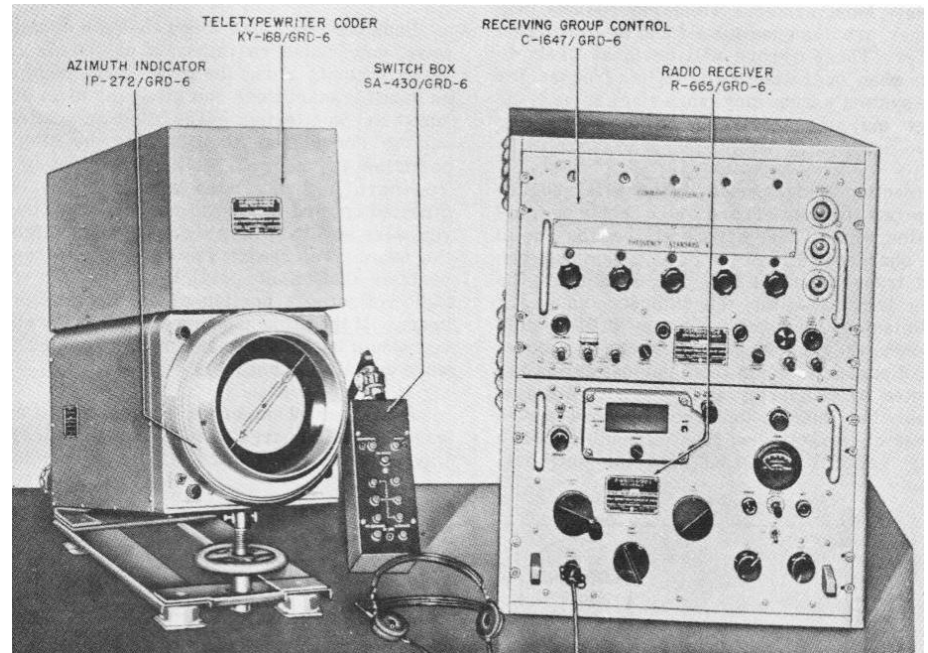
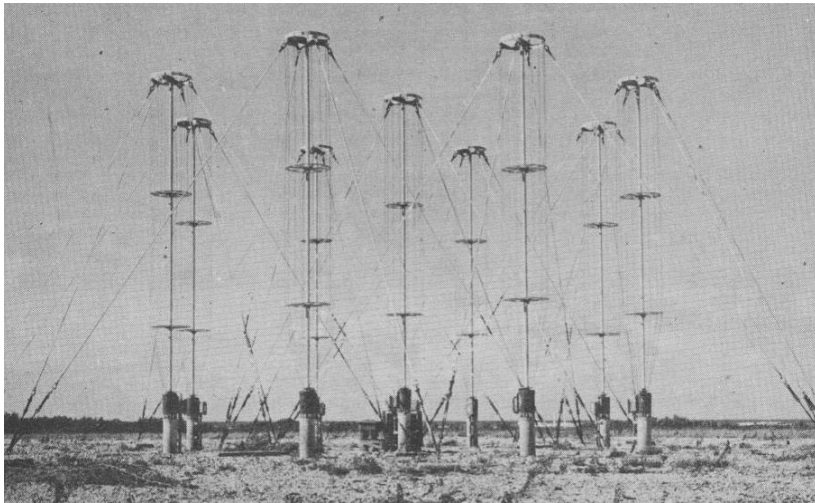


# High Frequency Direction Finding HFDF



# On Target Enterprises Overview

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- Woman-Owned Small Business
- Cocoa Florida Main Office
- Receiver development laboratory
- System test ranges
  - 500 acre open field range in Colorado
  - 15 acre jungle range in Florida
- Products
  - MISER: UHF/VHF detect/DF/record
  - WATCHDOG: HF detect/DF/map/record
  - SentryGo: Marine Navigational Radar detect/DF/characterize

# Direction Finding

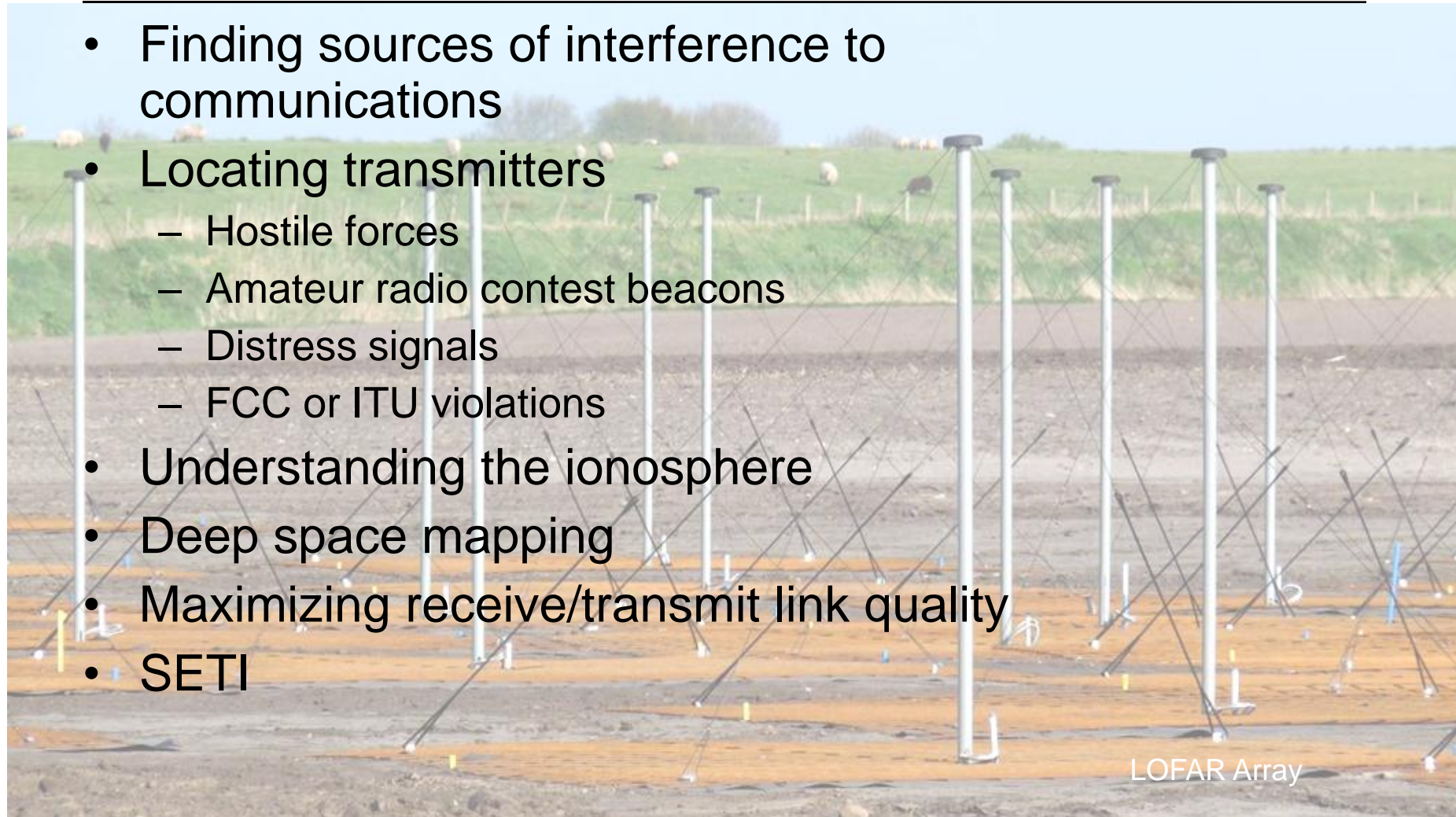
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- What is Direction?
- Azimuth and or Elevation
- Polarization
- Time (or time difference)
- Frequency (or frequency difference)
- Vector Space
  - Complex difference of signals between antennas



# Applications of HF Direction Finding

- Finding sources of interference to communications
- Locating transmitters
  - Hostile forces
  - Amateur radio contest beacons
  - Distress signals
  - FCC or ITU violations
- Understanding the ionosphere
- Deep space mapping
- Maximizing receive/transmit link quality
- SETI



LOFAR Array

# Classic Challenges to HF DF

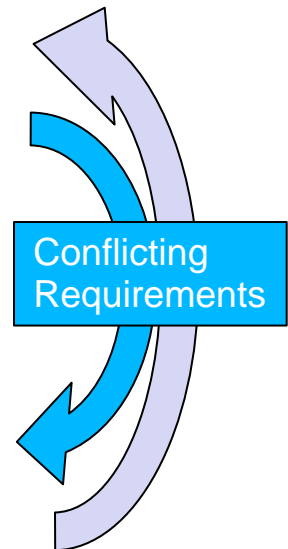
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- High interference
- Long wavelength (large footprint)
- Propagation variance
  - Atmosphere and Ionosphere
  - Time delay, Doppler
  - Polarization rotation, birefringence
  - Aggregate propagation paths
- Multipath
- Wide fractional bandwidth



# Tactical HF DF Challenges

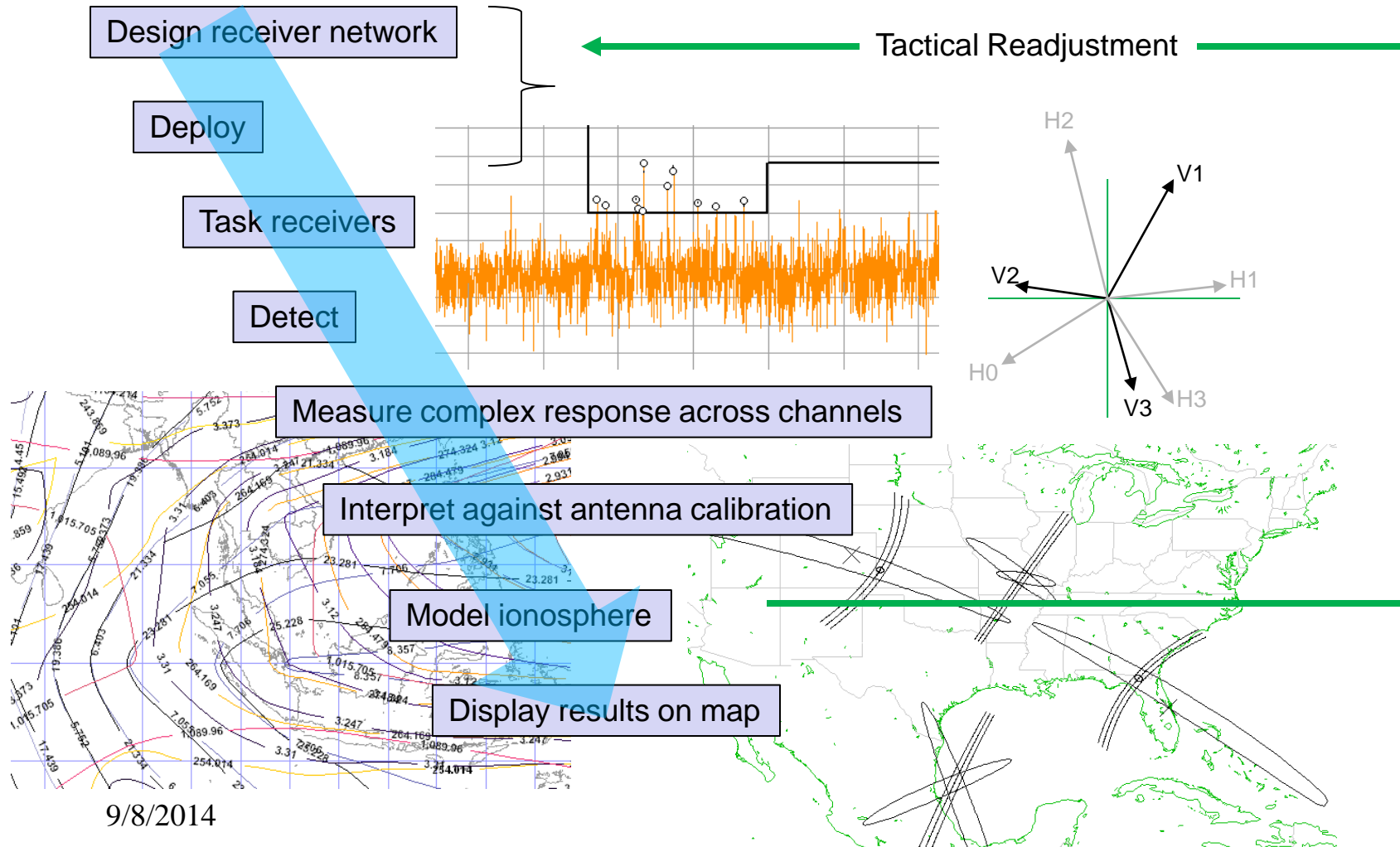
- “Tactical” systems need to be
  - Light weight, low power
  - Economical
  - Rugged, repairable
  - Quick to deploy, easy to use
- HF DF systems must exhibit
  - Sensitivity to weak signals (requiring large antennas)
  - Large dynamic range (requiring significant power)
    - In the presence of high interference across large bandwidth
  - Channel measurement accuracy (to determine “direction”)
    - Requiring large separation between antennas
  - Some method of calibration
    - To angle and polarization



# Technologies Applicable to Modern HF DF

- Active Antennas
  - Small, E or H field, no mutual impedance
- Fast Analog to Digital Converters (ADC)
  - Low power, high precision
- High speed data acquisition, transfer, storage
  - USB, Ethernet,
- Fast Digital Signal Processing (DSP)
  - Special purpose hardware, software, FPGAs
- Widely distributed time synchronization
- Wide area/bandwidth networking

# The HFDF Process





# On Target Enterprises

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## ***Services***

- System analysis
- Conceptual design
- Proof of concept
- Critical element demonstration

## ***Products***

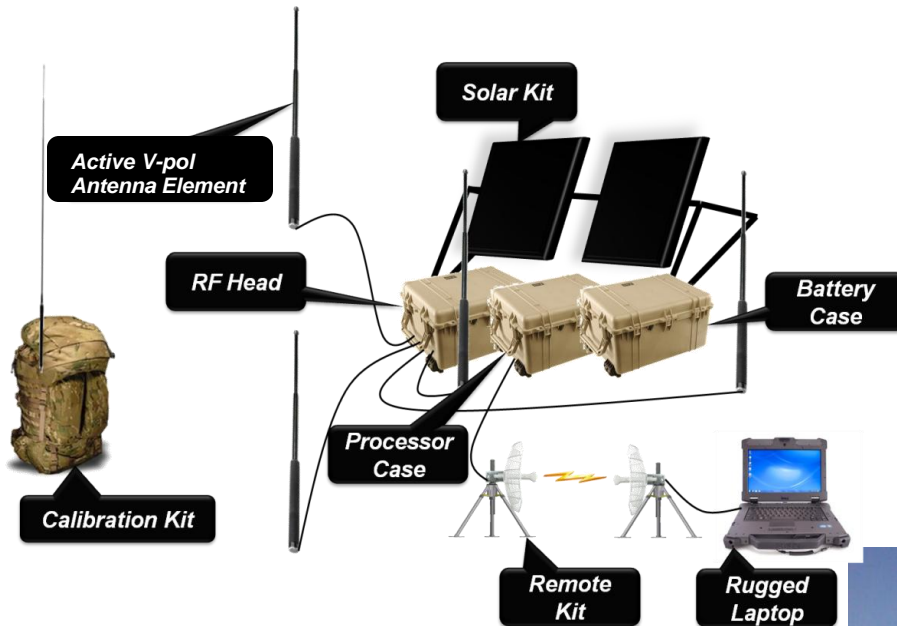
- Tactical radio detection and DF
- HF, UHF/VHF, microwave
- Small, lightweight, modular, rugged
- Low cost per unit
- Broadband access
  - Wideband continuously
  - Narrowband precision tasking
- Power solutions; battery, solar, shore
- Real-time monitoring and recent activity logging
- Integrated processing and laptop GUIs
- Field level
  - Array configuration
  - Software module interaction
  - Networking
  - Troubleshooting, repair

# HF System Modules

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- N-Wideband channels (50 MHz)
  - Coherent, time-synchronized, snapshot processing
  - 1 to 3 KHz frequency resolution
- M-Narrowband channels (11kHz to 200 kHz)
  - Slaved to wideband system
  - Coherent, time-synchronized, continuous processing
  - Arbitrary frequency resolution
- Worldwide tactical mapping
  - Array planning, site selection, accuracy prediction
  - Real time tactical display
  - Playback with customized processing of multichannel narrowband
- TDOA/FDOA narrowband time-tagging
  - Correlation processing
  - Self calibration, maintenance, and ionospheric monitoring from ionosondes
- Polydimensional analyzer (PolyAna)

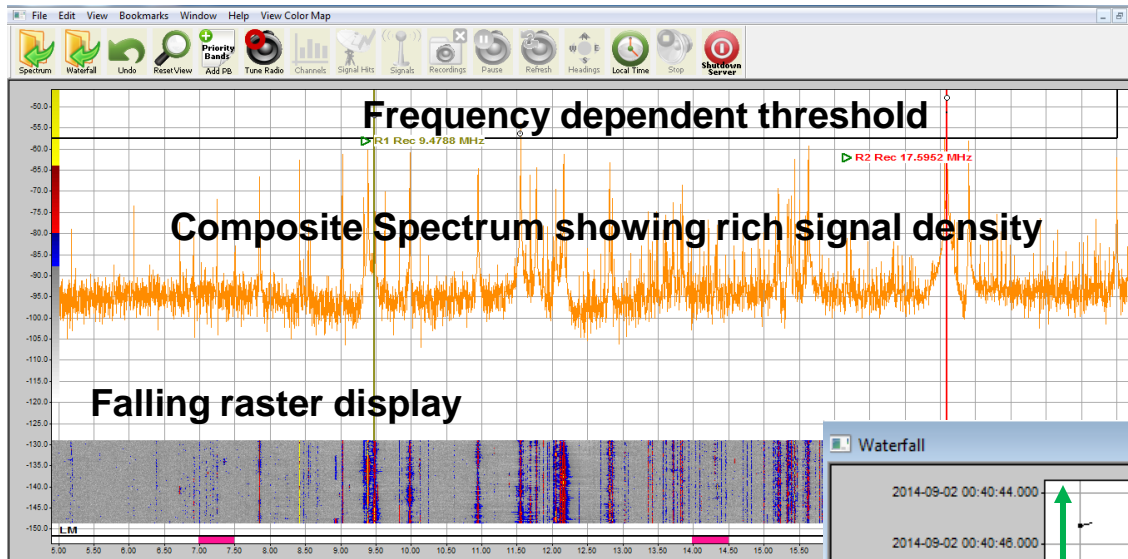
# Possible Deployment



- Polarization and array spacing driven by frequency range of interest
- Deployed, calibrated by two people in 1 hour
- Small SUV transportable
- 24/7 operation with solar/batteries

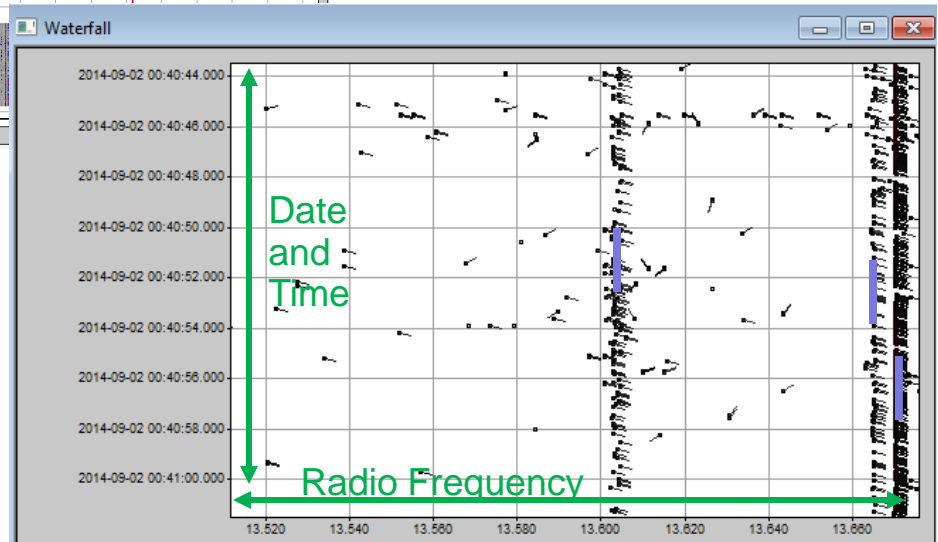


# Possible Operating Modes



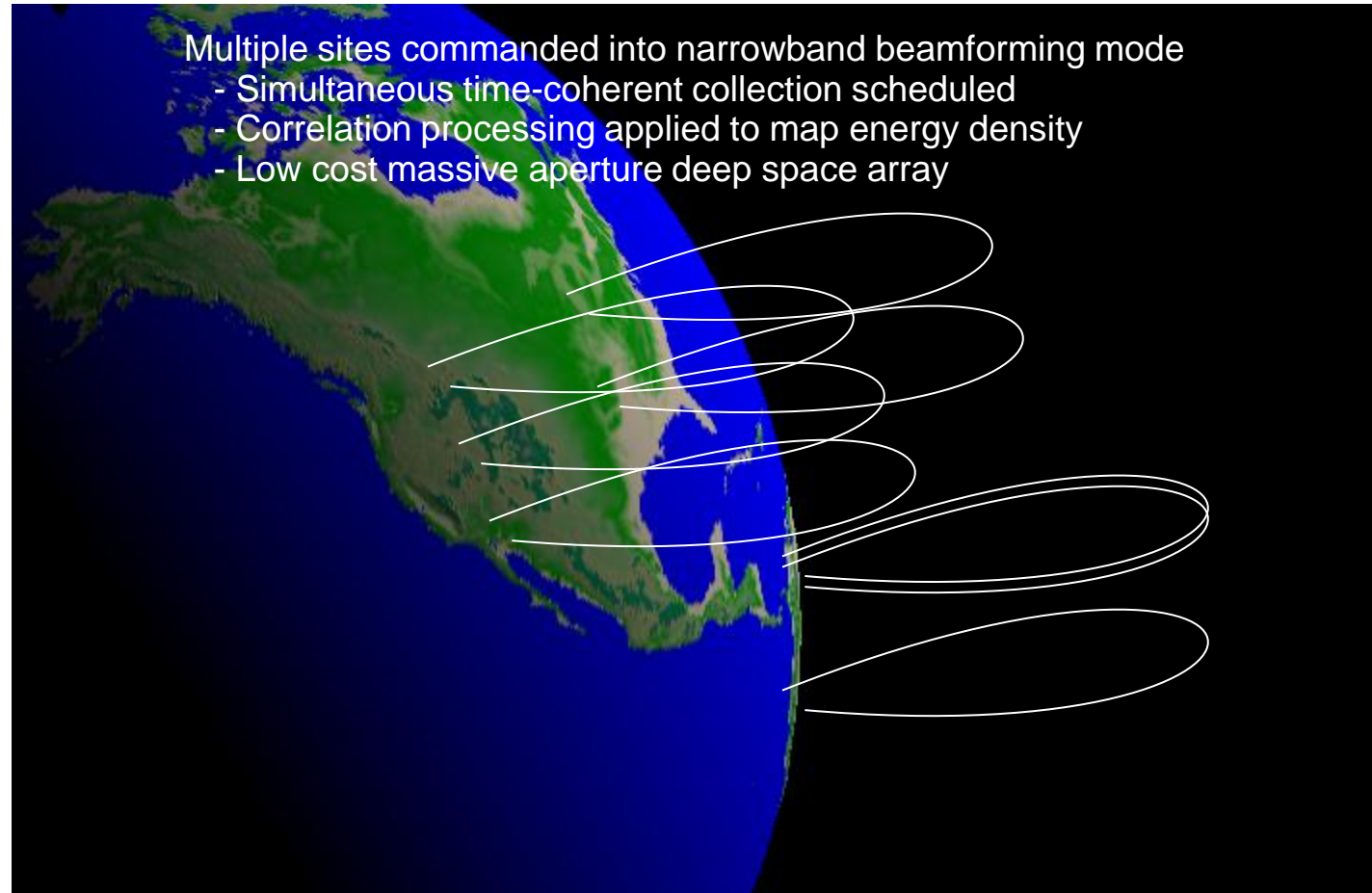
- Real-time full HF spectrum monitoring
- DF all signals simultaneously
  - Adjustable threshold vs frequency
  - Detections, DFs, etc. stored
  - Self triggered narrow band analysis

- Multi-day environment analysis
- Display every signal hit with DF
  - More than two weeks of data storage
  - Narrowband analysis overlays



# Possible Operating Modes

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# System Performance and Accuracy

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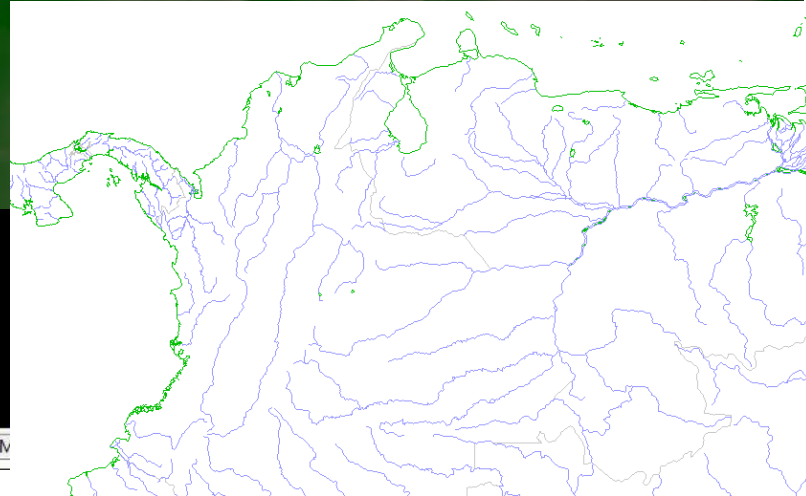
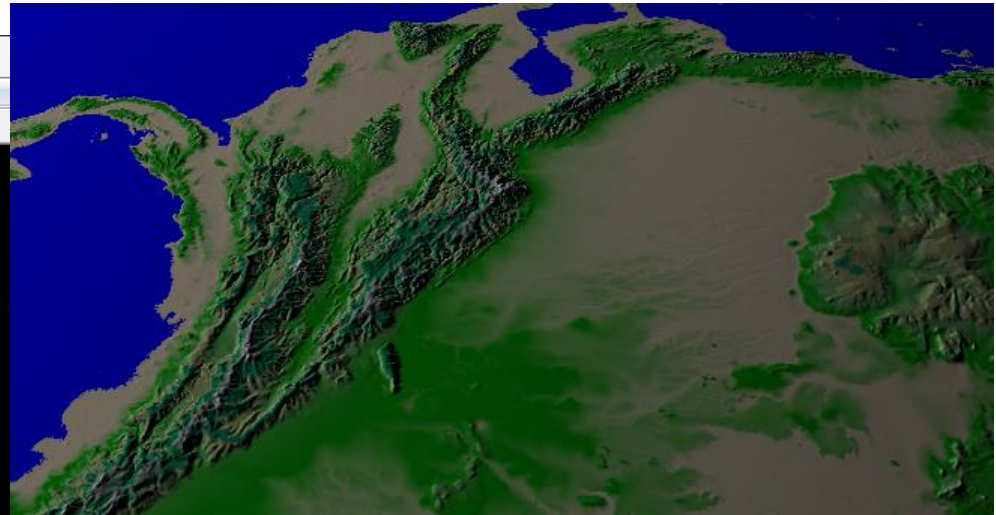
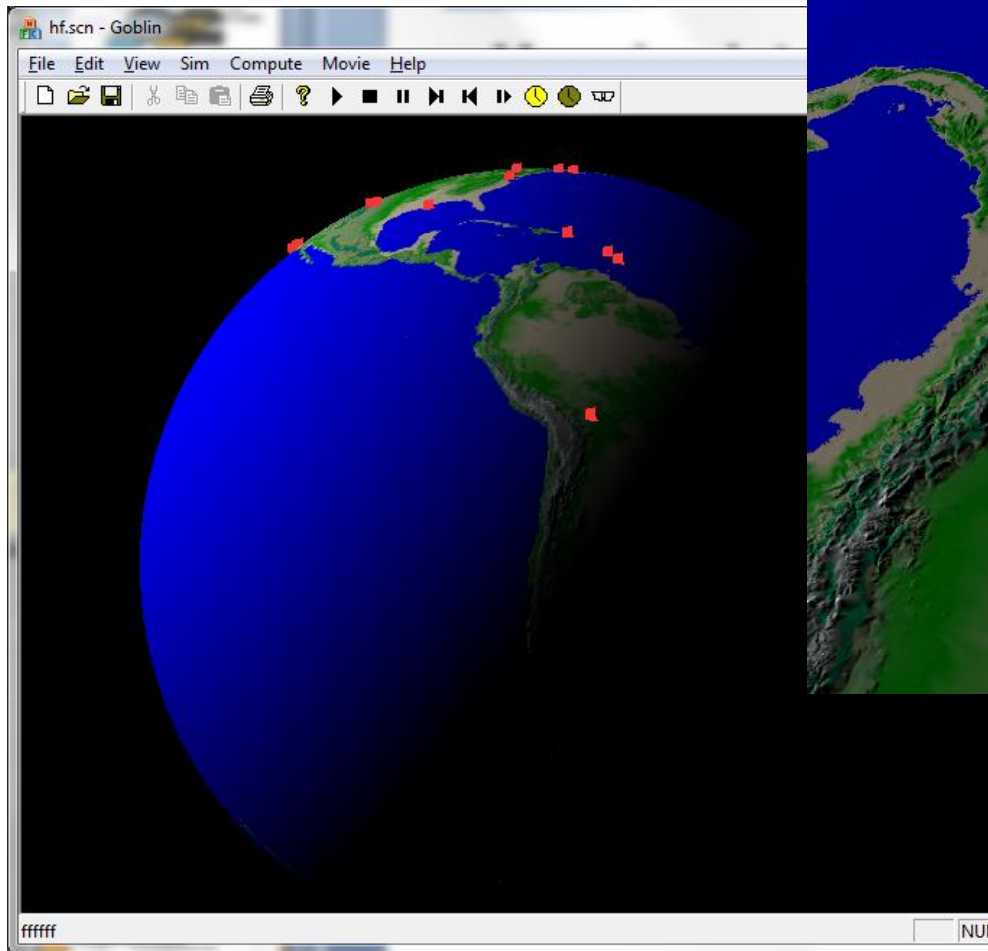
## ***Performance measure***

- Sensitivity
- Amplitude, phase accuracy
- Wavefront angle accuracy
- Incident polarization
- Solution delay
- Transmitter location solution

## ***Limiting Aspects***

- Noise
- Interference
- Signal Characteristics
  - Frequency, bandwidth
  - Transmitting power
  - Up-time
  - A-priori knowledge
  - Movement
- Selection of array elements and geometry
- Ionosphere characteristics and model
  - Real-time updates
  - Processing power
  - O vs. X propagation modes
- Inter-system network bandwidth
- Number of systems deployed
- Ability to relocate receivers
- Observables measured and processed
- System calibration

# Mapping Interface



# Thank You

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- John Hoover
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