Improving Signal Detection in Radio Direction Finding Systems
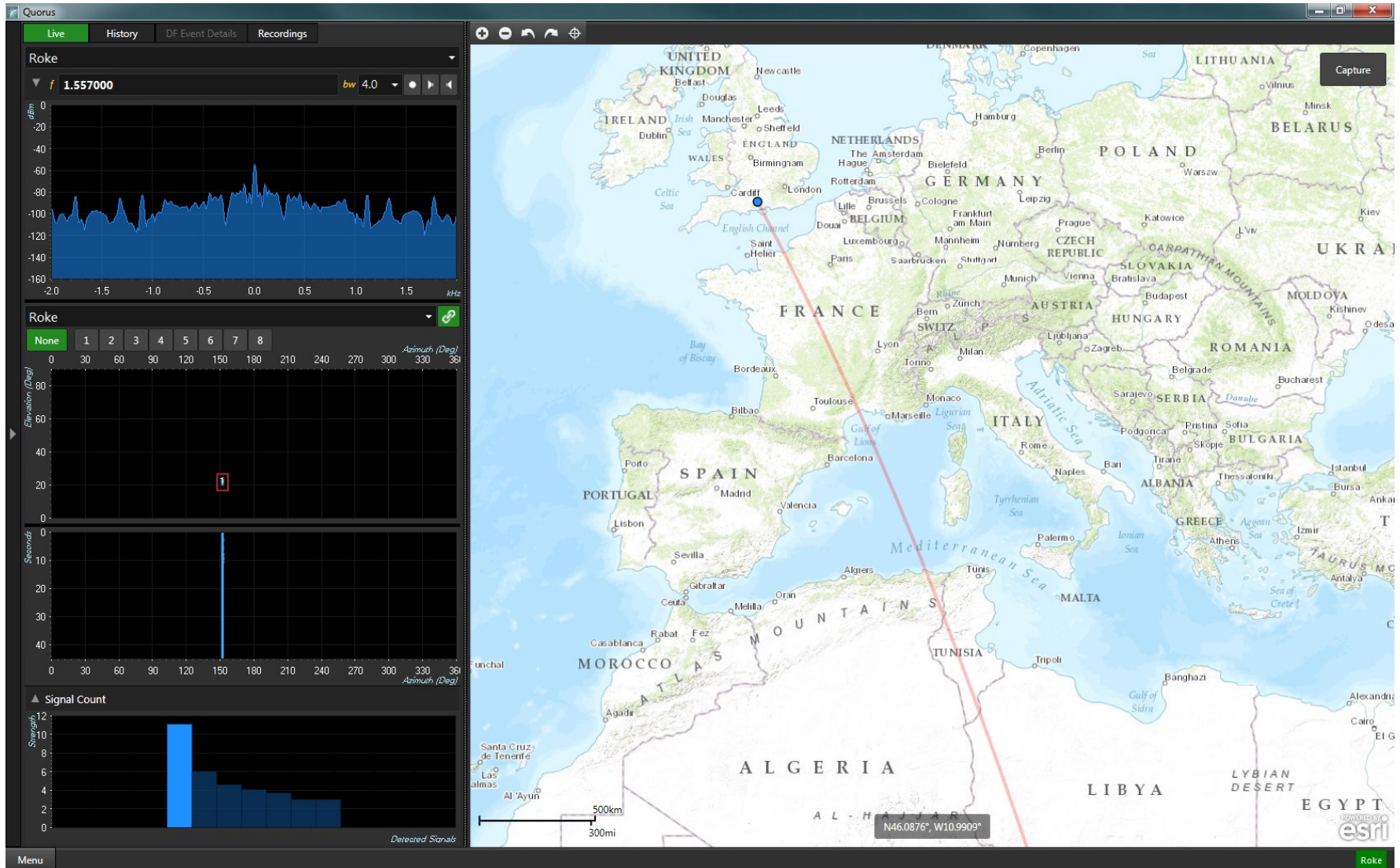
Dr. David Sadler

SSPD2016 Conference 22/09/16

Strategic direction finding – HF band
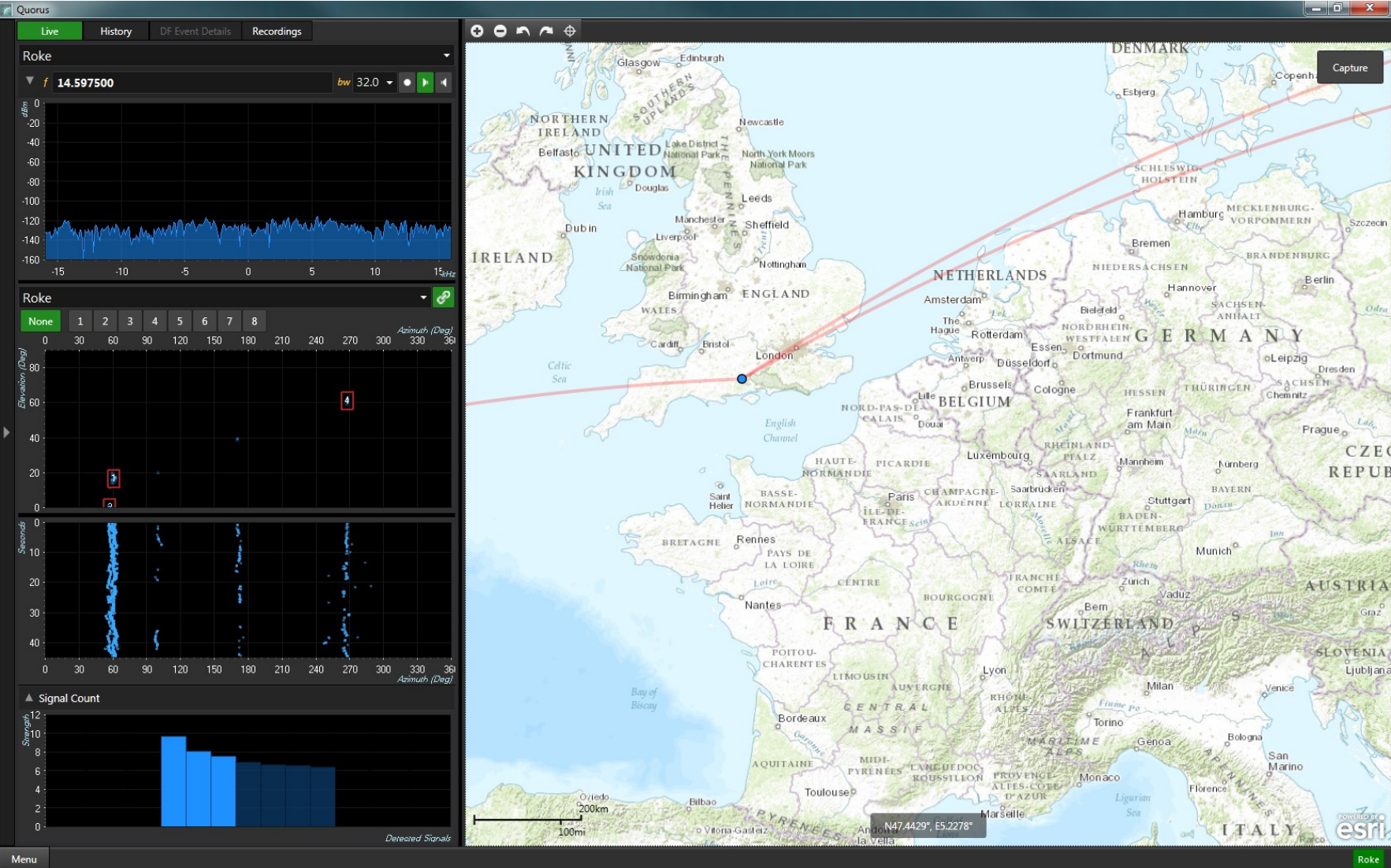
When it works well …

When it's difficult …

IntelligentInsight

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Signal detection problem

How to reliably count the number of co-channel signals?

- Need a solution to cope with

    - Spatially correlated noise

    - Non-Gaussian signals

    - Fading processes

    - Time-varying numbers of signals

    - Low number of data samples

    - Detection of the zero signals case

- Existing methods fail to cope with many of these criteria

    - Hypothesis tests

    - Information theoretic criteria

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System architecture
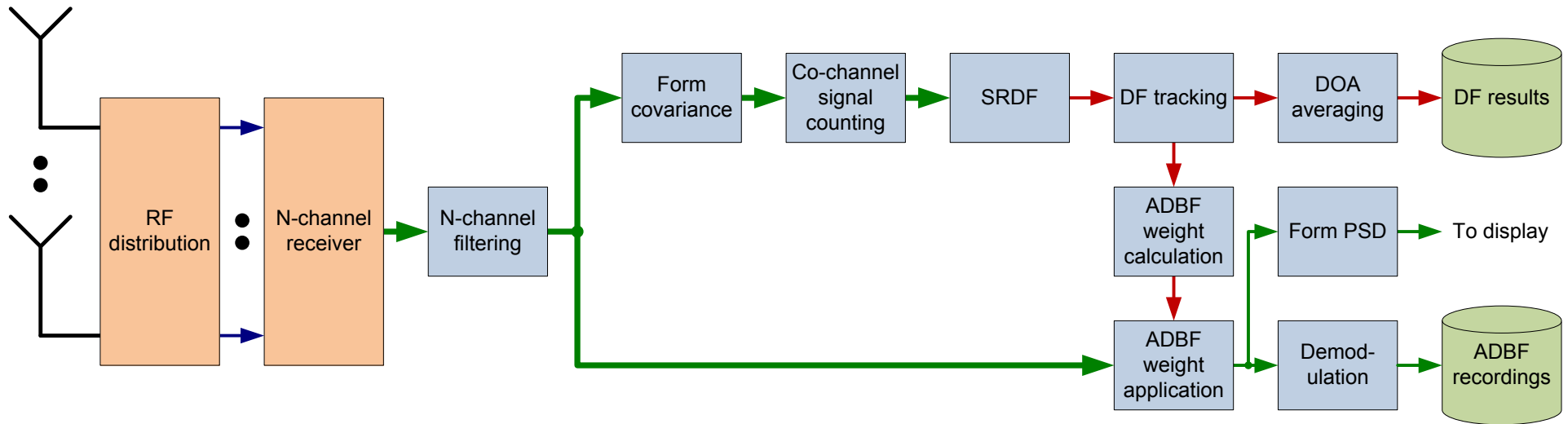
Is it actually worthwhile improving the detection algorithm?

– One small part of a system covering RF and DSP; hardware and software

– Is the detection performance significantly limiting the system performance?

Real-world constraints

Aim: to take a low TRL idea from conception through to a product

- Financial
    - Cost to develop, implement for production, verify, ascertain performance
    - Return on investment

- Technical risks
    - Must work on real data, not just in simulations
    - Accuracy & reliability - false alarms, missed detections, other aberrations!
    - Impact on the rest of the system when it goes wrong

- Commercial risks
    - Customer demand, time to market
    - Intellectual property, licensing

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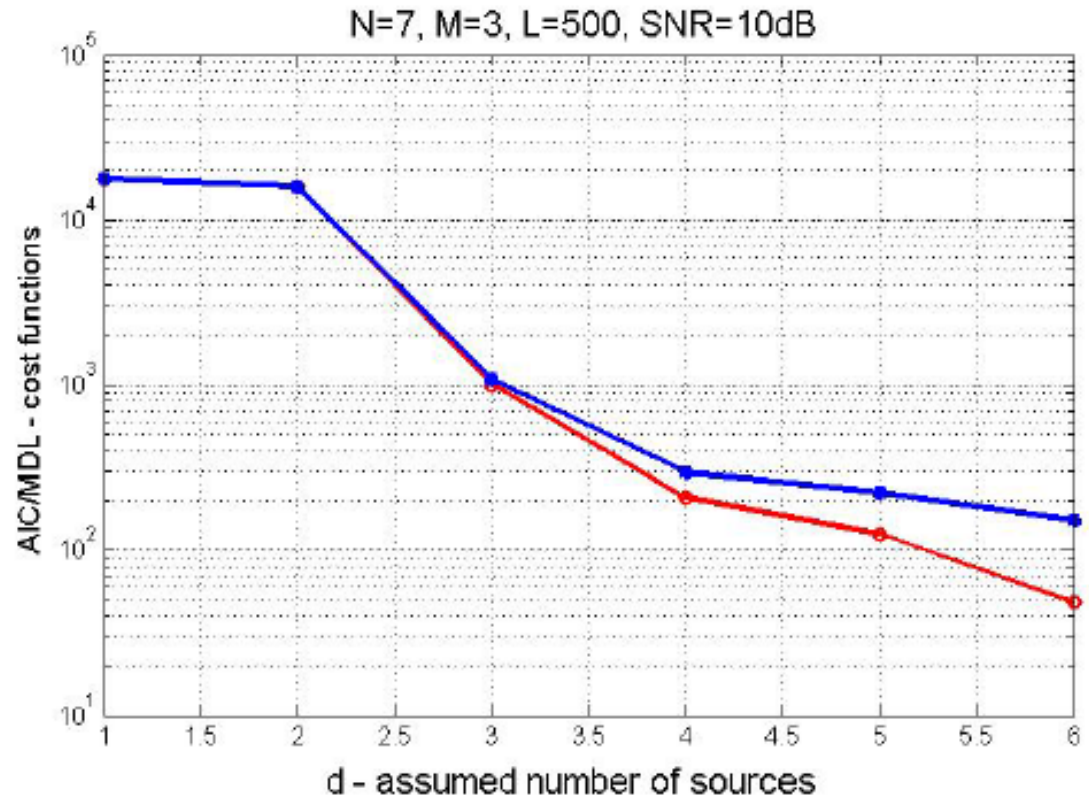Chemring Group

Engagement with academia

- Sensors & signal processing AIMday, October 2015
  - A question
  - A group of experts
  - One hour of discussion

- Ideas fleshed out into a joint proposal for EPSRC Impact Acceleration Account funds
  - Business case – needed for Roke to proceed
  - Innovation and technological breakthrough to qualify for IAA
  - Work schedule, deliverables etc.

- Now half way through a 1 year programme
  - Algorithm research performed by Prof. Tharm Ratnarajah and Dr. Jiang Xue
  - Roke provides oversight/steering and data collected using our HF system in Hampshire
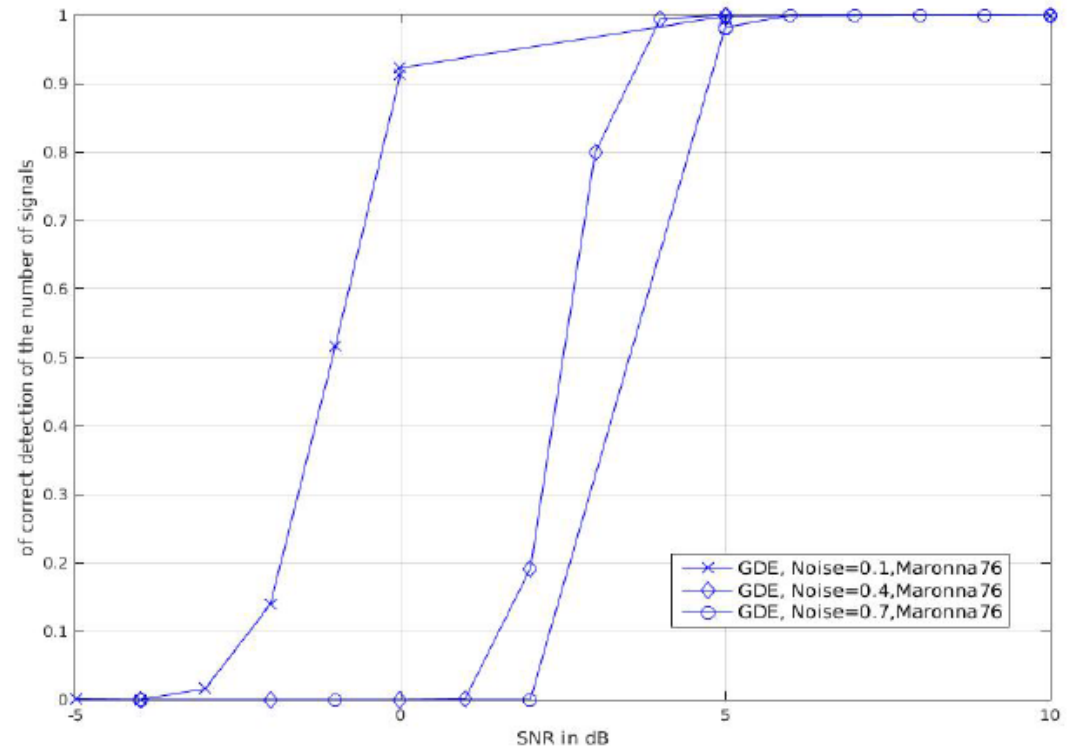
Avenues of investigation - ITC

- Robust statistics (M-theory) to improve covariance matrix estimation

- Modified information theoretic criteria

  – Standard MDL over-determines the number of signals in correlated noise

  – Modify the cost function to determine the biggest step change as *d* increases

N=7, M=3, L=500, SNR=10dB

AIC/MDL - cost functions

d - assumed number of sources

$$\widehat{k}_{MDL} = \arg \max_{k}\{MDL(k) - MDL(k-1)\}$$

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Avenues of investigation - GDE

- Gerschgorin disc estimator

  – Unitary transformation of the covariance matrix to reveal the Gerschgorin discs

  – Suppression of noise irrespective of correlation (in theory)

  – Radii are thresholded to separate the signal discs from the noise discs

- As the discs bound the eigenvalues, can GDE be combined with an information theoretic approach?

Avenues of investigation - EGM

- Eigenvalue gradients method

Calculate average gradient

$$\bar{\lambda} = (\lambda_1 - \lambda_N) / (N-1)$$

Calculate individual gradient

$$\bar{\lambda}_i = (\lambda_i - \lambda_{i+1}), i = 1, 2, \ldots$$

Compare gradients, if $\bar{\lambda}_i \leq \bar{\lambda}$ then stop and set $d = i - 1$

- All methods are currently being tested in simulation and with the Roke data set
- An academic paper is expected to follow…

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Research exploitation routes

- UoE hopes to exploit the research by:
  - Publishing papers
  - Winning follow-on research grants
  - Commercialisation by licensing of IP
- Roke's interest in exploitation includes:
  - Publishing papers
  - Implementation within the LOCATE product range
  - Extension to V/UHF bands and tactical systems
  - Application to government applied research work

These desires can complement each other!

Sarsen Antenna Array (N-Channel)

GPS Receiver

Antenna Control Unit (ACU)

Multichannel Digital Receiver (MCDWR16)

Digital Receiver (DWR16)

Data Server

SRDF & E-Copy

Geolocation Manager

Wideband Monitor

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