Mission Assurance in GPS Denied Environments

Mission Assurance

Agenda

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- Challenges of the EW threat environment
- Capabilities to mitigate jamming and spoofing
- Situational awareness and signal intelligence
- Summary

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Challenges of the EW threat environment

Global Navigation Satellite Systems

Precision Position and Timing

Primary method for precise Position, Navigation, and Time (PNT)

GNSS signals are critical to platform navigation and timing functions

GNSS are a low power signals – vulnerable to interference

Global Navigation Satellite Systems

How GPS Works

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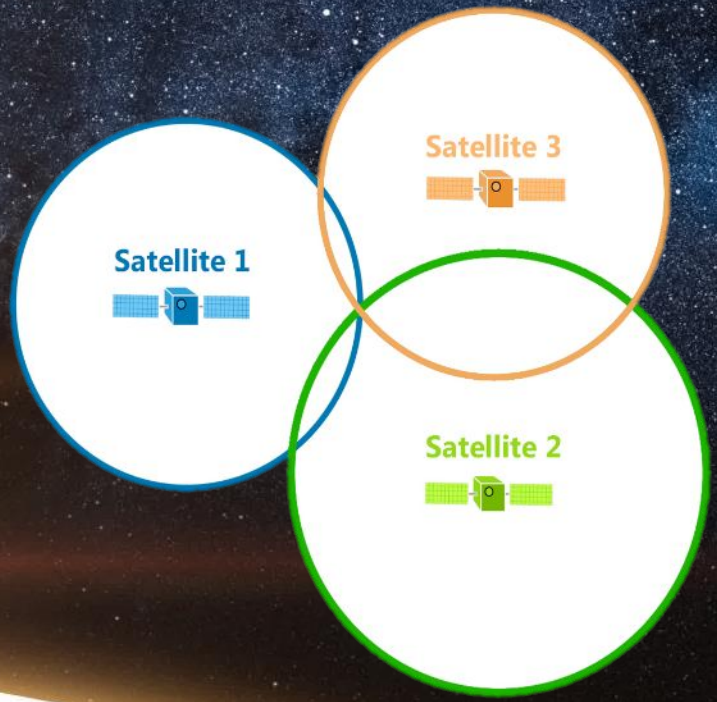
- 24+ operational satellites in orbit
- Average 12 satellites in view
- 4 satellites needed to triangulate position
- More satellites = better position accuracy



Global Navigation Satellite Systems

What are the different GPS codes

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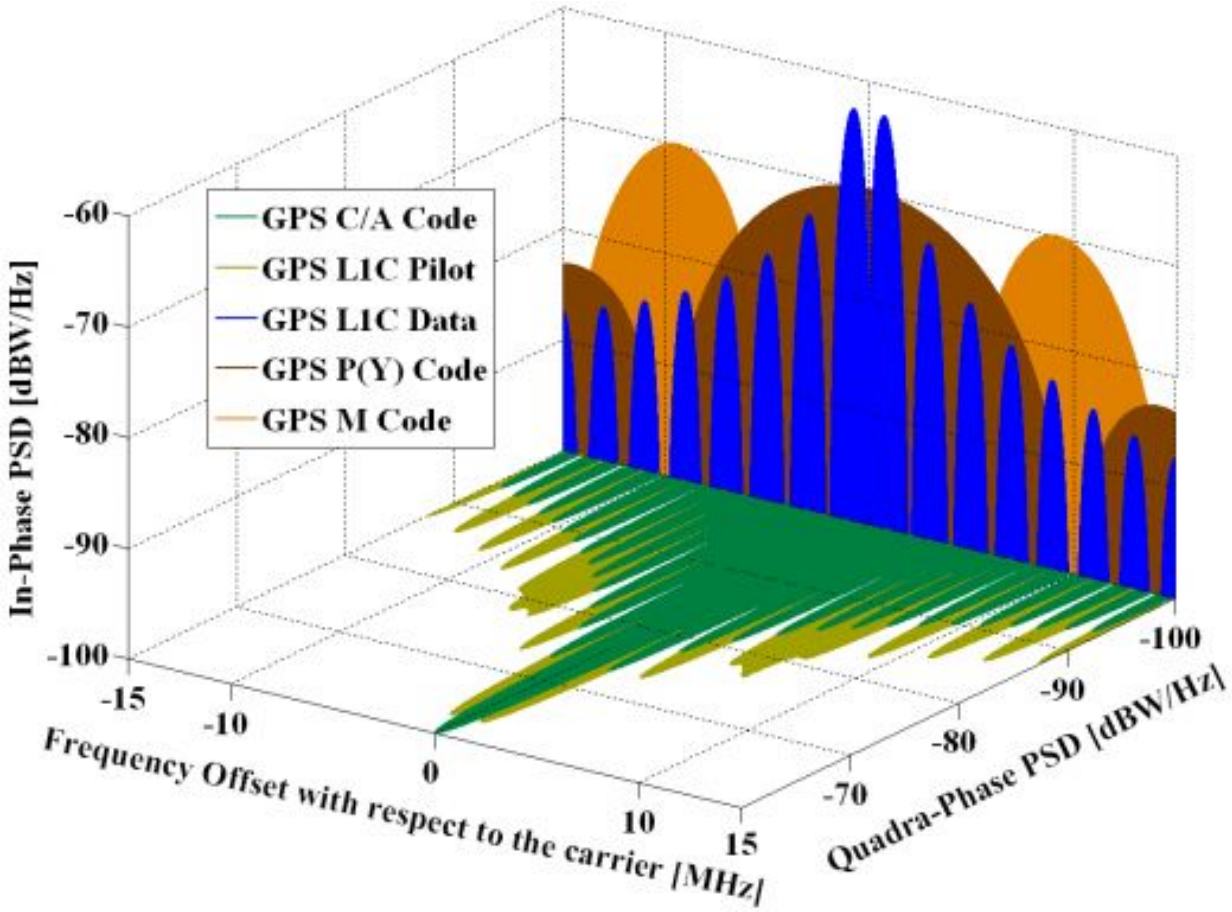
- Civilian Codes:
  - L1 C/A : Original civilian code.
  - L2C : New code for improved reliability and position precision.
  - L5 : New code for Aviation Safety
- Military Codes (encrypted):
  - P-code : Legacy Military code
  - M-code : New Military code



The Threat Environment

Electronic Attacks

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REPORT

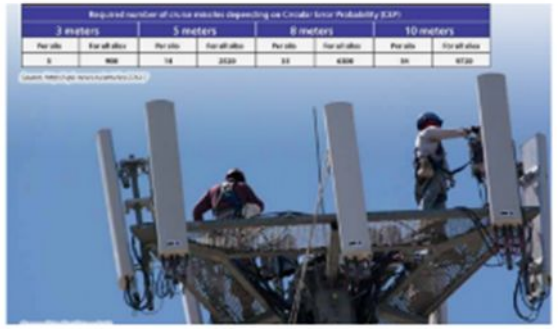
War-Zone GPS Spoofing Is Threatening Civil Aviation

A surge in spoofing from the Middle East to northern Europe is throwi
navigation systems off course

FORBES > BUSINESS > AEROSPACE & DEFENSE

GPS Spoofing in the Middle East Is Now Capturing Avionics

Russia will place GPS jammers on 250,000 cellphone towers to reduce enemy cruise missile and drone accuracy in the event of large scale conventional war



Tweet

Pin It

Russian Jamming System Blocks All NATO Electronics Inside Bubble 600 Km in Diameter over Syria

Cyber attacks on shipping rise amid geopolitical tensions

State-backed hackers present a fresh threat to an industry that has long faced security concerns

The Dangerous Rise of GPS Attacks

Thousands of planes and ships are facing GPS jamming and spoofing. Exp
networks, and more.

BT identifying 2,000 signals a second indicating possible cyber-attacks

Increase comes amid 'AI arms race' between hackers and businesses attempting to bolster their defences

AVIATION NEWS

GPS Spoofing Signals Traced To Tehran

Oct. 21 2016 - 03:10

The Kremlin Eats GPS for Breakfast

Why geolocation in central Moscow has become a real headache

Russia accused of EU and Nato cyber-attacks

Reuters

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Airline industry to meet in January over GPS spoofing spike

Cost of Living | War in Ukraine | Climate | UK | World

Technology

Study maps 'extensive Russian GPS spoofing'

Critical incident over London hospitals' cyber-attack

The Threat Environment

Specific Methods

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Jamming

- High power signals
- “Deafen” the receiver / drown out the wanted signals
- Very easy to generate (even unintentionally!) – don’t need any information content
- Stops the GPS from maintaining lock to the satellites
- Inertial systems may be available for back-up for short periods

Spoofing

- Signals that resemble legitimate GPS signals but are intended to “seduce” the receiver with erroneous information
- Much harder to generate effectively but may be lower power signals
- Receiver may not know it’s being attacked

Mitigating Threats: Jamming and Spoofing

Jamming Protection

Suppression of high power signals

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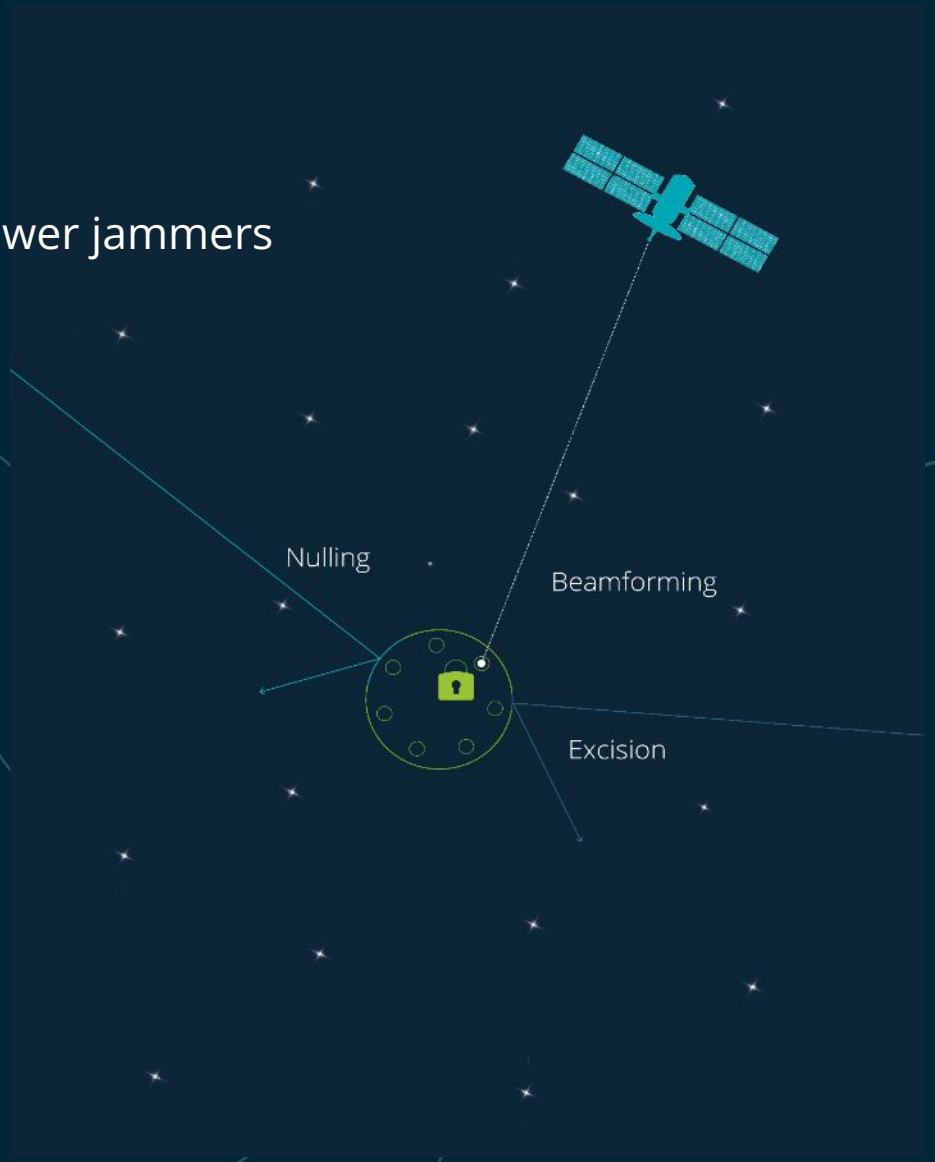
- There are two common spatial to provide protection against high power jammers

Nulling

- Detection and suppression of jamming signals
- Up to (N-1) directional nulls (N = number of antenna elements)

Beam steering

- Track available satellites by focussing a beam on each one
- Requires close coupling with the EGI receiver
  - Position of satellites
  - Orientation of platform
- Absolute performance is a function of the aperture size
- High performance but Increased processing overhead



Rotary Wing Considerations

Effects of rotor modulation

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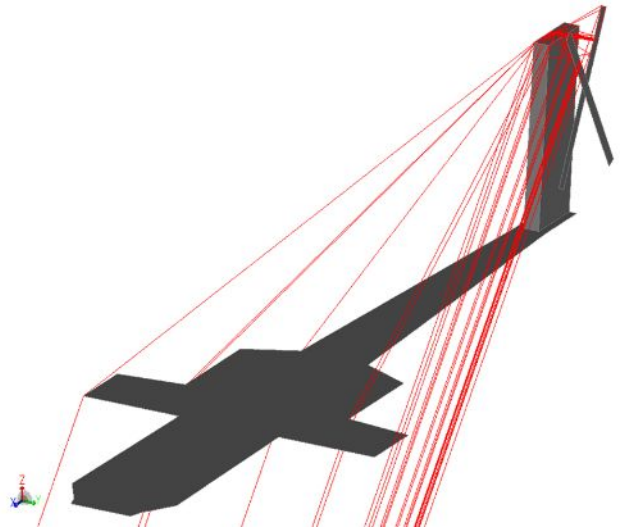
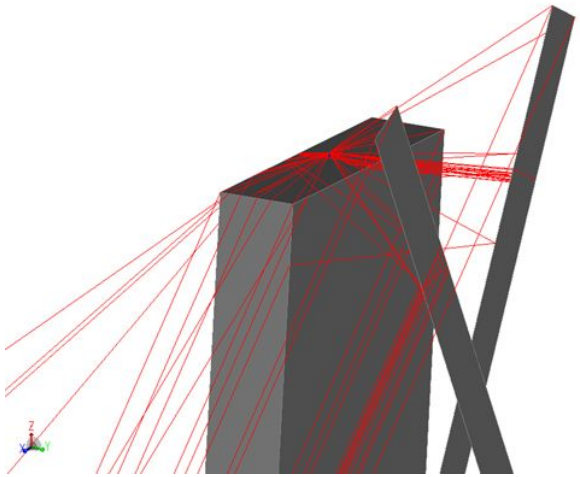
- Rotary wing suffers from multipath effects from both rotors



- These are rapid, transient effects that will look like additional jamming sources

- Consideration is needed to ensure that the algorithm can cope with a fast changing environment



Spoofing Protection

Detection and suppression

- Spoofing signals are lower power than jamming signals and are harder to detect
- Effects of a spoofing attack may be harder to spot than jamming

Approaches to Detection

Multi-Constellation
compare PNT data across sources

Receiver Detection
multiple signals in the correlator

Signal protection
cryptographic methods for verifying signal authenticity

Array methods
detect and suppress the spoofing source

Live Skies Data

Anti-Spoof Capability

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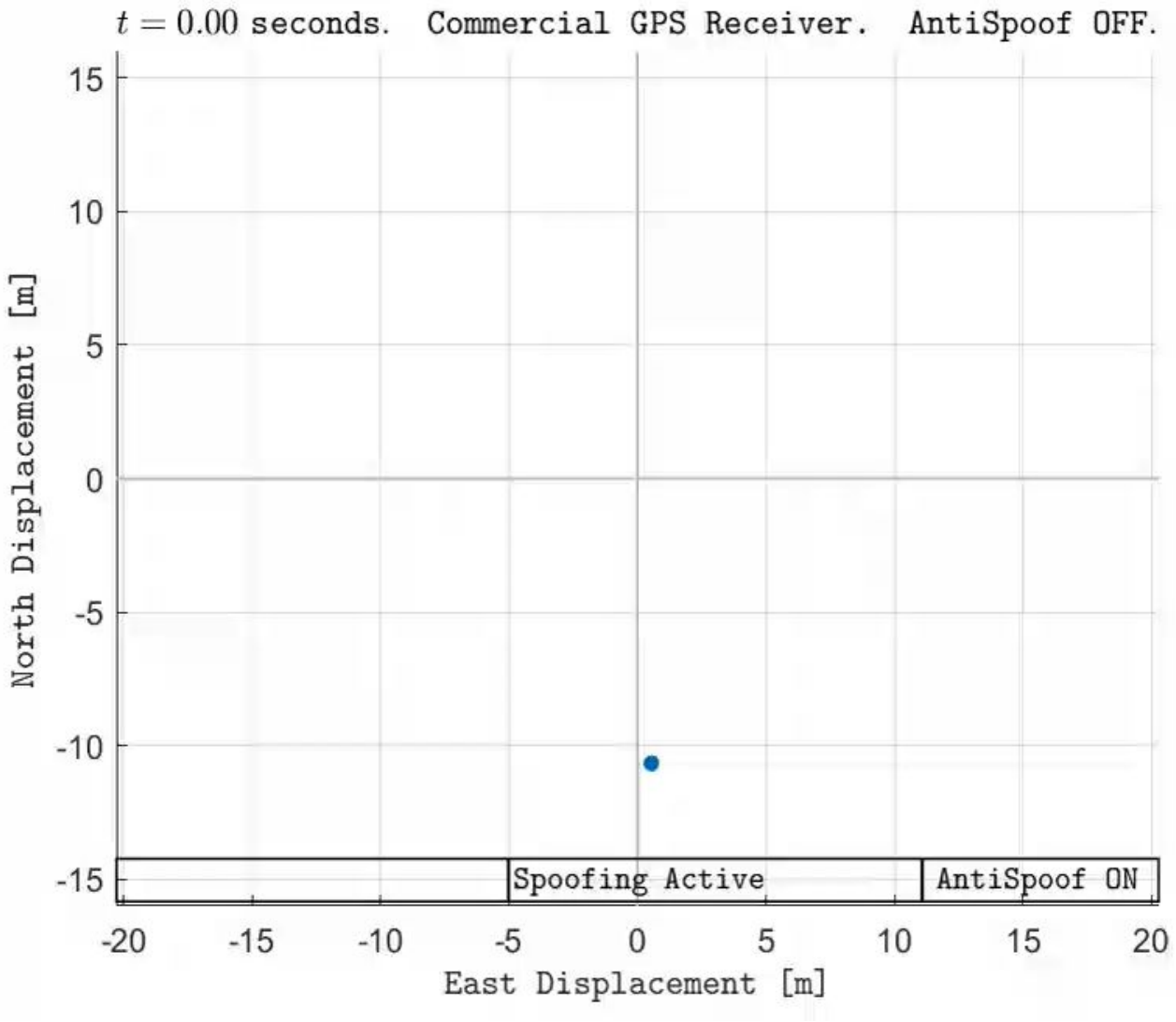
- Capability tested against sophisticated spoofing attacks.
- Capability protected receiver in all cases.
- All receivers captured by spoofer when unprotected.

REAL WORLD TEST DATA



Situational Awareness

Signal Intelligence #1

Detection and Direction

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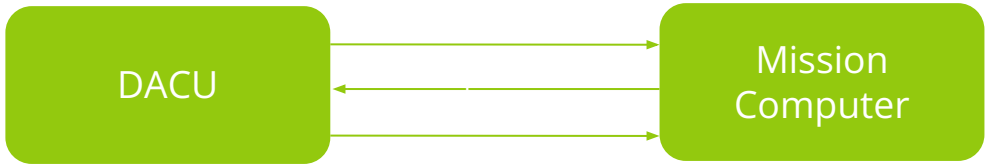
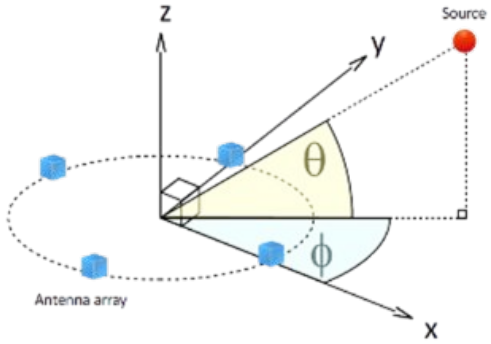
- **Jammer Detection:**
  - Tactical warning
  - Situational awareness

- **Direction Finding:**
  - The system employs the MUSIC algorithm to provide jammer bearing
  - This provides a bearing in azimuth and elevation relative to the antenna
  - The mission computer can then convert to an absolute bearing
  - Overlay of absolute bearings will generate a Position Fix






```
Manifold OK: Y
Data valid: Y
Operating band: L2
Num jammers: 1
DF executed: Y
Num directions: 1
Dir   0: Azim =  10, Elev =   0, Metric = 9498
```

Signal Intelligence #2

Advanced Functions

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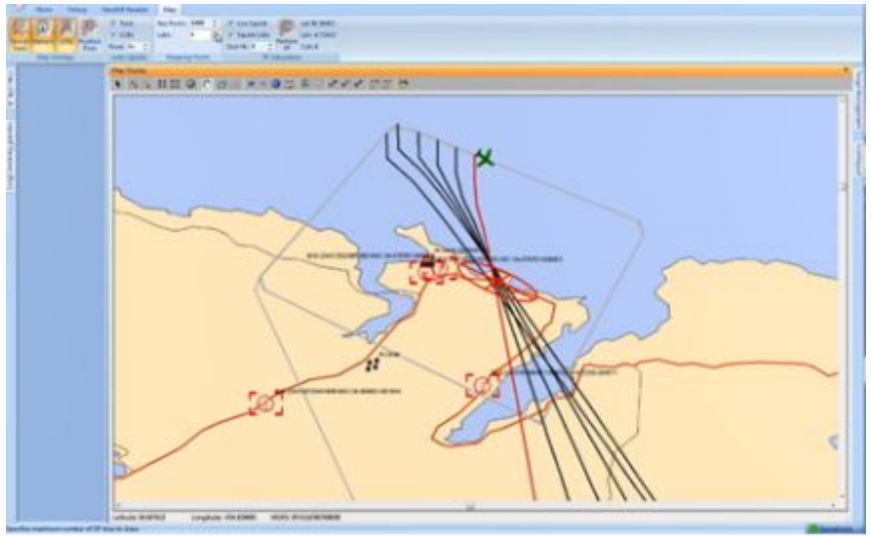
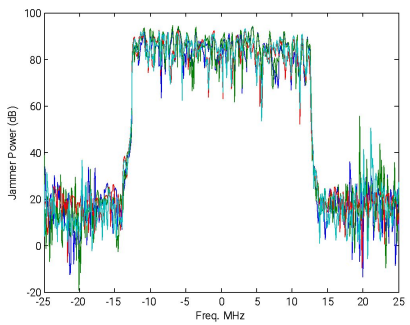
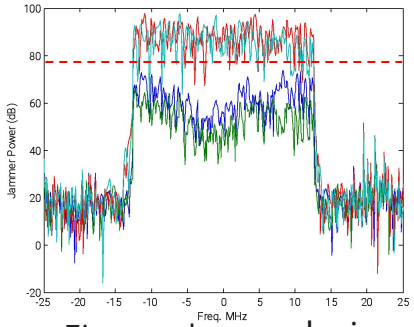


- Signal Capture
  - Record and playback I&Q data of digitised jamming waveforms
  - Supports Specific Emitter Identification (SEI)
  - Allows performance evaluation against emerging threats
  - (supports algorithm enhancements for a software defined platform)
- Spectral Decomposition
- ty

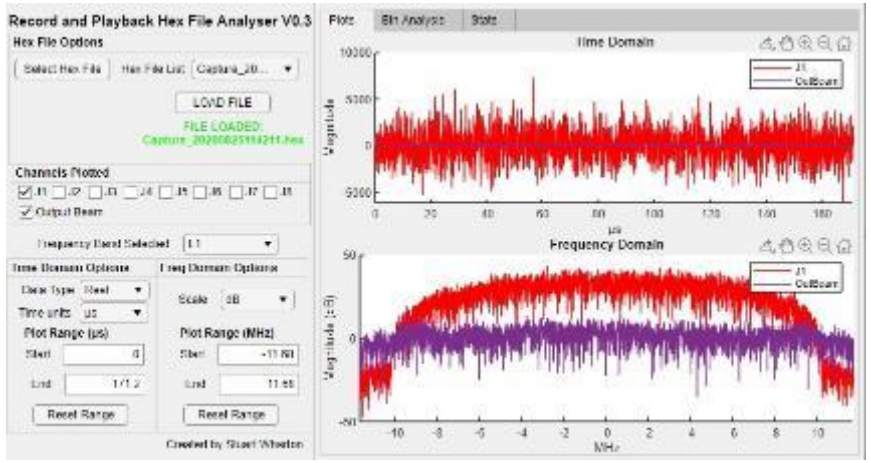


Rx signal per antenna

Spectral decomposition



Eigen-value analysis



Summary

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