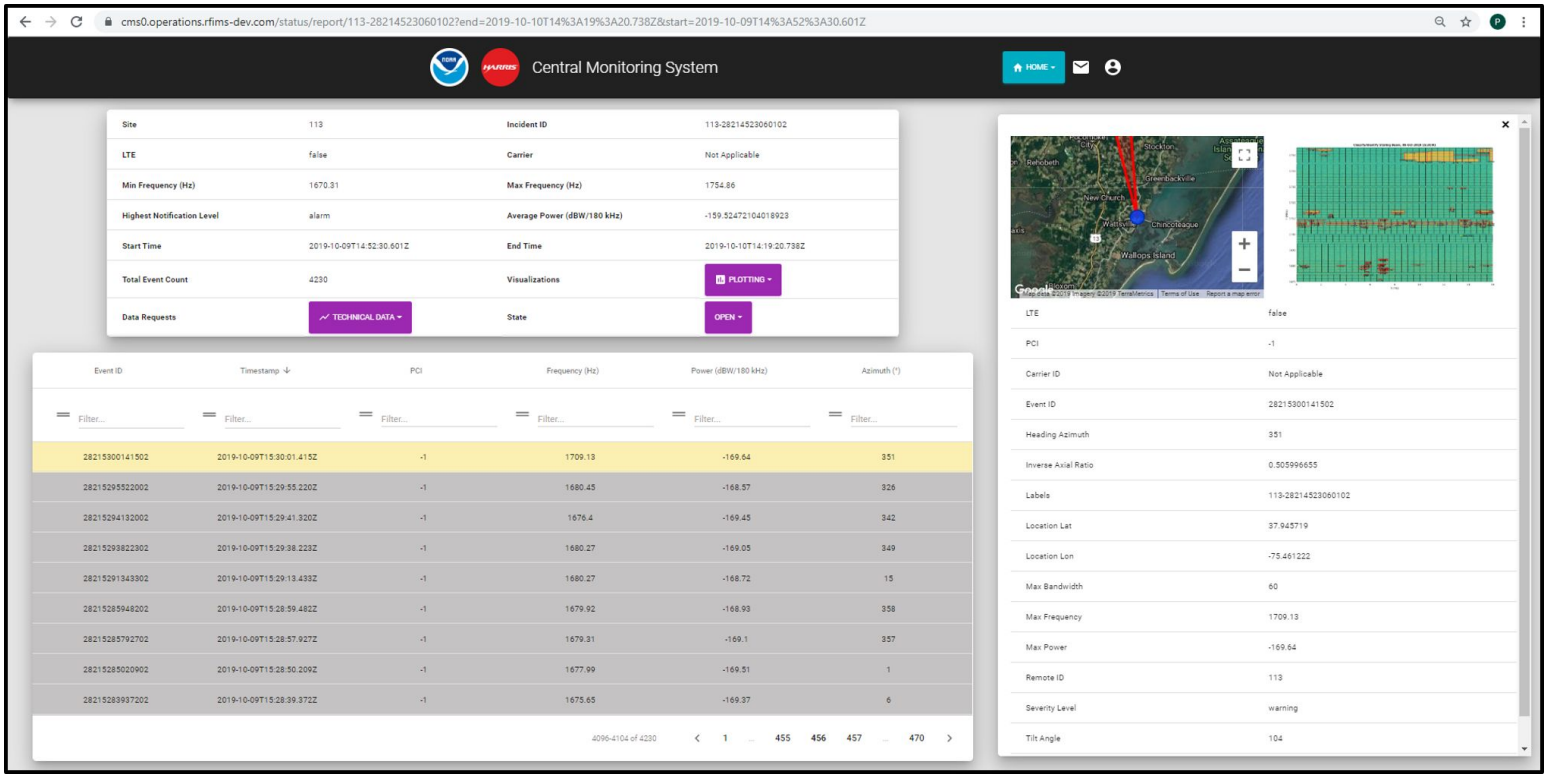
RFIMS Operational View



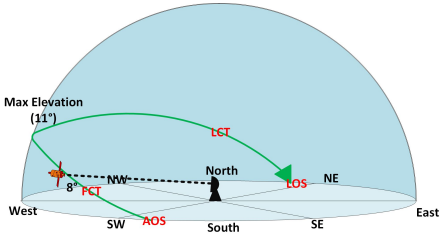
Spectrogram - RFIMS Analysis Tool

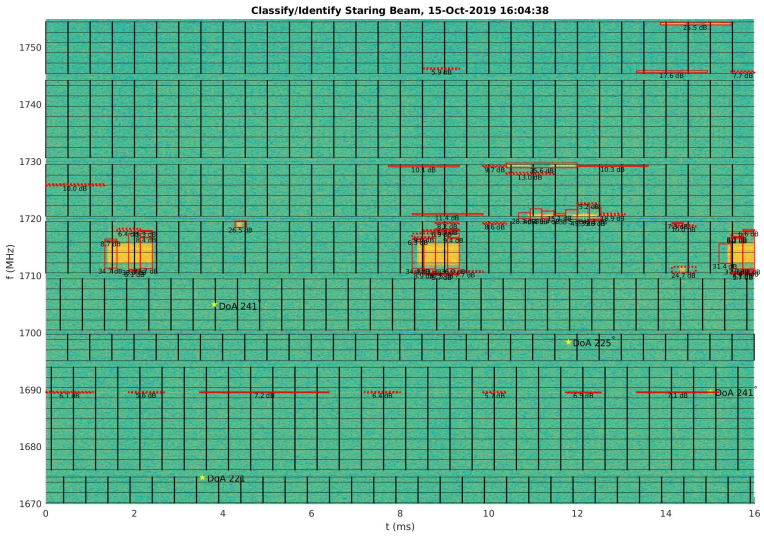


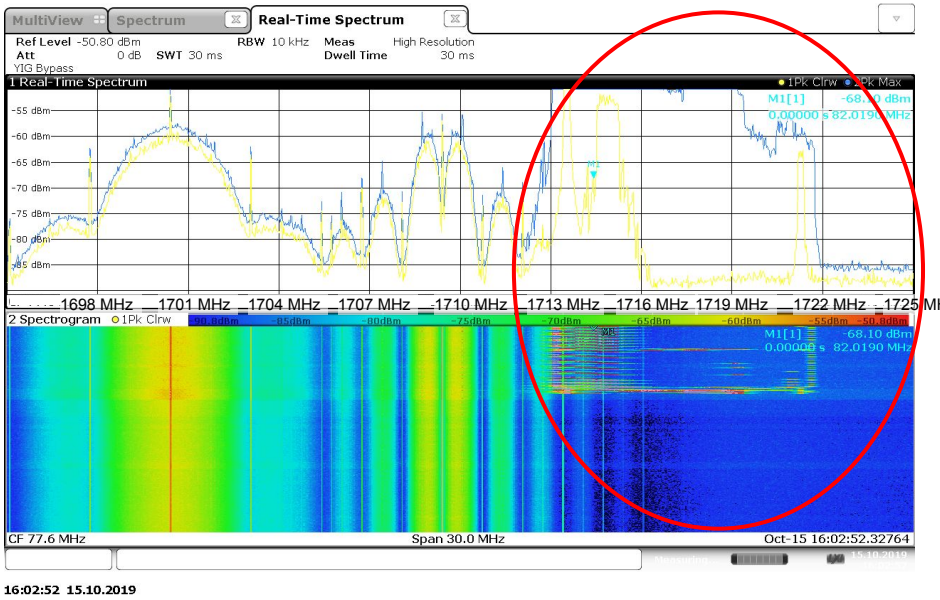
Central Monitoring System Interface



NOAA 18 RFI - 15 October 2019

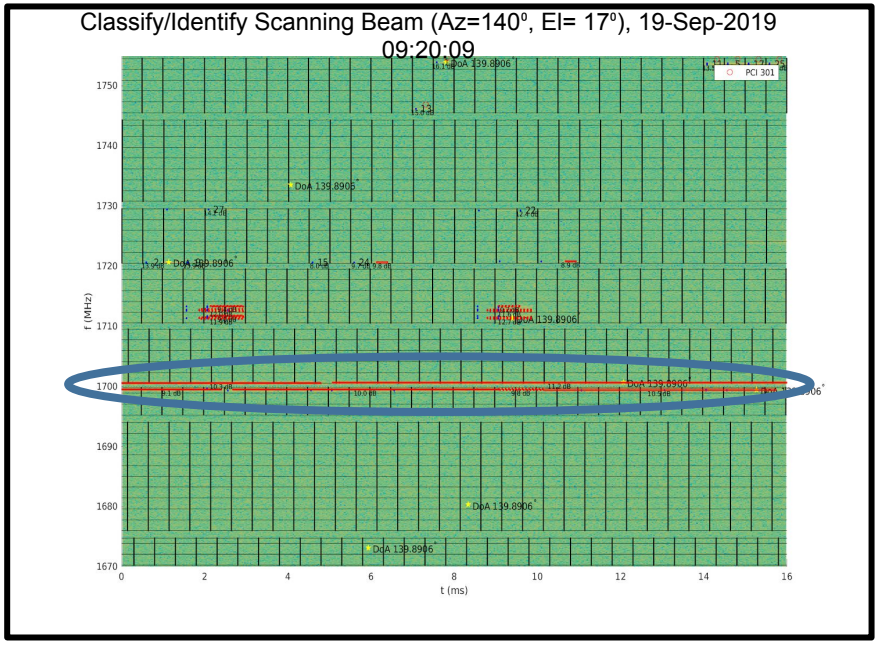


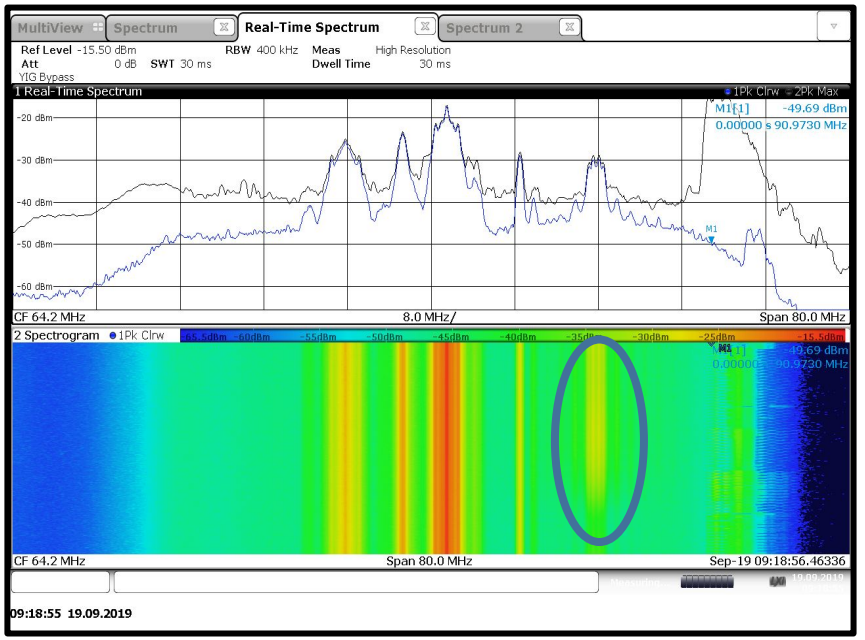




GOES-R Interference

- 140 degrees azimuth, 17 degrees elevation





What is next with RFIMS

- In December 2020 the first article of RFIMS will be delivered to NOAA's testbed at NTIA's Table Mountain facility for further testing and capabilities assessment.
  - Table Mountain facility is a radio quiet zone.
  - The facility is equipped with antennas and receivers that are normally found at NOAA's ground stations. i.e. POES and Metop systems, GRB, (DCS and HRIT/EMWIN soon to be acquired).
  - The facility will also house an emulated LTE network that operates its uplink at AWS-3.