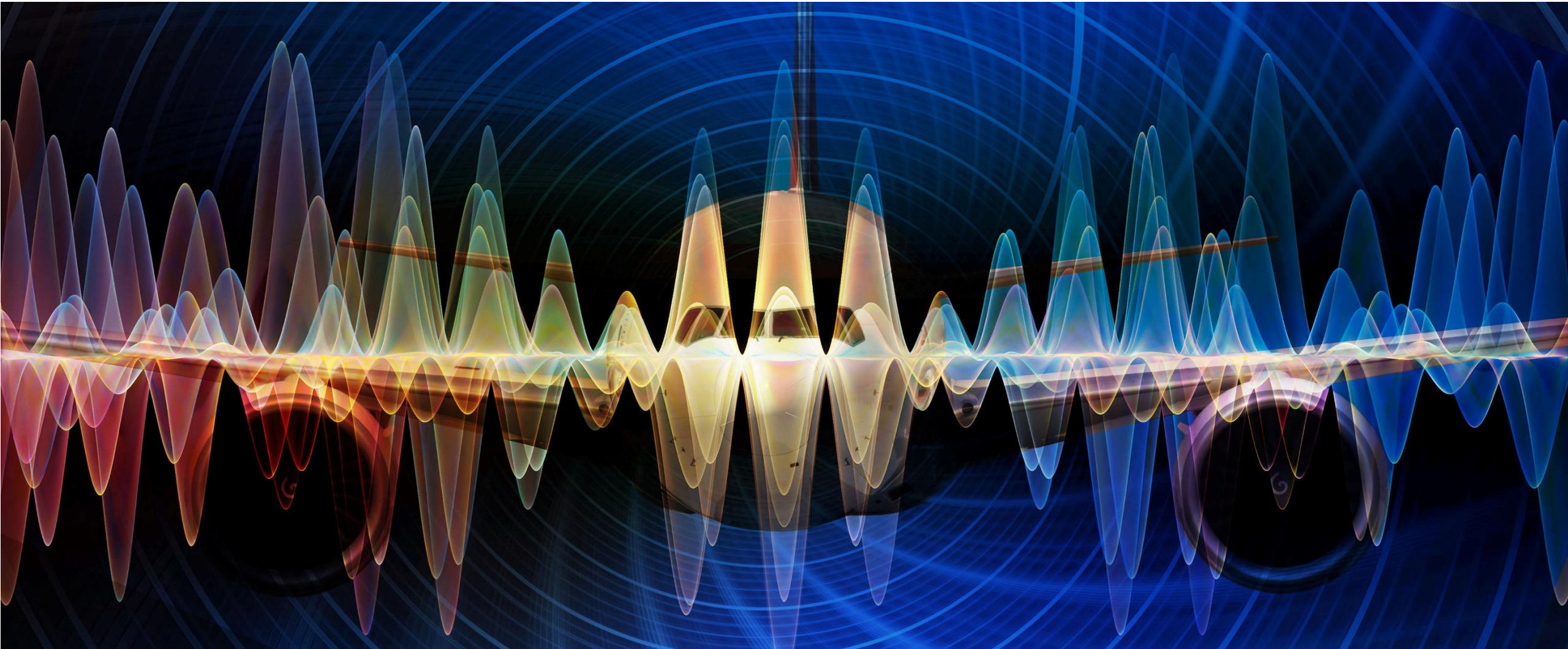
SPECTRUM
ENGINEERING

Presented to: USTTI
By: Michael Weiler, Group Manager
FAA Spectrum Engineering Services
Date: June 2022

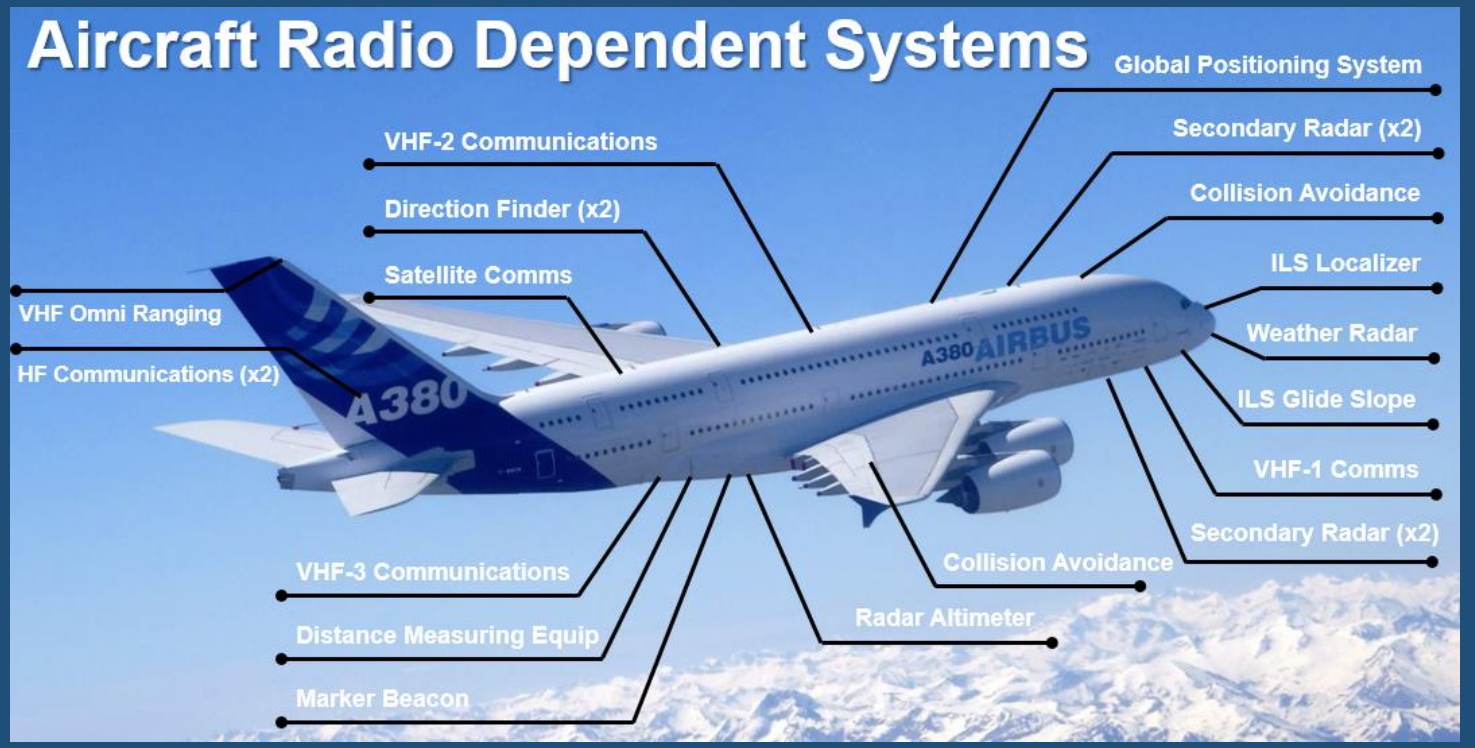


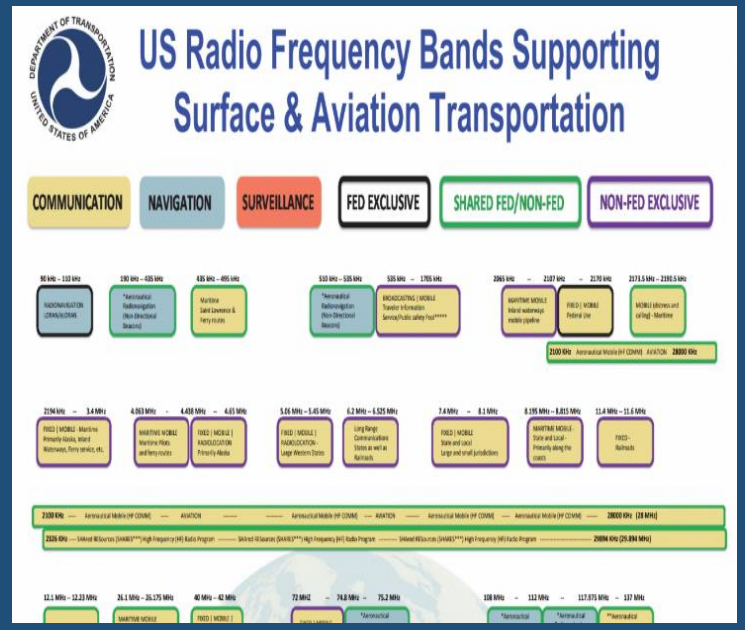
Overview

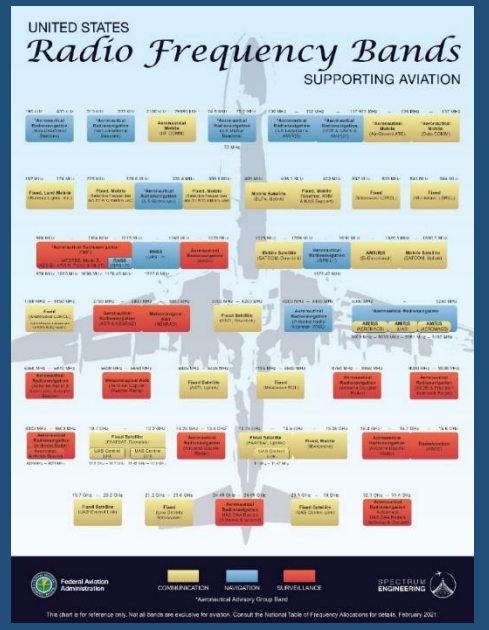
- Spectrum & Aviation
- FAA Spectrum and who we are (AJW-15)
- What we do
- Safety Management Achievements
- Innovations
- Moving Forward
- Q&A

Spectrum in Aviation

- Limited Resource
- Critical for all agencies
- FAA is 2nd largest user
- Leverage >30K frequencies in NAS
- Mission Critical
- Most impact to the public Safety







SPECTRUM ENGINEERING

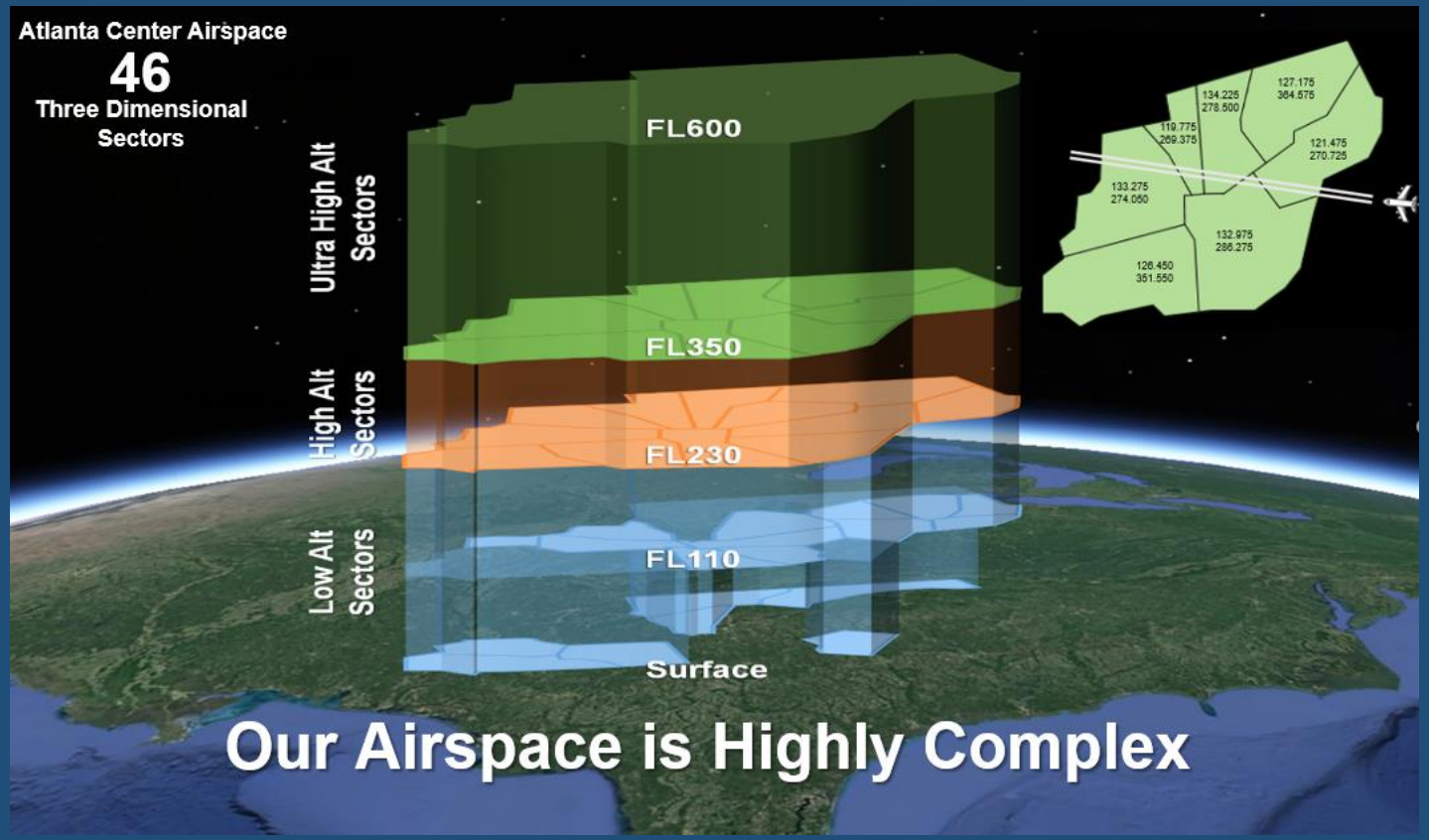
What We Do

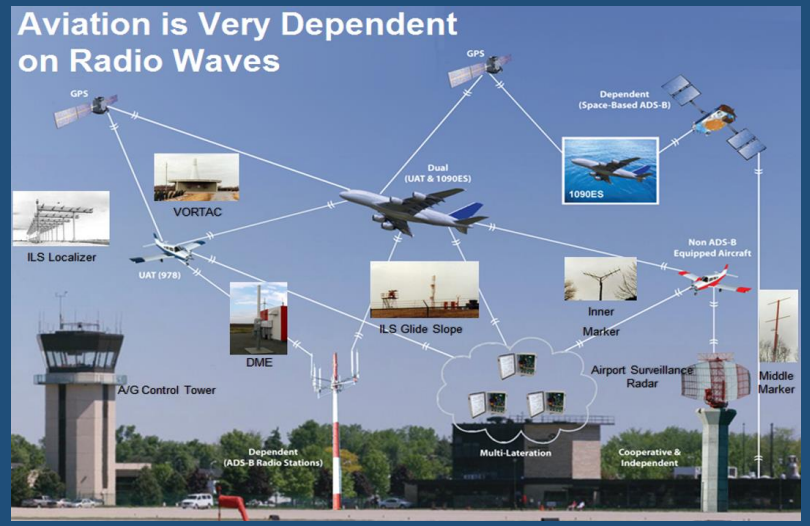
Mission

We secure, manage, and protect the necessary radio frequency spectrum resources to provide the safest, most efficient aerospace system in the world.

Vision

We strive to provide superior radio frequency spectrum services and efficiently integrate tomorrow's needs safely into our aerospace system. We work across boundaries to develop innovative solutions for our stakeholders.





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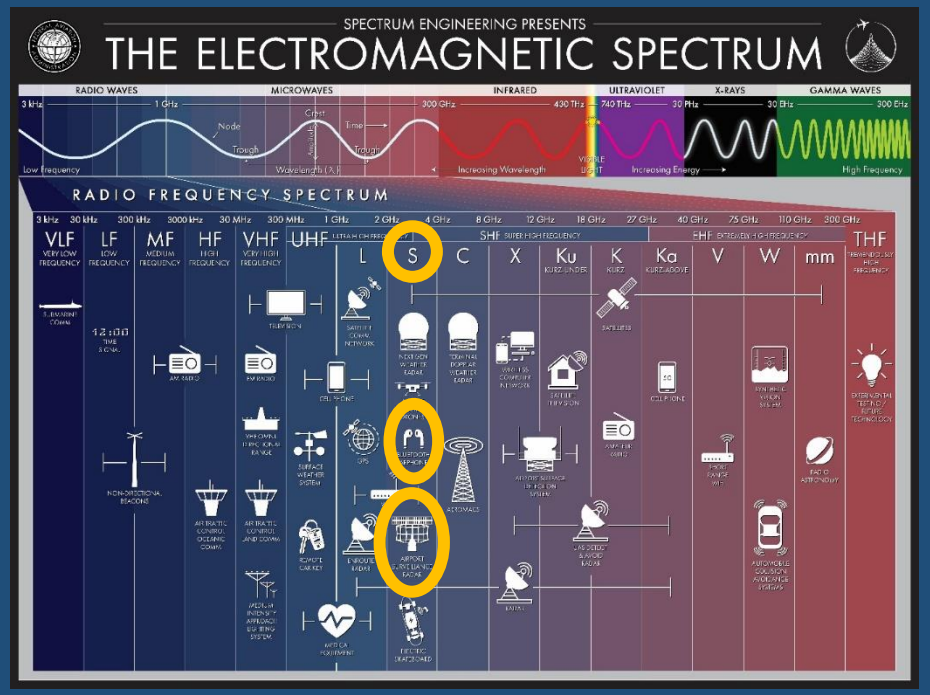
What We Do Best

We Secure: Developing international & domestic civil aviation spectrum policies and standards by participating in federal & international forums, developing international system standards & coordinating equipment certification.

We Manage: Engineering new & existing radio frequency assignments and conduct coverage analysis to ensure safe and efficient NAS operations.

We Protect: Conducting radio frequency interference (RFI) investigations to keep the NAS operational and collaborates with external stakeholders on high priority classified security projects.



Example: Your Bluetooth headphones operate in the S Band along with the FAA's Airport Surveillance Radar

Virtually everything in the NAS uses the radio frequency (RF) spectrum.

Since most aviation related equipment operate in the same band as everyday items, these frequencies need to be protected from Radio Frequency Interference (RFI).

Rules and Regulations Authorities

- **Communications Act of 1934 as Amended**
  - Established Radio Spectrum usage in the USA
- **Federal Aviation Act of 1953 as Amended**
  - Authority for FAA's use of Radio Spectrum
- **Office of Management and Budget Circular A-11**
  - Spectrum Authorization Before Expenditure of Funds
- **ITU Radio Regulations**
- **International Civil Aviation Organization (ICAO)**
- **NTIA Manual of Regulations and Procedures for Federal Radio Frequency**
- **FCC Rules and Regulations, Part 87**

National Airspace System (NAS) Facilities

(numbers are approximate)

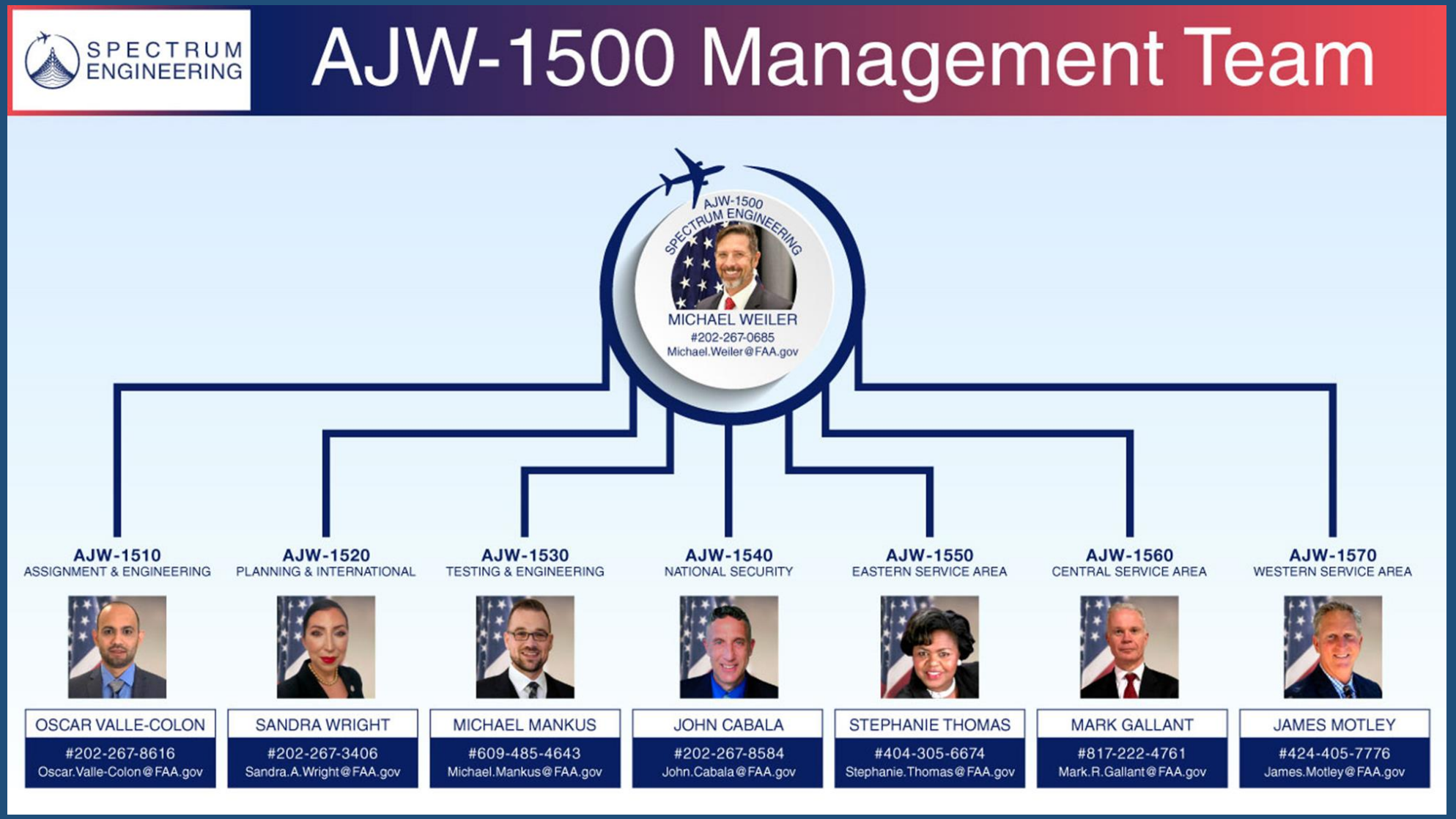
Communication	**9000 VHF and 5000 UHF facilities**
Navigation	**1000 VOR, 1300 localizers, 1100 glideslopes, 1100 DME, 2500 other**
Surveillance	**700 SSR, 900 primary, 1600 other**

COMM **NAV** **SURV**

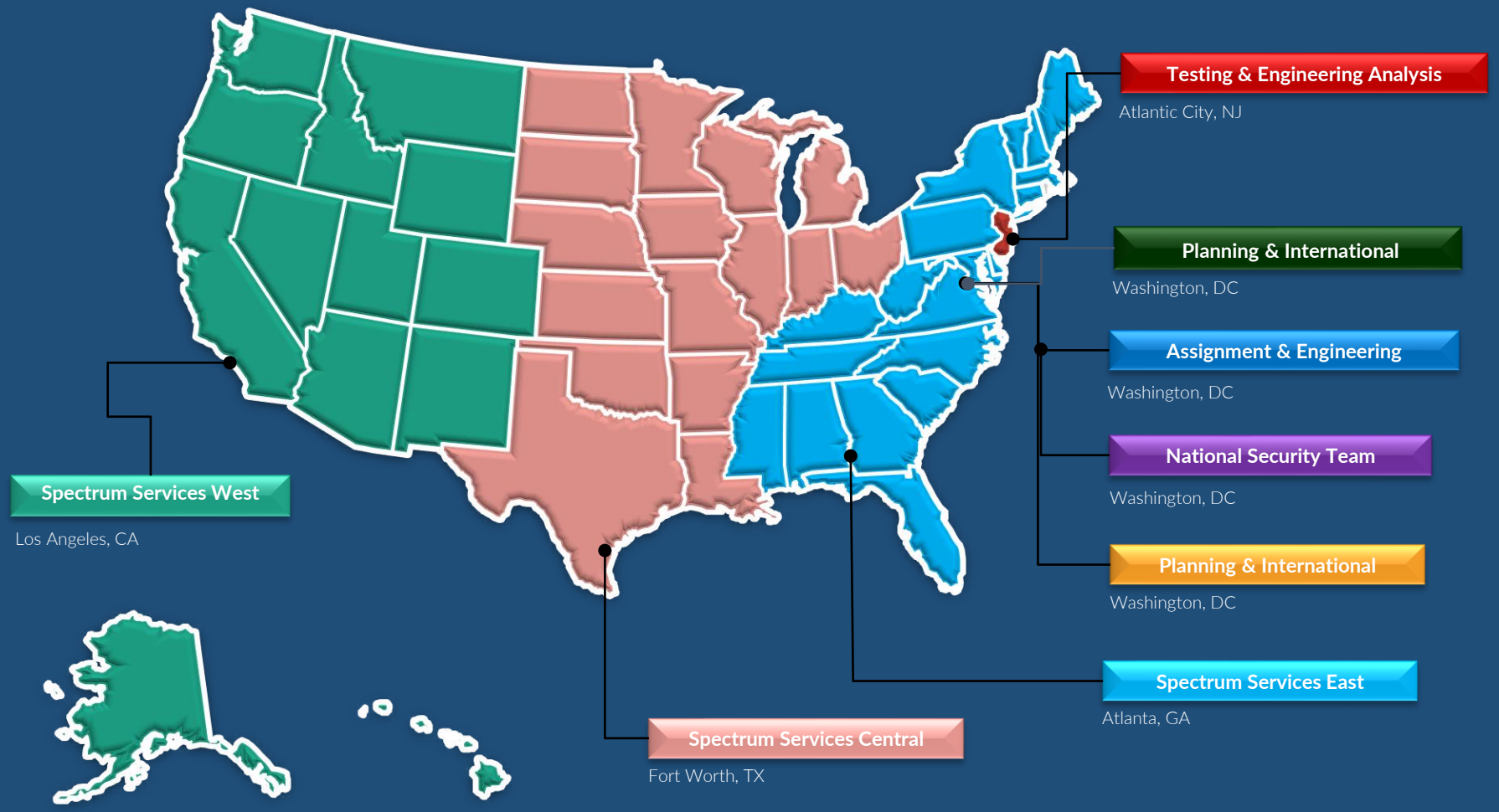
Frequency Assignments by Agency

Agency	Number of Assignments Approximate
Air Force	35000
FAA	32000
Army	30000
Navy	26000
Justice	21000
Homeland Security	19000
Agriculture	17000
Interior	14000
Coast Guard	13000
Other Agencies (combined)	37000

FAA Spectrum Engineering Organization



FAA Spectrum Engineering Locations



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What We Do

Assignment & Engineering Team

- Engineer Frequencies providing Interference Free Communications, Navigation, and Surveillance (CNS) services through out the NAS.
- Acquire, maintain and protect NAS NTIA frequency authorizations
- Manage and protect the NAS operational spectrum requirements
- Chair the IRAC Aeronautical Assignment Group (AAG)
- Execute the Civil Aviation Interference Resolution Program
- Represent FAA at IRAC Frequency Assignment Subcommittee (FAS)

Planning and International Team

- Develops spectrum specifications for NAS
- Ensures FAA systems meet Spectrum Standards
- Chair ICAO Frequency Spectrum Management Panel
- Conduct Studies necessary to help ensure RFI free spectrum
- Represent FAA at the IRAC and it's Subcommittees
- Engage in RTCA Inc. Special Committees
- Represent aviation in US delegations to international forums

Testing and Engineering Analysis Team

- Perform spectrum research, testing and analysis of aeronautical CNS and NAS systems.
- Validates spectrum technical characteristics and vulnerabilities of NAS based systems.
- Develops advance technology systems for NAS RFI signal detection, location, mitigation and key NAS digital signal processing requirements

National Security Team

- Analyze NAS impacts from Electronic Attack (EA) requests from fed agencies
- Analyze NAS impacts from the DoD's Link-16 system sharing our L Band
- Coordinate EA and Link-16 impacts with AJR and AJT for safety mitigations

Service Area Teams (Including Alaska, Hawaii, Guam)

- Perform and Engineer NAS frequency requirements
- Coordinate NAS Frequencies with Mexico and Canada
- Lead and resolve NAS Spectrum RF Interference Investigations
- Coordinate and support Military Exercises & Events

Our Collaborative Relationships

Department of Defense (DOD)

Assess the impact of new systems on the NAS, coordinate frequencies for military exercises, develop technical standards, deconflict GPS jamming, JTIDS, Electronic Attack, and CIED & CUAS operations to protect NAS CNS Systems from harmful interference.

Federal Communications Commission (FCC)

Coordinate domestic frequency assignments and international concerns.

Radio Technical Commission for Aeronautics (RTCA)

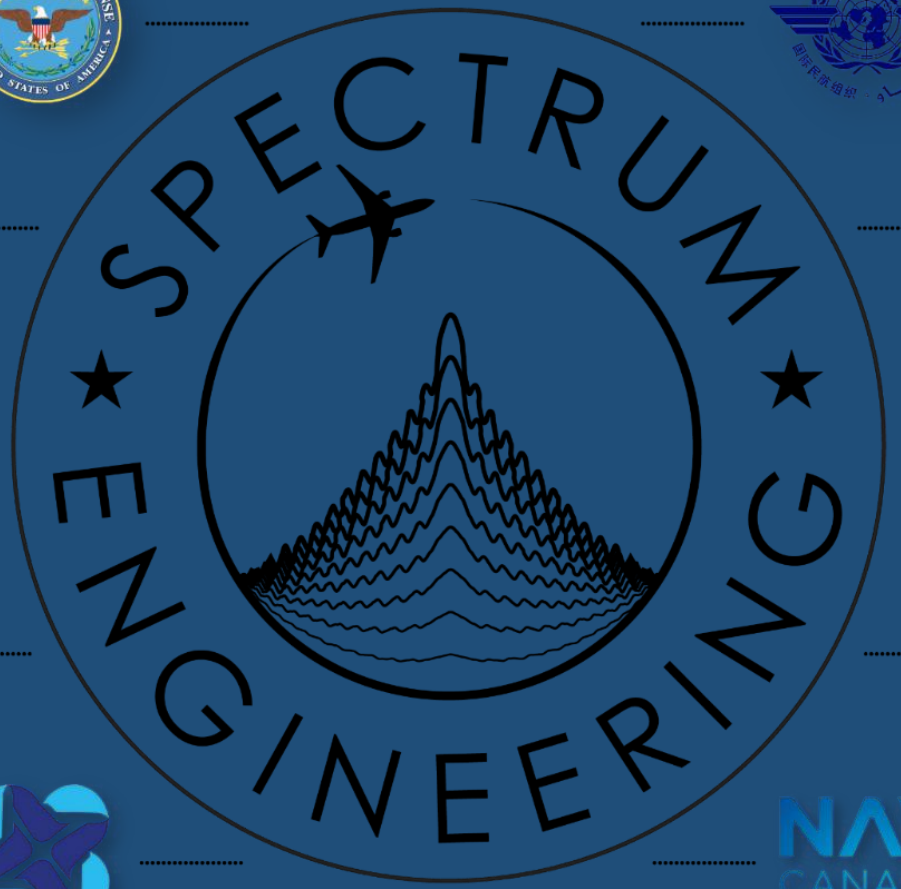
Work to develop technical standards for avionics equipment including Minimum Aviation System Performance Standards and Minimum Operational Performance Standards.

National Telecommunications & Information Administration (NTIA)

Provide representation at the NTIA in order to participate in developing policies, programs, procedures and technical criteria for the Federal use of the radio frequency spectrum. In addition, coordinate frequency assignments with 19 Federal agencies through the Interdepartment Radio Advisory Committee (IRAC).

Servicios de Navegacion en el Espacio Aereo Mexicano (SENEAM)

Coordinate use of radio frequencies to prevent radio frequency interference between countries.



International Civil Aviation Organization (ICAO)

Assists in developing international Standards and Recommended Practices (SARPs) for worldwide use.

Inter-American Telecommunication Commission (CITEL)

Develops consensus for proposals on radio frequency allocations among the countries in our region for the International Telecommunications Unions (ITU) World Radiocommunications Conferences (WRC).

North Atlantic Treaty Organization (NATO)

Part of an alliance of countries from Europe and North America that consult and cooperate in the field of defense and security, and conduct multinational crisis-management operations.

International Telecommunications Unions (ITU)

Assists by developing recommendations on radio frequency compatibility between services, adopting new frequency allocations and participating in the WRC.

NAV Canada

Coordinate use of radio frequencies to prevent radio frequency interference between countries.

RTCA Incorporated

- **Employs a consensus-driven process on issues affecting air traffic management operations**
- **Generates minimum performance standards (MOPS) for CNS/ATM systems and equipment**
- **MOPS generally are the basis for FAA regulatory requirements**
- **The Spectrum Engineering Service participates in the Special Committees dealing with spectrum related issues:**
  - GPS (SC-159)
  - ADS-B (SC-186)
  - Unmanned aircraft systems (SC-228)
  - AMS(R)S (SC-222)
  - ATCRBS & Mode S (SC-209)

https://www.rtca.org/content/about-us-overview

FAA NAS NextGen

- **NextGen is a wide ranging transformation of the entire national air transportation system to meet future demands both in the air and at airports**
- **Incorporates satellite based technologies to the mix of legacy ground based technologies**
- **Purpose is to reduce congestion, and improve the passenger experience**
- **New capabilities are based on RNSS**
  - Include GPS (L1 & L5), GALILEO, GLONASS
  - Additional planned global RNSS systems
  - Augmentations - GBAS, SBAS, Regional
  - Automatic Dependent Surveillance-Broadcast
  - VHF Data Link Mode 2

FCC Coordination

- **Title 47 CFR Part 87**
  - Rules under which civil aviation uses spectrum
- **FAA comments on draft FCC rule makings via the IRAC process**
  - Primarily those which have potential impacts to aviation
- **FAA works with FCC Enforcement Bureau**
  - Resolve RFI affecting aviation radio services
- **Works with FCC on PPSG**
  - PPSG tasked to look at Federal spectrum for repurposing for civil wireless, etc.

DoD Coordination

- **FAA has the responsibility to manage the spectrum associated with the National Airspace System (NAS) as per Section 8.3.16 of the NTIA Manual**
- **DoD Spectrum Management Office (SMO) sends frequency assignment request to FAA for pre-coordination.**
  - Issues, e.g., DoD use of civil frequencies (e.g. GPS) for testing, are worked out between FAA and DoD,
  - FAA coordinates with DoD over large scale exercises, e.g., RIMPAC, Bold Quest, Red Flag

- **DoD SMO submits frequency assignment to NTIA for vote**
- **NTIA grants permission to radiate**
- **FAA works with AFTRCC to coordinate Joint use of spectrum by civil and military for aircraft flight testing**

DoD (continued)

- **International AIMS PO**
  - Conduct box, platform, interoperability and performance testing
  - FAA interest is to ensure conformance with agreed EMC standards necessary to protect civil systems
  - FAA participates in the DoD AIMS PO Configuration Control Board (CCB) held quarterly discussing AIMS Manual update
  - Technical discussion on change proposals (CPs) of 1030/1090 MHz system characteristics and requirements
  - FAA is also a voting member on those CP at CCB

International Civil Aviation Organization (ICAO)

- **A specialized agency of the United Nations with 190 Member States**
- **Created in 1944 to promote the safe and orderly development of international civil aviation throughout the world**
- **Sets standards and regulations necessary for aviation safety, security, efficiency and regularity, as well as for aviation environmental protection**
- **Panels on which the FAA participates**
  - Aeronautical Communications Panel
  - Navigation Systems Panel
  - Aeronautical Surveillance Panel
  - Frequency Spectrum Management Panel
    - Chaired by FAA/Spectrum Engineering Service engineer

International Telecommunication Union-Radiocommunication (ITU-R)

- **Produces Recommendations which address**
  - Spectrum sharing between systems
  - Cross-border electromagnetic compatibilities
  - Most countries adhere to Recommendations as if they were law
- **Produces Reports**
  - Provide technical and operational background on specific issues
  - Provide system characteristics and RFI susceptibilities
    - for use in radio frequency compatibility studies and
    - sometimes referenced in Recommendations
- **Drafts Conference Preparatory Meeting (CPM) Report**
  - ITU-R technical and operational guidance for WRC delegates

https://www.gsma.com/spectrum/wrc-series/

ITU-R Study Groups with FAA Participation

- **Study Group 1 Spectrum Management**
  - General Radio Frequency Management
- **Study Group 4 Satellite Services**
  - GPS, SATCOM and compatibility with non-aviation systems
- **Study Group 5 Terrestrial Services**
  - Aviation systems and services including radar and avionics
- **Study Group 7 Science Services**
  - Compatibility with earth-exploration-satellite service operating in spectrum allocated to aviation services

World Radiocommunication Conference (WRC)

- **Meets every three to four years, or so**
  - Establishes radio frequency allocations, globally
  - FAA participates on the U.S. delegation
  - Critical for civil aviation due to aviation's global nature
- **WRC-19 Agenda Items (AIs) of interest for FAA/aviation**
  - 1.7, protection of voice and data links
  - 1.10, implement GADSS
  - 9.1 issue 4, integrate suborbital vehicles into NAS

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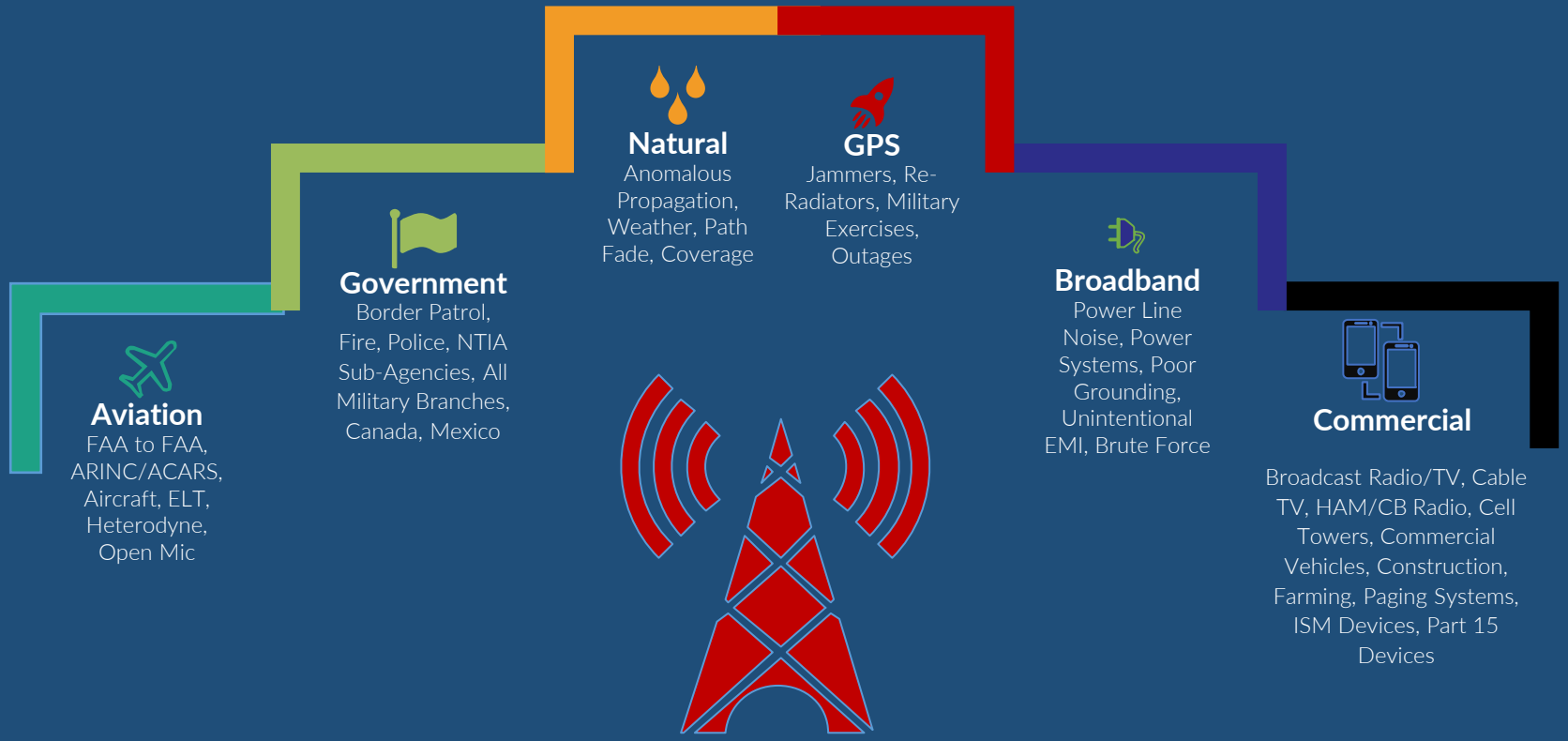
The Inevitable – Radio Frequency Interference

- **RFI = Electromagnetic interference (EMI) when it is considered in the radio frequency spectrum.**

  - Definition – According to Section IV, Article 1.166 of the International Telecommunication Union's (ITU) Radio Regulations (RR) it is defined as:

- **«*The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio-communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy*».**
- **In accordance with ITU RR (Article 1) variations of RFI are classified as:**
  - Permissible interference
  - Acceptable interference
  - Harmful interference

The Overall RFI Sources Variety Challenge



In actuality, any modern electronic technological innovation as well as natural electromagnetic events have the potential to produce interference to systems making use of the Radio Spectrum

The Overall RFI Sources Difficulty Challenge

Intermittent

We can't get a fix on a signal that isn't broadcasting. Super intermittent signals create problems in terms of resource distribution – we can't dedicate a person to sit and wait for the RFI to occur.

High Altitude Aircraft Pilot Only Reported

When the interference can't be observed from the ground antenna, the FMO has a tough time knowing where to begin the search.

Venn-Diagram analysis is often used as well as FAA flight inspection aircraft using direction finding equipment (expensive).

Broadband Digital Phase Shifting

Most direction finding equipment is not suited for tracking broadband signals or signals that frequency shift.

This is made worse by the fact that broadband and shifting signals often affect more than a single frequency at a time.

Any RFI event has unique characteristics that present a variety of difficulties to achieve resolution and no specific incident can be taken for granted

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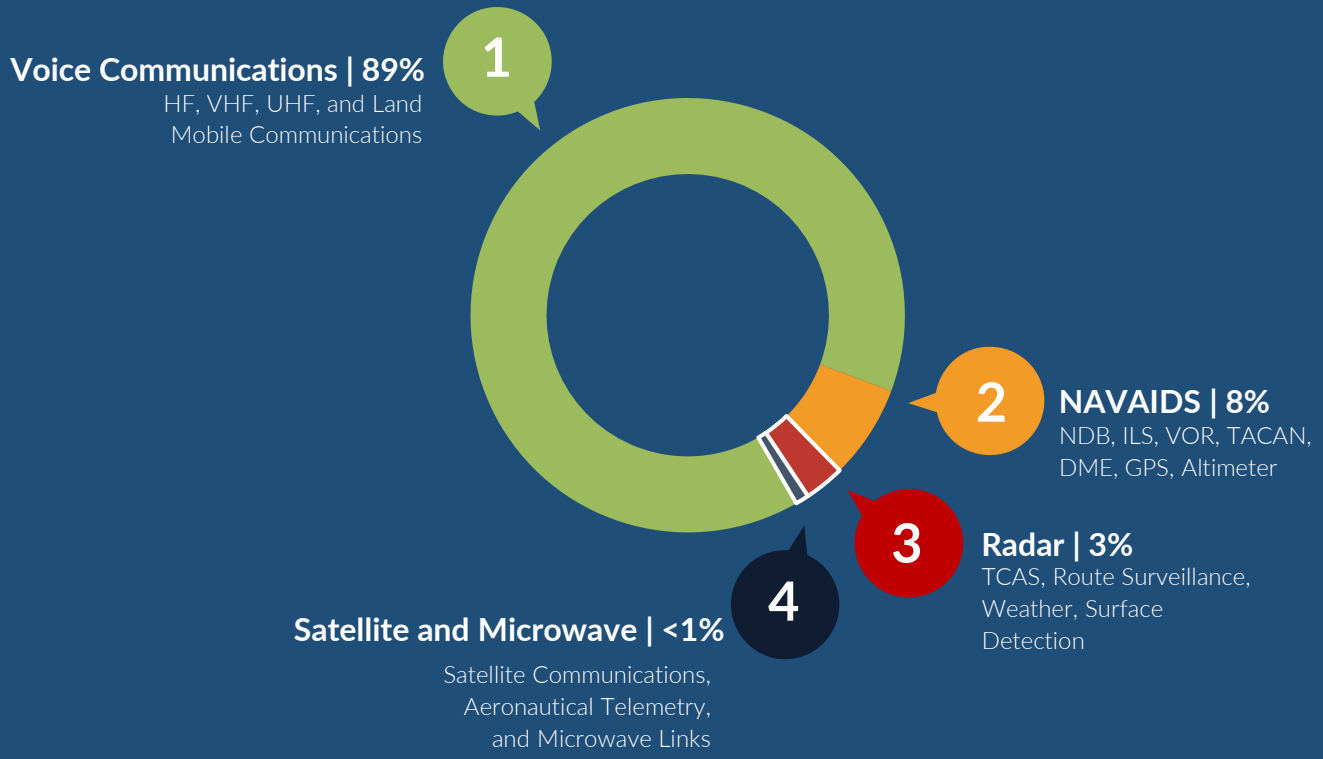
NAS Systems Effected by Percent



Percent distribution for data recorded from January to December of 2018

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The RFI Investigation Art

Spectrum Engineering Specialists doesn't do it all Alone:

Collaboration and Many NAS Experts Contribute Every Day

Airway Transportation System Specialist

Thousands of NAS technicians tasked with systems support for each piece of airspace equipment

Spectrum Engineering trains 60-75 Air Traffic Systems Specialists (ATSS) a year in advanced techniques for the Art of RFI detection, identification, analysis and tracking

ATSS Serve as the first line of defense against RFI, beginning to work RFI from the local level before requesting assistance from Spectrum Engineering

Spectrum Engineering provides and deploys direction finding equipment to ATSS to assist in RFI mitigation

SpectrumEngineering Specialists

10 to 12 overall Spectrum specialists who work the most difficult and severe cases of interference across the nation

Armed with state-of-the-art radio direction finding equipment that is capable of tracking down even the toughest instances of interference

Ultimately responsible for the resolution of each reported instance of radio frequency interference

Travel the country working cases based on the impact of the interference to the NAS

Innovations Accomplished

- RFI Vehicles delivered for daily operational use in the NAS enabling workforce to track RFIs
- eLMS Trainings on-demand to understand Spectrum processes

- Ten Assets Across the Country
- State of the Art Hardware / Software
- Rapid Deployment Upon RFI Cases

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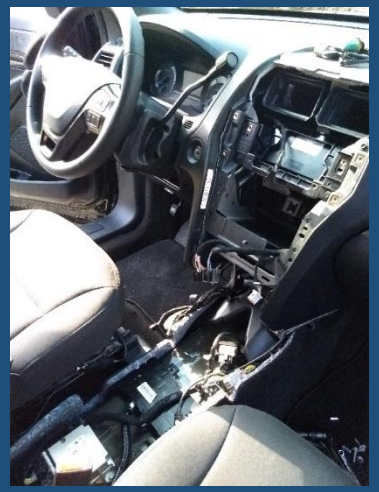
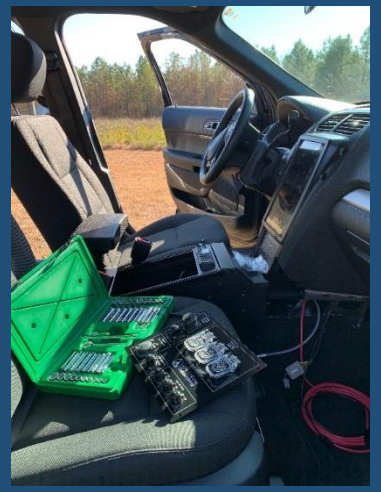
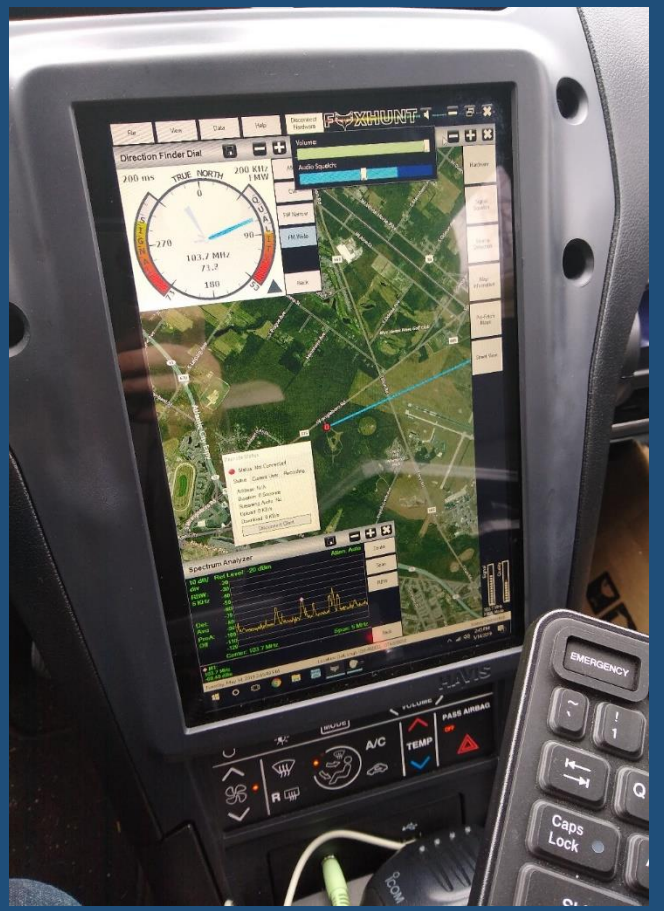
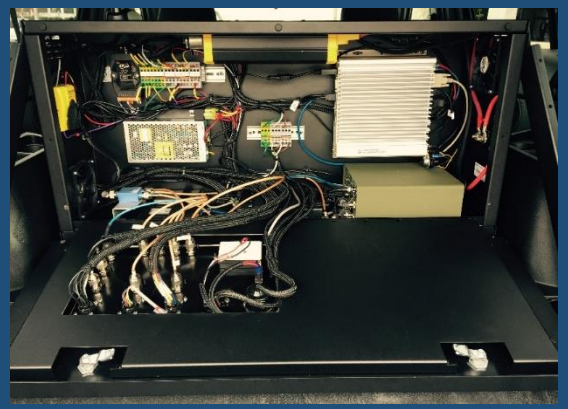
Fully Developed In-House

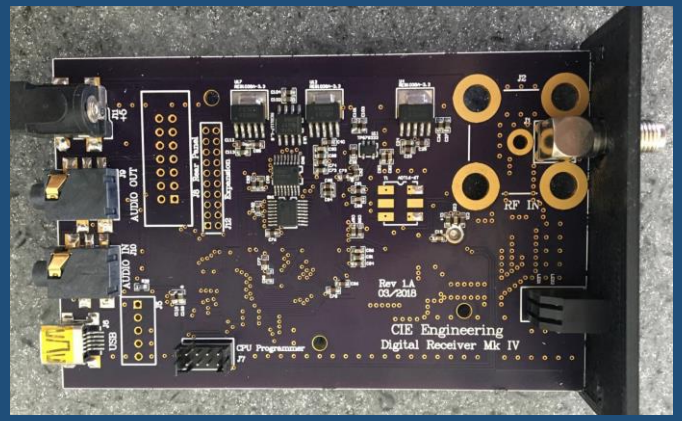








Cost Saving Innovations

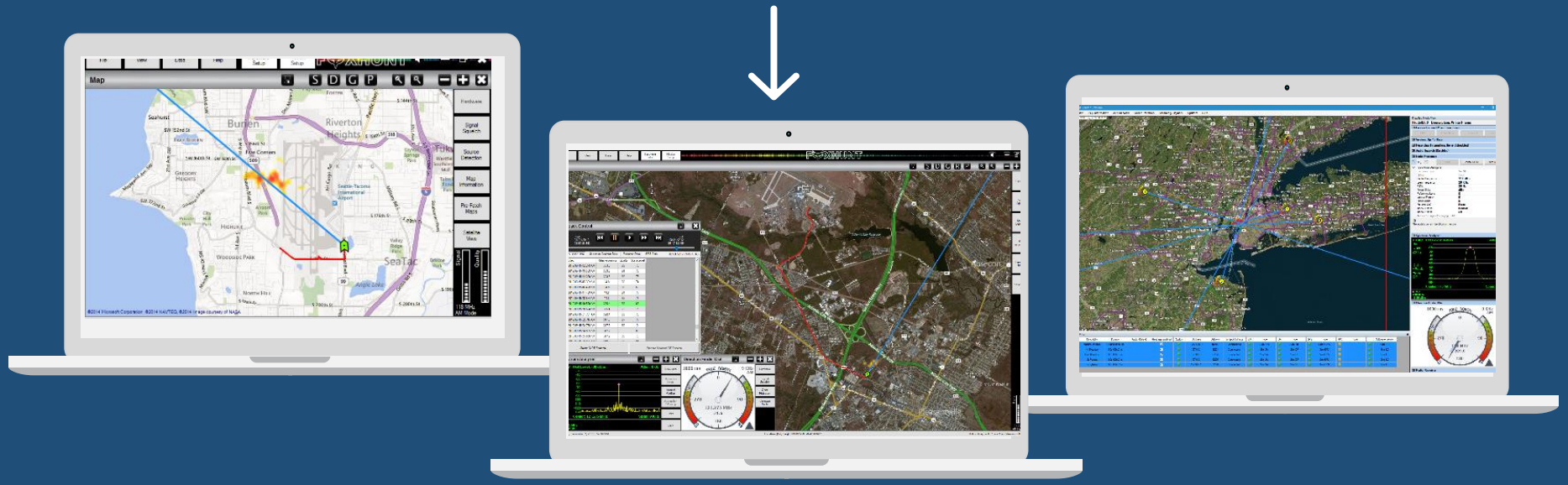


- Designed In-House Direction Finders & Antennas
- Hardware Can be Custom-Built to FAA Mission
- RFI Metrics Drive the Cost-Saving Engineering Decisions
- Cost Reductions Allow for More NAS Deployments
- Larger Foxhunt Footprint Improves Situational Awareness
- Costs Are 15X Lower than COTS Alternatives

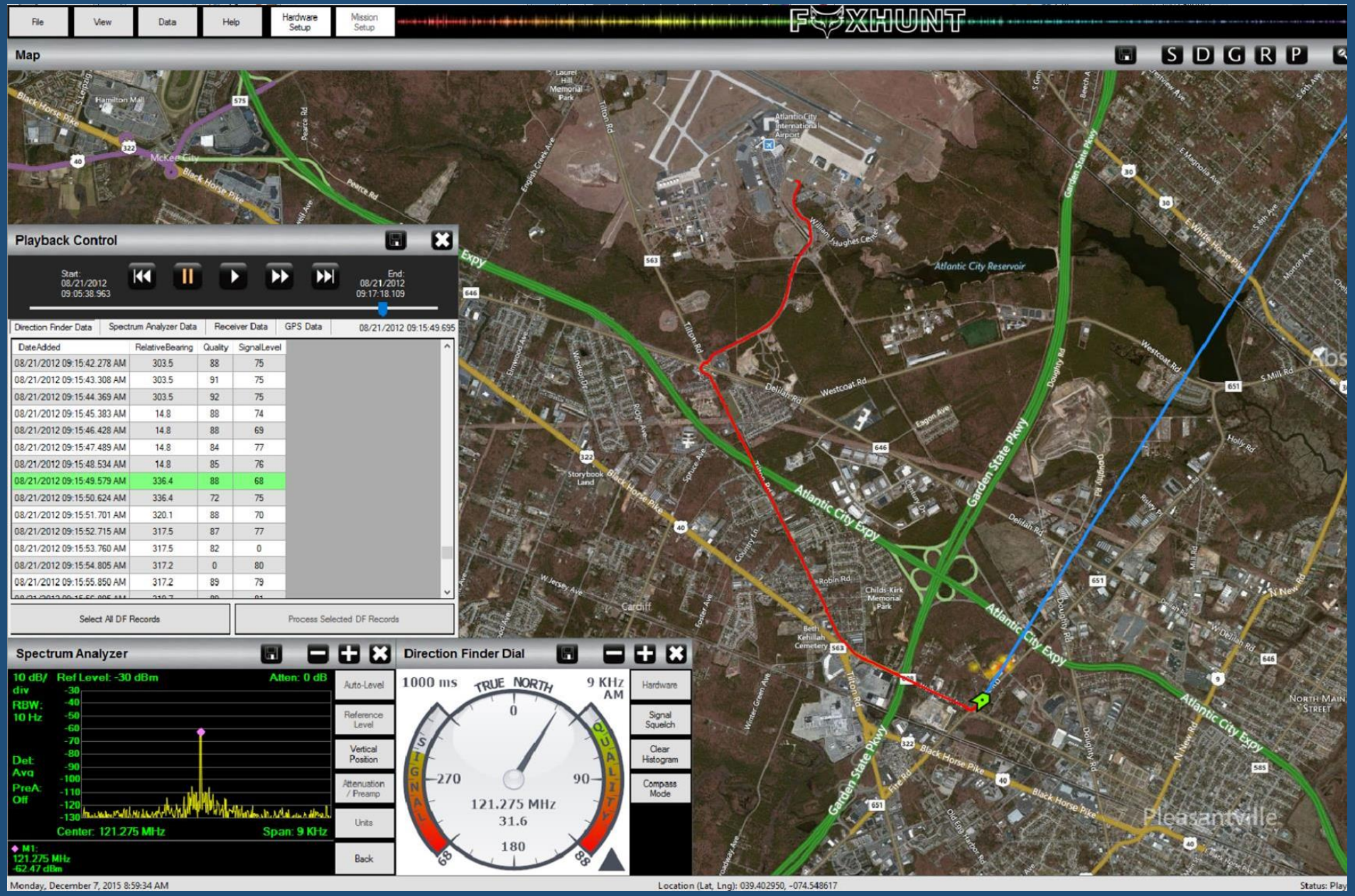
FoxHunt Software Innovation

Purpose-built direction finding software designed in-house at the FAA

Development of a universal radio direction finding software suite was launched in 2011 within the FAA. The goal was to provide a single common interface to multiple pieces of similar RF equipment and to assist Spectrum Engineers by analyzing incoming data to provide real-time analysis of interference.



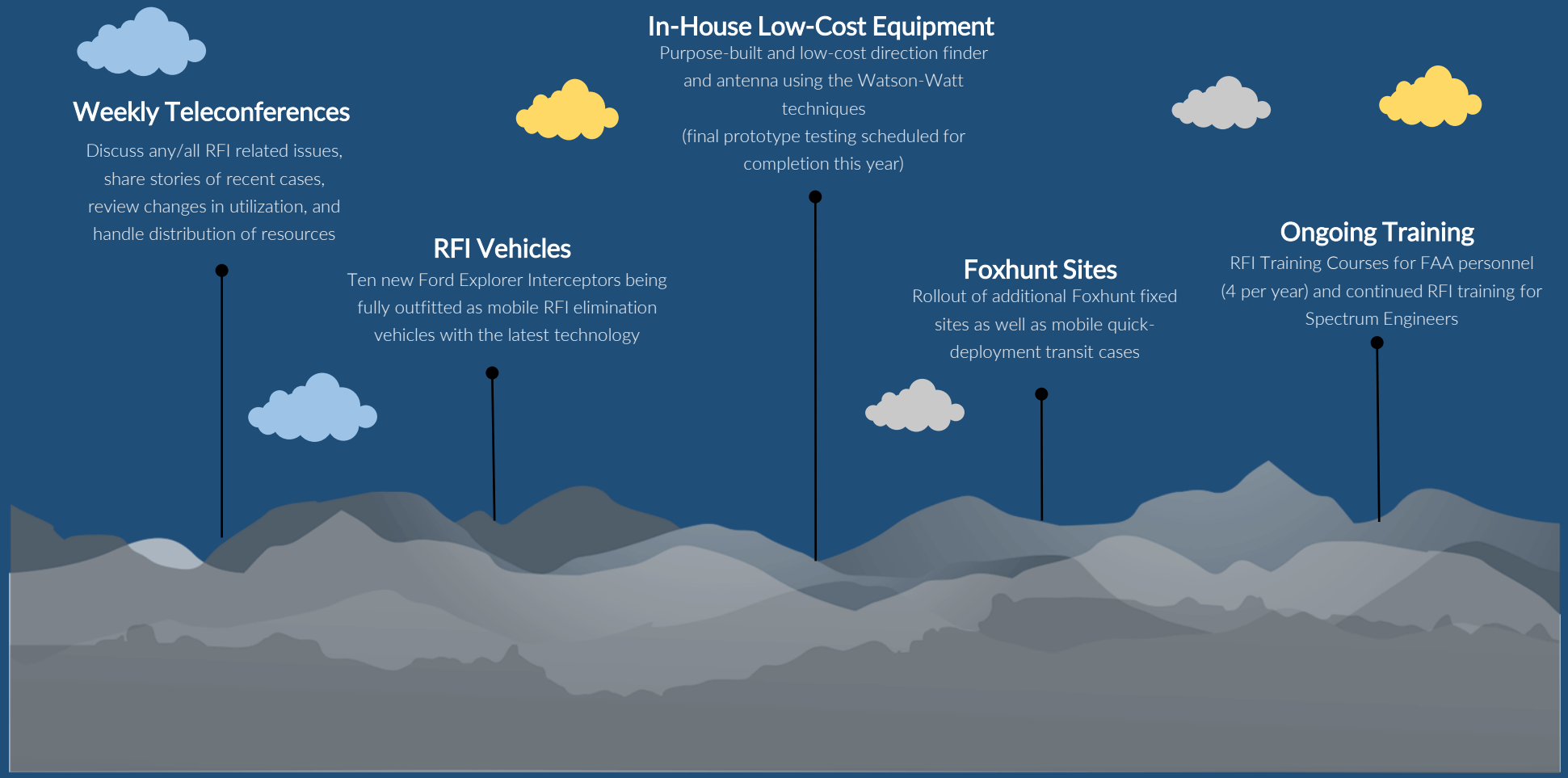
GUI User Friendly Innovations



Enterprise Multi-Sensor Network Innovation

FAA Spectrum Ongoing RFI Efforts

Budget pressure is a primary driver for innovation



Weekly Teleconferences

Discuss any/all RFI related issues, share stories of recent cases, review changes in utilization, and handle distribution of resources

RFI Vehicles

Ten new Ford Explorer Interceptors being fully outfitted as mobile RFI elimination vehicles with the latest technology

In-House Low-Cost Equipment

Purpose-built and low-cost direction finder and antenna using the Watson-Watt techniques
(final prototype testing scheduled for completion this year)

Foxhunt Sites

Rollout of additional Foxhunt fixed sites as well as mobile quick-deployment transit cases

Ongoing Training

RFI Training Courses for FAA personnel (4 per year) and continued RFI training for Spectrum Engineers

SPECTRUM ENGINEERING

Our Automation Tool Suite

We engineer, manage and protect >30,000 frequency assignments in the NAS, so that we can provide sufficient coverage and limit harmful interference. We could not do this without Enterprise Automation. This is Integral to NAS Operations

Automated Frequency Manger – Core of SES:

- Coordination between NTIA, NAVCAN and Mexico
- Advanced Engineering tools and validations protocol
- Complex aeronautical modeling and simulations

Expanded Volume Services Management

- Engineer navigation aid Flight procedure protections
- Manage Extended Service Volume (ESV) Database

Web Frequency Coordination Request Portal

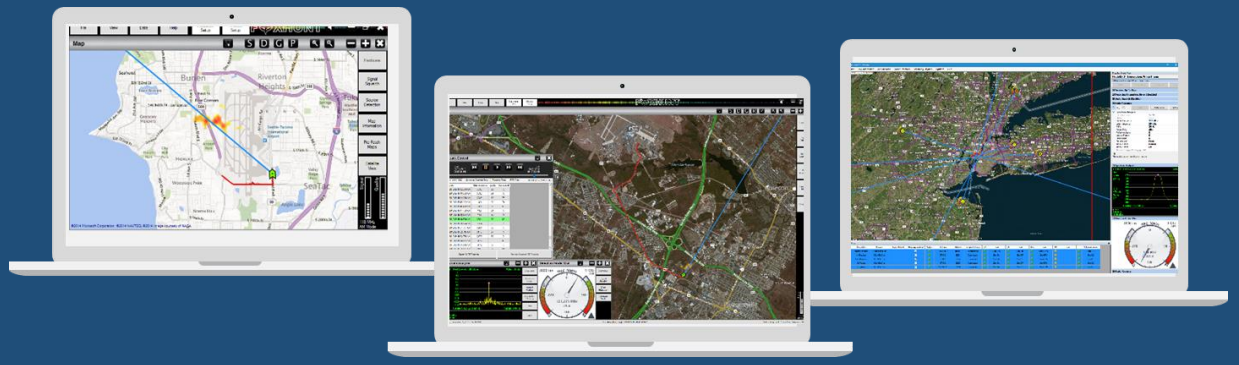
- Coordinate Federal, Military and Non-FED frequency Requests impacting U.S. civil aviation.

Web Facility Transmitting Authorization Application

- Access & Process all FAA Facility Authorizations

Fox Hunt Software:

- Development of mobile performance radio direction finding software suite.
- Provides a dynamic common interface to visualize multiple data sources and to assist Spectrum Engineers by real-time analysis of interference from incoming data



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Challenges

Current Issues & New Entrants

- UAS in the 5030-5091MHz Band
- Engineering and allocation for C-UAS and C-PNT
- 5G C-Band Compatibility with legacy NAS Radar Altimeters
- Link-16/JTIDS Operations and Exercise Support in NAS
- Congested Communications Bands Proposals/Analysis VDL2/3
- Spectrum Efficient National Surveillance Radar (SENSR)

Spectrum Auctions and Sharing

- FCC is “Auctioning the 2.5-2.7 GHz Band”
- Adjacent to ASR and NEXRAD radar at 2.7-2.9 GHz
- 2.7-2.9 GHz previously identified in NTIA repurposing reports

Spectrum Workforce Enhancement

- Knowledge drain through workforce retiring
  - Specialized multi-technical labor force –
  - Need for interagency collaboration –
  - Develop Focused in-house training
- Multiple Technology skilled resources
- Learning of newer emerging Industry technologies
- Need for More Automation Integration (AI/ML) &Tools

Radio Frequency Interference

- Broadband and Digital Phase Shifting protocols - difficult to track and isolate, signals affect multiple frequencies
- Intermittent Signals - create problems in terms of resources waiting for signal to appear for capture.
- High Altitude Reported Signals- expensive to address
- Terminal Doppler Weather Radar Interference Resolution Issue

Initiatives + Innovation

- Completed Spectrum Strategic Plan for FY21-25
- Delivered RFI Vehicles fully in-house developed for high performance use enabling better accuracy to track & resolve RFIs
- Deployed FoxHunt software suite providing a single common interface for multiple RF subsystems and equipment assisting Spectrum Engineers in real-time analysis of NAS interference
- Innovative Elements Include:
  - In-House Designed Direction Finders & Antennas
  - Use of RFI Metrics to drive the Engineering Decisions
  - Custom-Built hardware aligned to FAA Mission
- Spectrum Processes eLMS Trainings available on-demand
- Business goal for FAA Spectrum to develop more training material
- Ongoing training sessions across the CONUS for Spectrum Tools
- Outreach events with DOD on Frequency Coordination processes
- Integrate technologies (AI/ML) to more efficiently manage Spectrum

WE THANK YOU!

Michael W. Weiler

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Federal Aviation Administration

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https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/safety_ops_support/spec_management