Darren Nicholls - CRFS

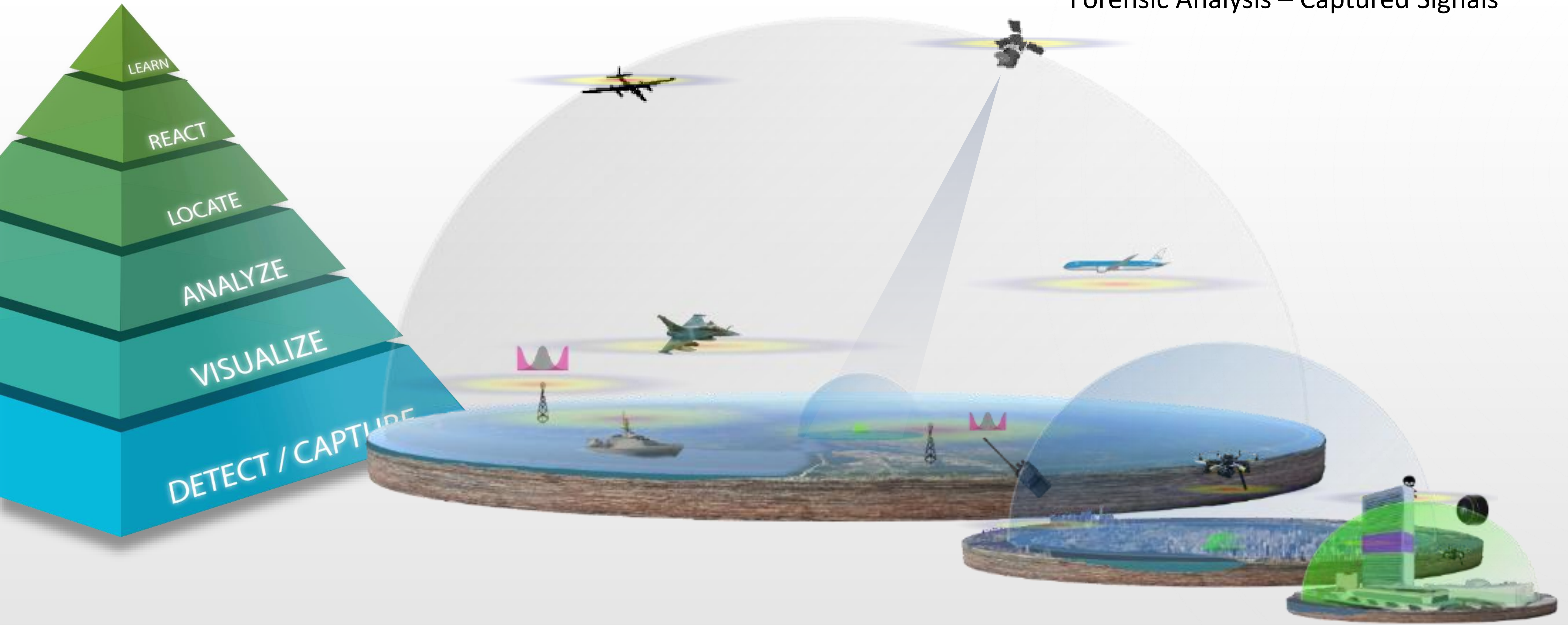
Augmenting existing radar and air defense systems

Maximizing operational life, and filling capability gaps while delivering rich intelligence

Spectrum Dominance

Key elements for successful spectrum dominance

Wide Area Monitoring
Macro/Urban Monitoring
Micro Monitoring – Compounds & TSCM
Forensic Analysis – Captured Signals



OV-1: Operational View - Wide

CRFS Concept of operations

Wide Area Monitoring:

- Marine Surveillance
- Air Defense & Space – 3 Dimensional
- Civil Aviation
- Spectrum Management
- Interference Hunting
- TDOA, AOA & Hybrid geolocation

RFeye AirDefense

Passive long-range 3D geolocation

- Wide-area (400+km) RF 3D geolocation and intelligence system
- Identify and track aircraft RF emissions while remaining invisible to electronic detection.
- Ideal for border monitoring, radar augmentation, target acquisition, spoofing detection, jamming detection
- 3D TDOA to achieve highly accurate tracking of "low and high-speed RF emitters"

RFeye AirDefense Applications

Multi-mission capabilities

Missile cueing

Can provide key data to create a cue for a missile defense system

Surveillance

Provides covert intelligence on the movements of adversarial aircraft

Jammer location

Can provide precise geolocation of jamming source – In built GPS Holdover

Missile tracking

Can track missile flight paths and act as part of a missile early warning system

Drone/UAS detection

The same technology can be configured the detect and alert to the presence of drones/UAS

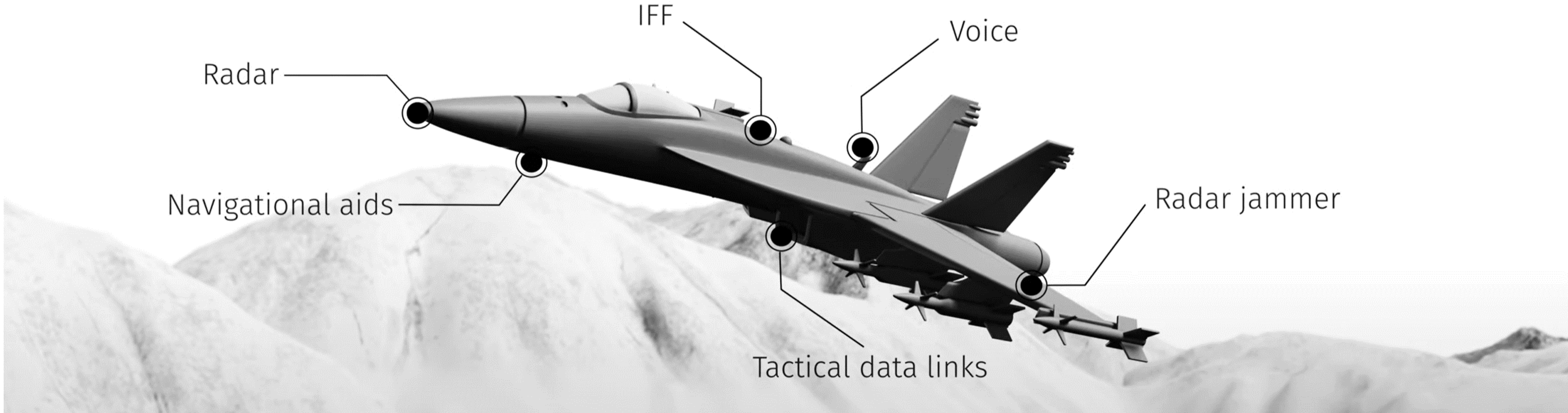
Training

Flying dark, verified EMCON training

See without being seen

Passive RF detection

- Most aircraft will emit some sort of RF signal
- RFeye AirDefense can detect and geolocate these transmissions
- While you can monitor their RF transmissions, they won’t be able to see you.



Two basic TDOA approaches

- **Classic TDOA**
  - Sample periodically and cross correlate
  - Suitable for FDM signals
  - Too simplistic where signals are "bursty"

- **Detector Directed TDOA**
  - Similar principle to sampling oscilloscope
  - Sample wide tranche of spectrum periodically
  - Sample may contain many signals separable in either time or frequency or both
  - Carve out the signals of interest and return to the client

Both modes are supported by CRFS systems

Context

Air navigation band example detectors

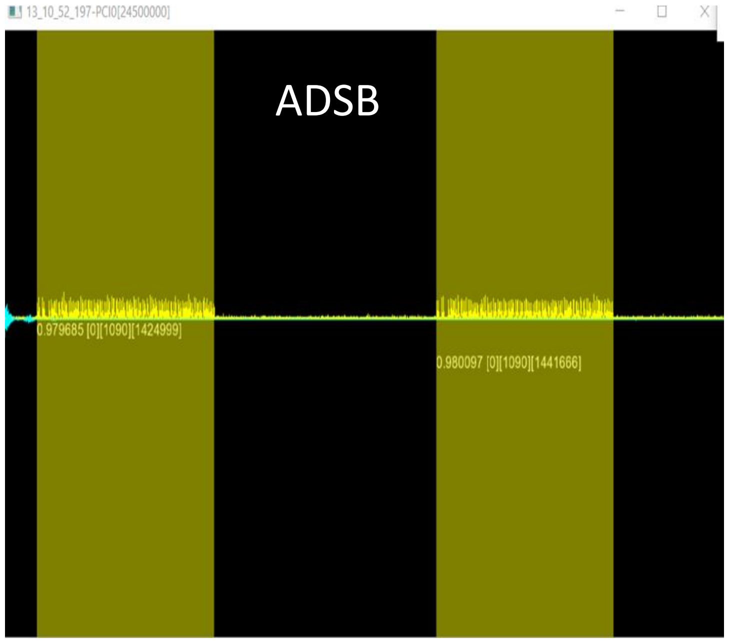
- **LINK16**
  - NATO data link standard
  - Requested by customer for pilot training
  - Frequency hopping 6.4us bursts on 13us time grid with 5MS/s MSK modulation
- **TACAN/DME**
  - Pulse pair each of 3.4us spaced 12, 30, 36us apart, unmodulated
- **ADS-B**
  - Squitter type 17 contains clear to air flight information
  - Lat, Lon, Alt, Speed, Heading …
  - Demodulated by detector and used to test system accuracy
- **IFF-SSR**
  - Modes 1,2,3,A,C and 4

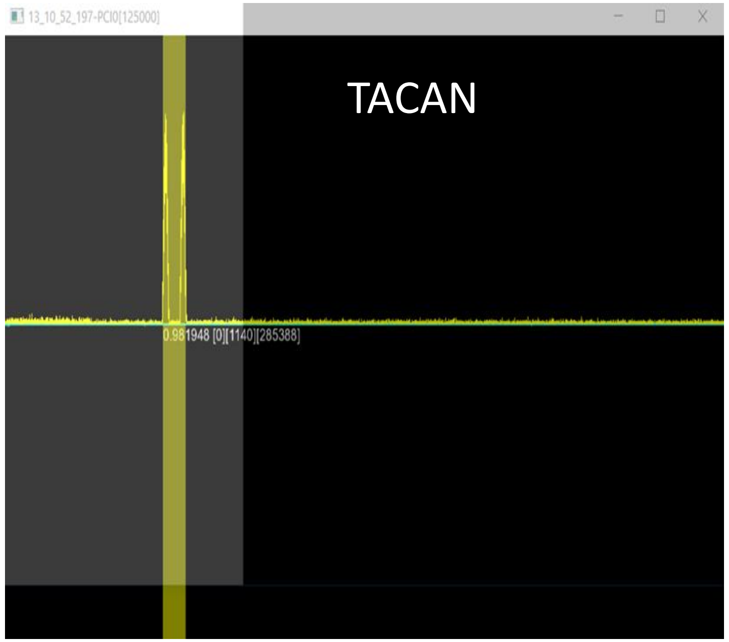
- **PULSE**
  - All the above share a common pulse detection mechanism followed by custom qualification
  - The generic pulse detector gives direct access to the pulse detection mechanism
  - Qualification steps can be configured
  - Multiple PULSE detectors can be configured to detect different pulse profiles
- **ENERGY**
  - Started as a "CW" detector
  - What about non-constant envelope signals e.g. AM/MPSK etc…?
  - Spectrally based rather than time based
  - Multiple ENERGY detectors can be configured to detect different signal profiles

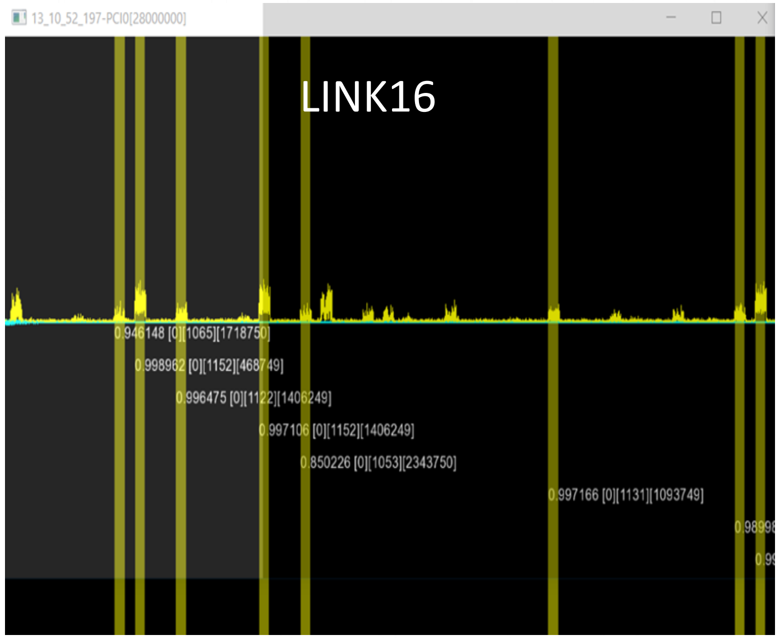
Pulse Detectors

RF fingerprints

- Identify signals by pulse parameters
- Automatically trigger geolocation



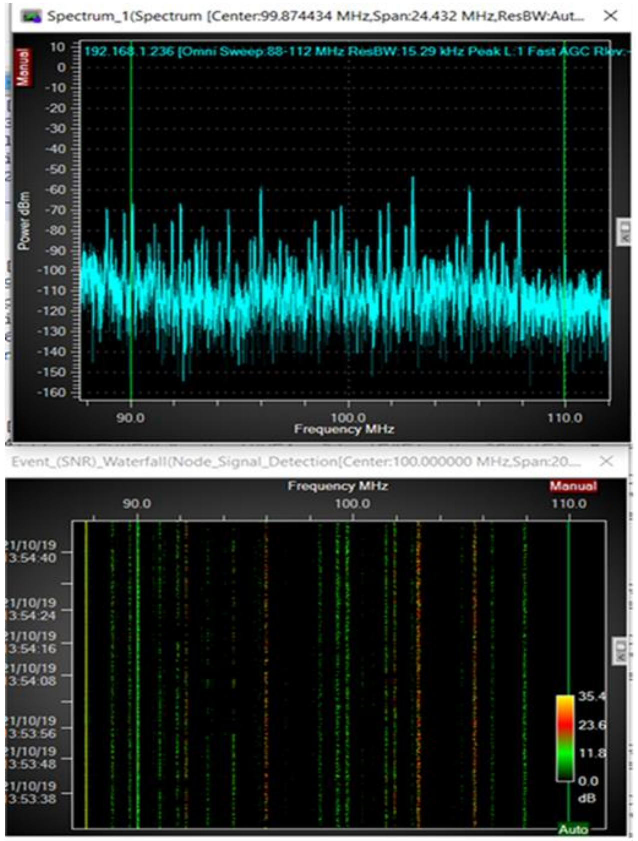


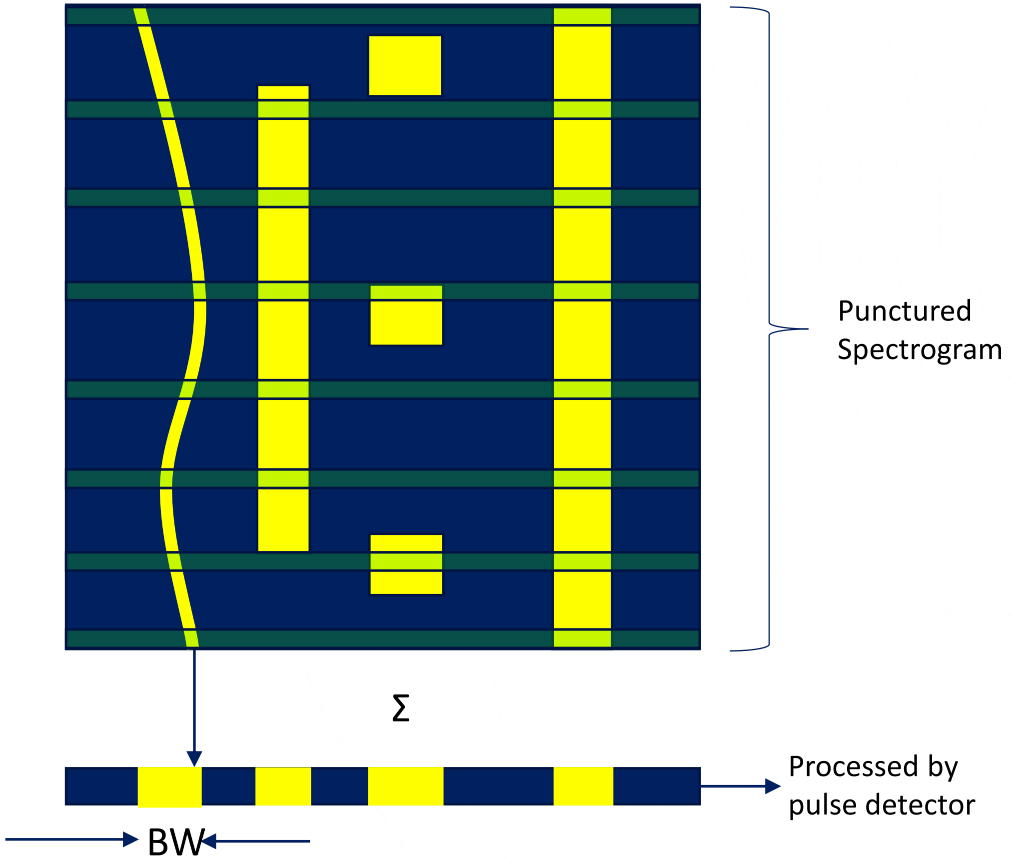


Energy Detectors

RF fingerprints

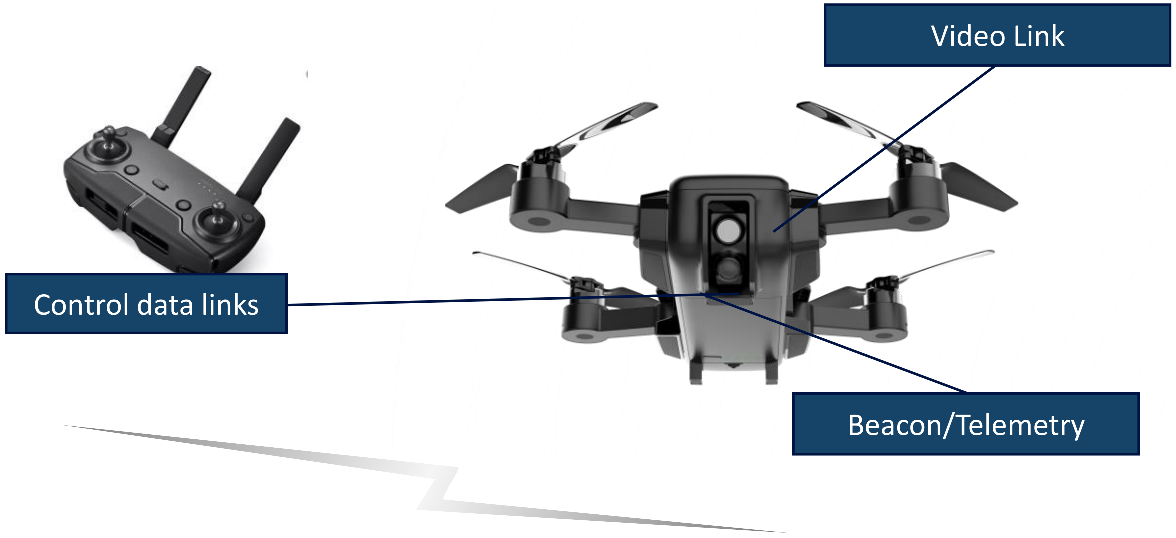
- Identify signals by energy signature
- Automatically trigger geolocation





Drone Emissions

Known & Unknown Energy Sources



Augmenting radar

Adding another pair of eyes

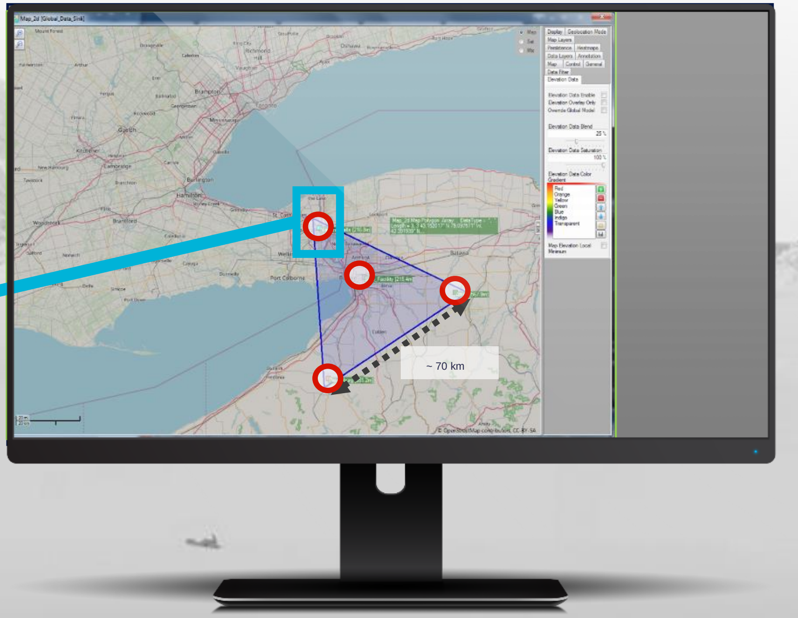
- Radar stations can be detected and identified by their EM emissions
- An enemy aircraft detecting the radar could:
  - Change their flight path
  - Deploy jamming counter measures
  - Destroy the radar with radar seeking missiles

- RFeye AirDefense can passively detect the hostile aircraft without them being aware they are being tracked.
- RF geolocations data can be feed into command-and-control systems, so the radar only turned on when it is needed.

How it works

AirDefense setup

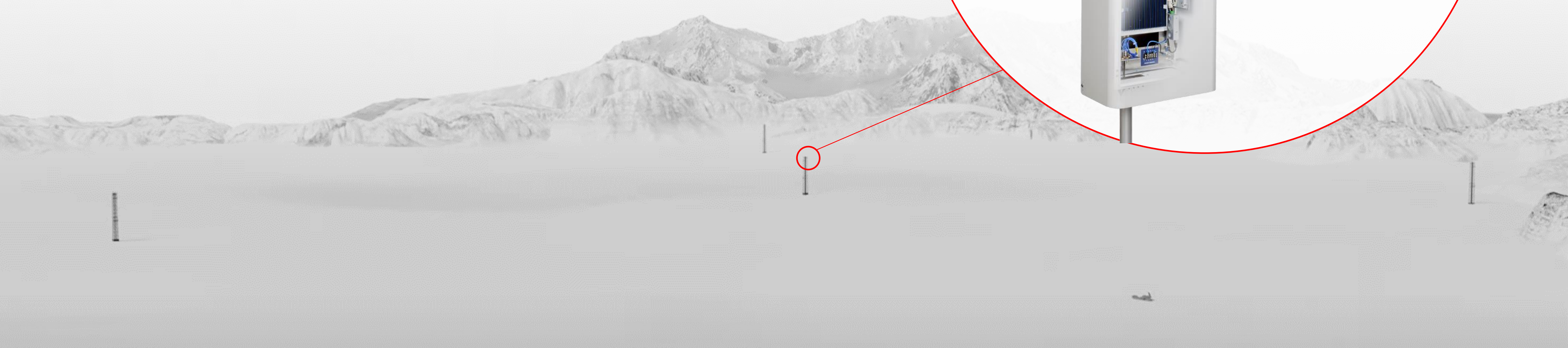
- RFeye AirDefense uses a network of four or more RFeye receiver Nodes
- Received signals are geolocated using 3D TDOA (Time Difference of Arrival)
- Results displayed within RFeye Site include:
  - Current and previous location: Lat/Long
  - Predicted flight track
  - Altitude: ft/m
- This information can be used to calculate
  - Course
  - Heading
  - Speed



RFeye receivers

RFeye Node with omnidirectional antenna

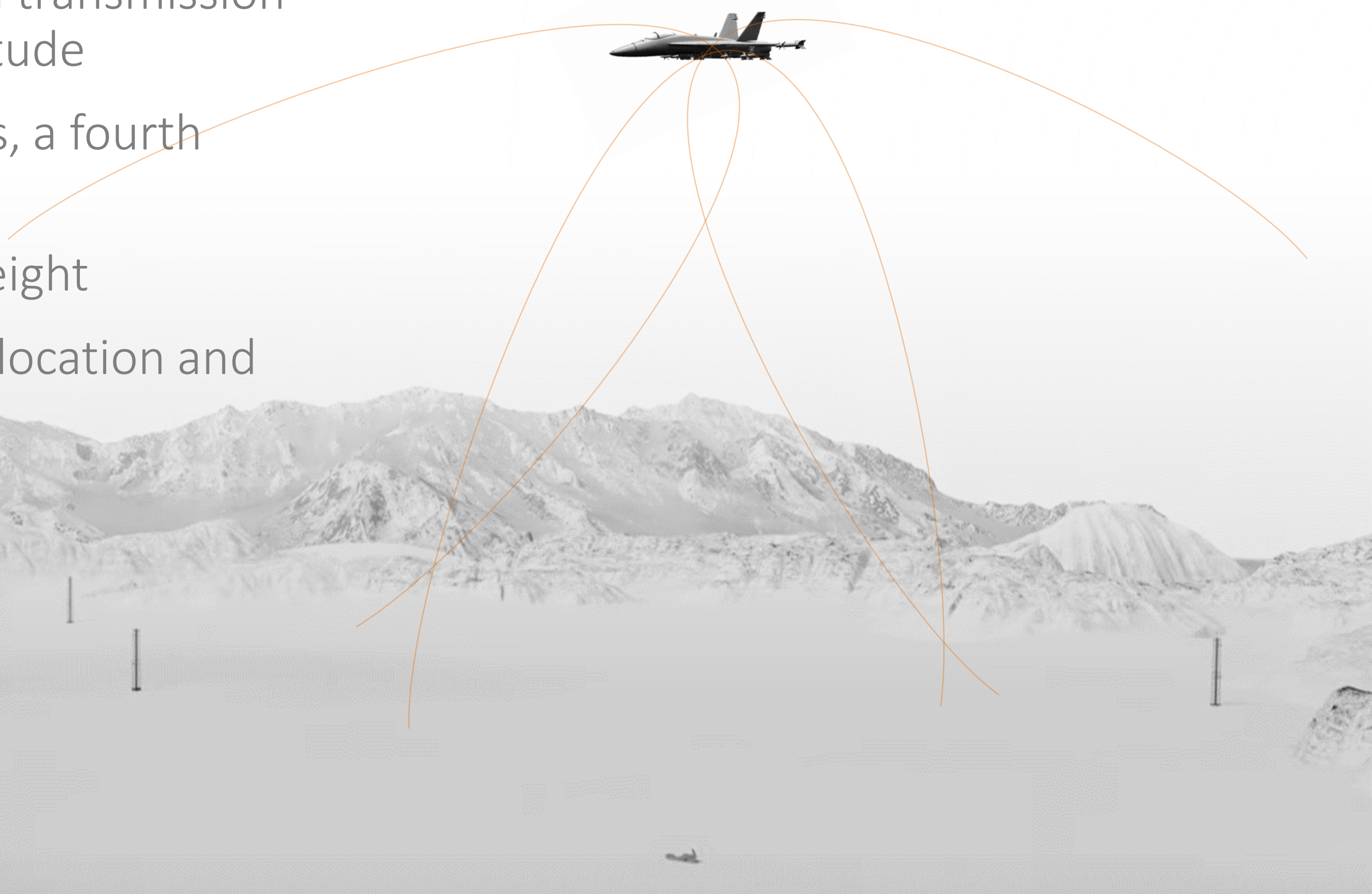
- Wide Band – Super heterodyne
- 9kHz to 8/18GHz
- 100MHz IBW
- Ultra low noise
- Inbuilt processing



3D-TDOA

Three-dimensional geolocation of airborne targets

- 2D TDOA will give the longitude and latitude of a transmission but no indication of the third dimension i.e., altitude
- To extend TDOA geometry into three dimensions, a fourth receiver is needed
- This creates a third hyperbolic curve to define height
- The point where all three intersect, will give the location and altitude



CRFS

Air Defense in Action

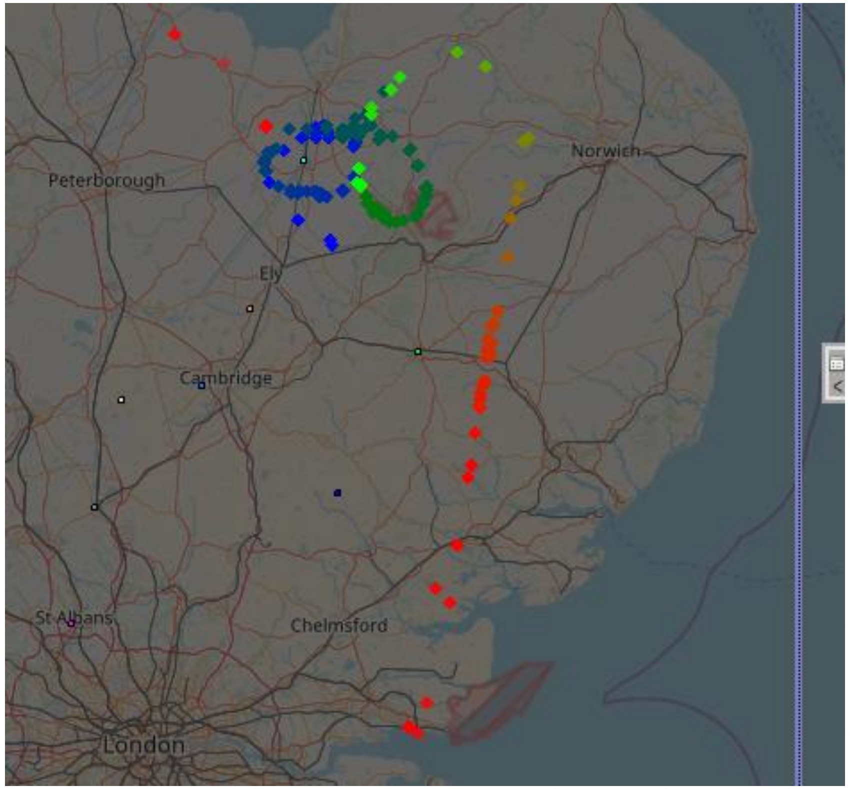
TDOA for air and ground emissions

Flight path v Time

Aircraft Link-16 Track vs. Time

- Aircraft transmitting Link-16
- Time indicating presentation
- Blue is oldest
- Red is most recent
- Aircraft was not transmitting either DME/TACAN or ADS-B
- Second aircraft entered from north after first aircraft departed area

Time:
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20



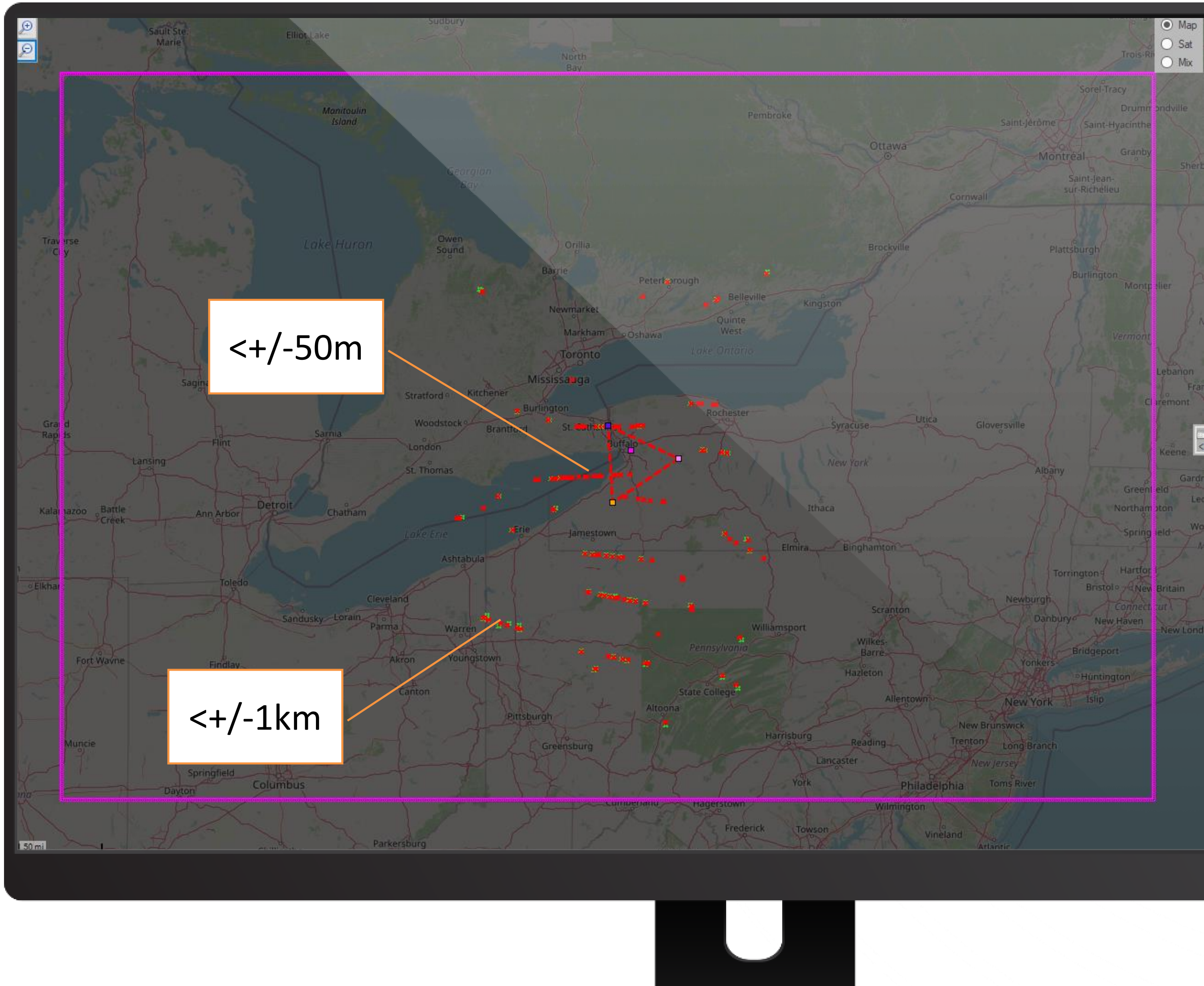
Here we see a Link-16 emission revealing an aircrafts flight path over the UK in real time

Accuracy

Live analysis

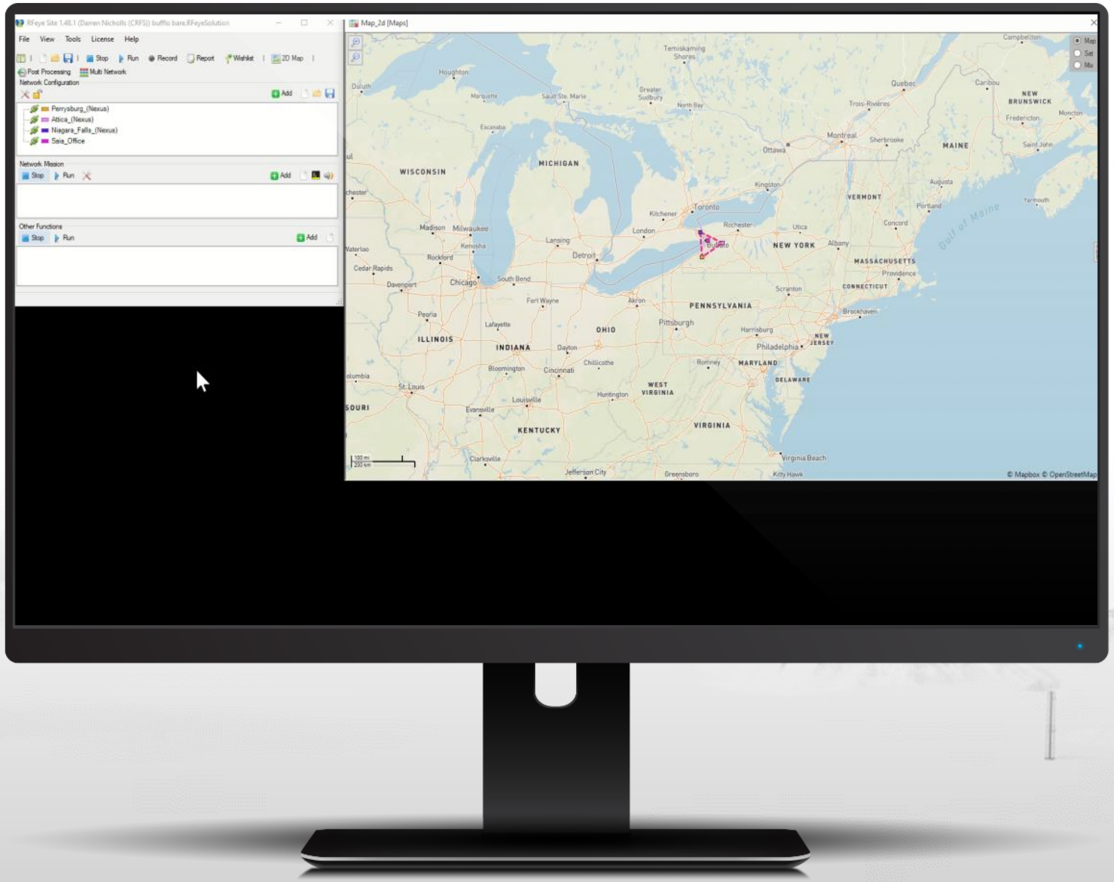
Comparing ADS-B detections to decoded ADS-B position and altitude data.

- Typical accuracy inside and close to network:
  - **< +/- 50 m**
- Typical accuracy up to 200km from network:
  - **< +/- 1 km**



Live Prosecution

Recorded for brevity



Conclusion

DETECT – LOCATE - PROTECT

CUE RADARS

Cue radar targeting without giving away location

BORDER SECURITY

See across borders – Wide area intelligence picture

TRAIN TO WIN

Train to win - EMCON verification

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Thank You