HOW WE KEEP PACE WITH MODERN/FUTURE RADAR

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THE MODERN RADAR ENVIRONMENT

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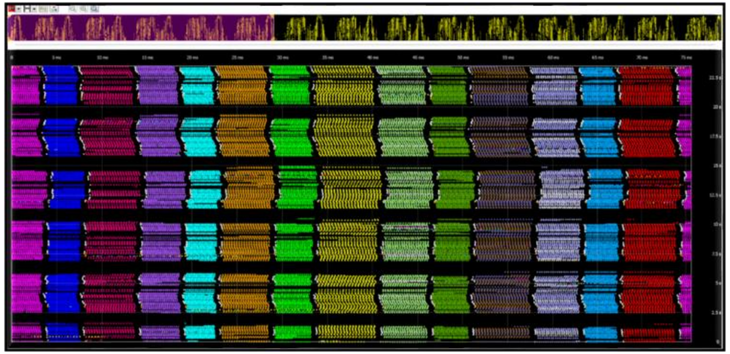
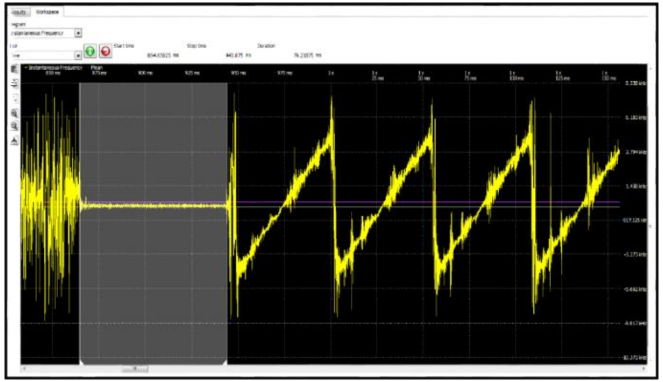
RADAR DEVELOPMENTS



- Rule of thumb….EW technology lags advances in radar design by something like 10 years…EW seems now even further behind the radar development curve.



- Radars are rarely single frequency single mode devices any more.
- Multi-mode, multi-function, complex pulse modulation, frequency agility, software defined (therefore reprogrammable) - Easy to detect but incredibly difficult to fully characterise.
- LPI radars - just plain difficult to even detect

- Sight lost of the threat from legacy systems which utilise decades old engineering that in fact are able to detect platforms using the most modern of technologies

CHALLENGES

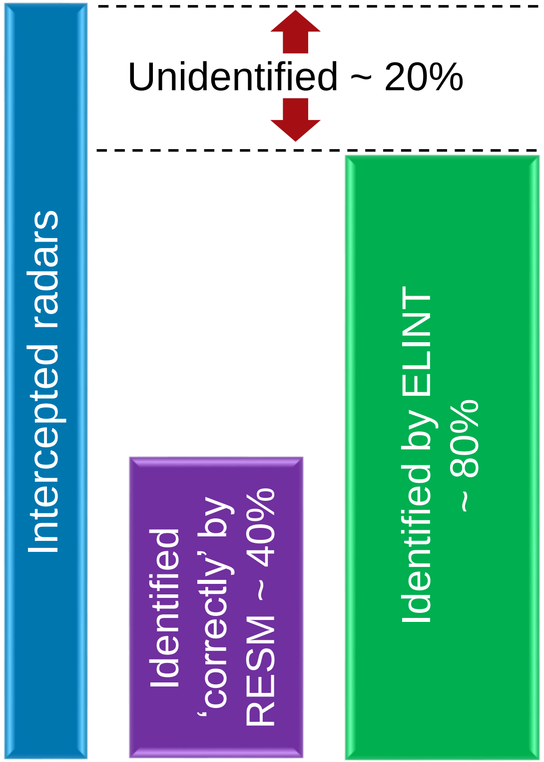
Radar Technology

- Rapid advancement and increased capabilities
- New generation of multi-function systems (phased/active array systems, LPI etc.)
- Affordable and sold worldwide

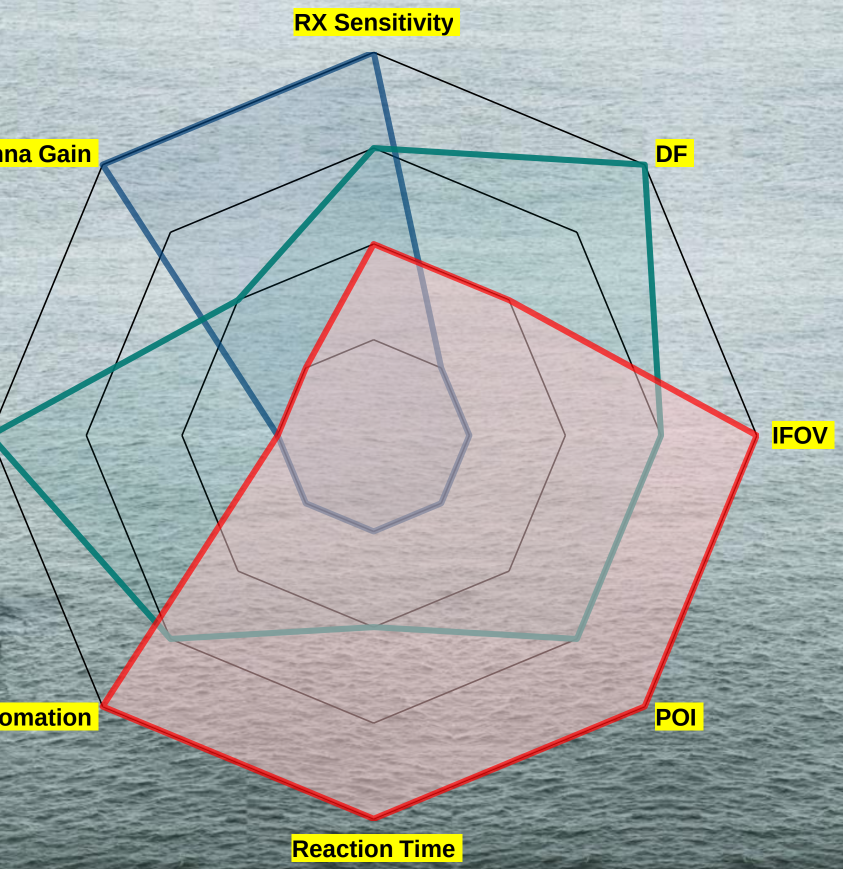
Relevance for ELINT/RESM

- Eroding range advantage
- Hard to detect, identify and analyze (frequency & waveform agile)
- Systems at the limit

RADAR CLASSIFICATION



REQUIREMENTS



TECHNOLOGY TRENDS

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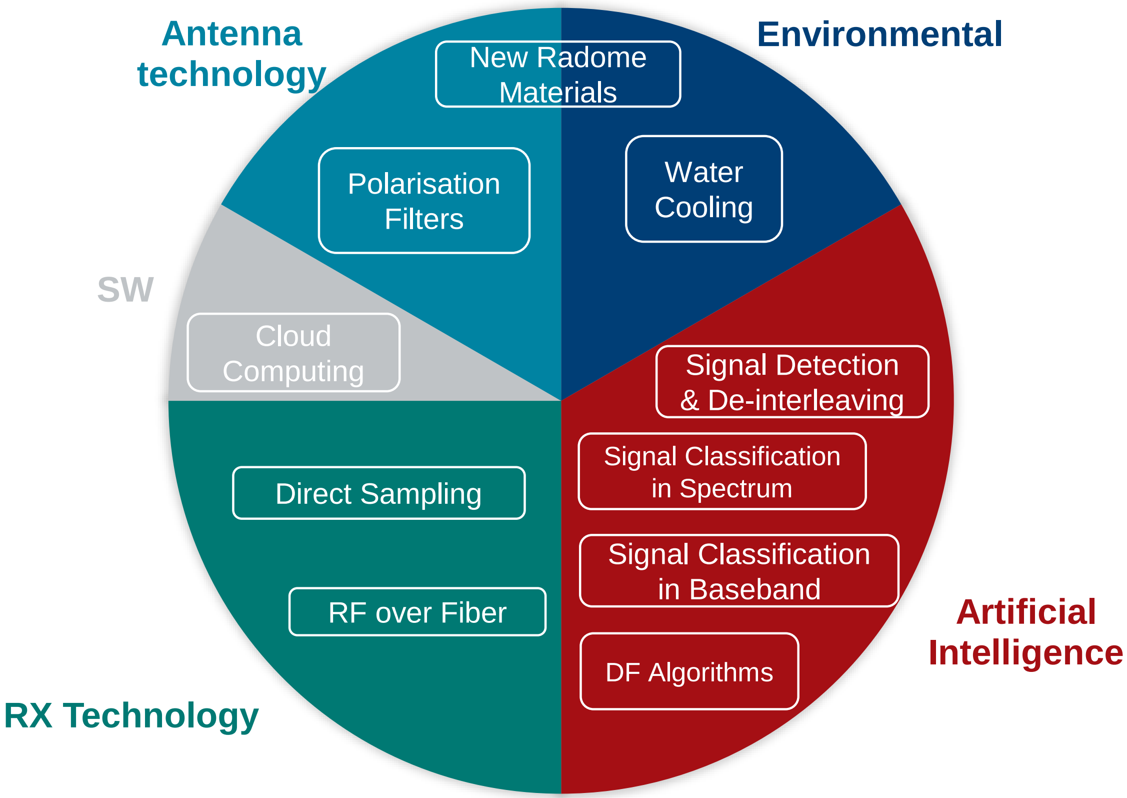
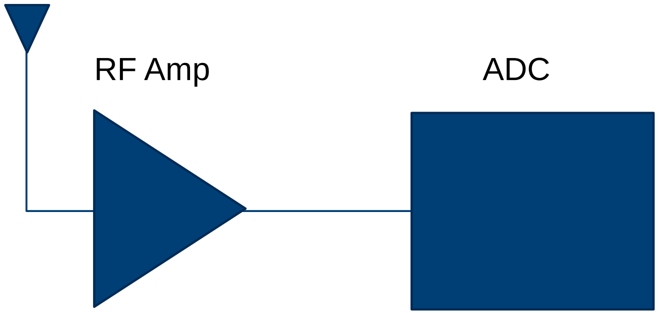
TECHNOLOGY TRENDS



DIRECT SAMPLING



Customer Requirement

- 100% POI for the frequency range up to 40 GHz in combination with good analog characteristics (e.g. dynamic range)
- Analyze signals with bandwidths / RF agility up to 12 GHz

Potential Solution

- Direct sampling receiver based on advanced ADC (ASIC) technology

Technical Feasibility

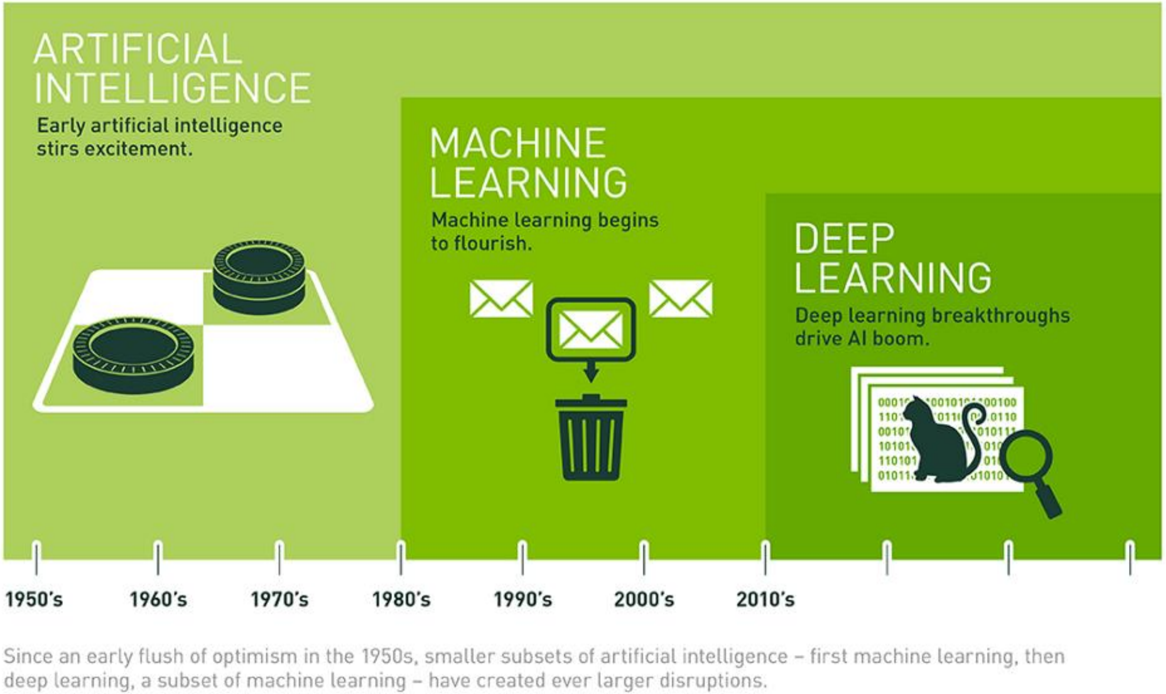
- ASIC technology is available
- Current ADC speeds now fast enough to achieve higher radar frequencies
- Overall performance can now match that of dedicated RF HW

DIRECTION FINDING

- **CURRENT SOLUTION**
  - Direction finders are using Watson-Watt (WWT) method and/or correlative interferometer (CI) method

- **DISADVANTAGES**
  - Performance limitations regarding direction finding in multi-wave scenarios (ambiguities)
  - Performance limitations in regions with low aperture and high aperture (ambiguities)
  - Antennas must be modelled and be exact to achieve good performance

ARTIFICIAL INTELLIGENCE



DIRECTION FINDING

Customer Requirement	Potential Solution
• Increased early-warning time through improved range and accuracy of direction finding • Lower manufacturing cost	• AI supported DF algorithms • Less computational efforts and more flexibility for supporting complex antenna structures

AI DF ALGORITHMS

- **FUTURE SOLUTION**
  - AI (DL/ML) aided direction finding methods

- **ADVANTAGES OVER CURRENT SOLUTION**
  - Computational power / complexity can be reduced
  - Time for DF Antenna measurement (model function) can be significantly reduced
  - DF performance regarding reflection immunity and DF angle error can be reduced

AI BASED SIGNAL DETECTION & DEINTERLEAVING

Customer Requirement

- Robust signal detection for high POI and reliability (lower false alarm rate, higher detection rate)
- Challenges:
  - Colliding signals
  - Interferences
  - Fluctuating amplitude

Potential Solution

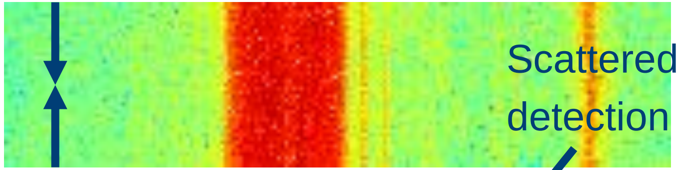
- AI methods for detection and de-interleaving based on spectrum data

Technical Feasibility

- Quality depends on a-prior knowledge (labeled test sets)
- High effort for data gathering, maintenance and labeling

MOTIVATION

- **Modern Detection**
  - **Based on energy**
    - Average spectrum
    - Estimate noise/detection threshold
  - Frequencies above threshold: signal candidate bins
  - Combiner logic for candidate bins
- **Limitations**
  - Error prone combiner logic
  - No collision detection/resolution
  - Fluctuating energy levels (SSB): Non-satisfying detection
  - Weak signal detection fails if a very strong signal exists in the vicinity

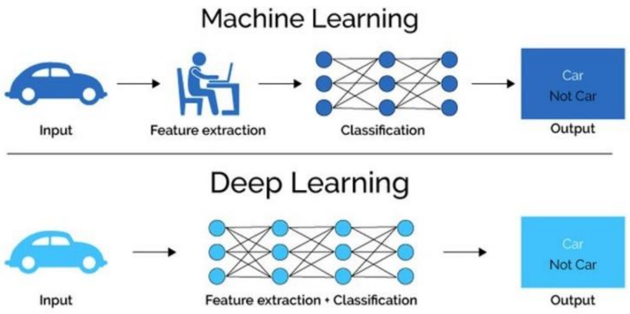


Example spectrogram

Average spectrum

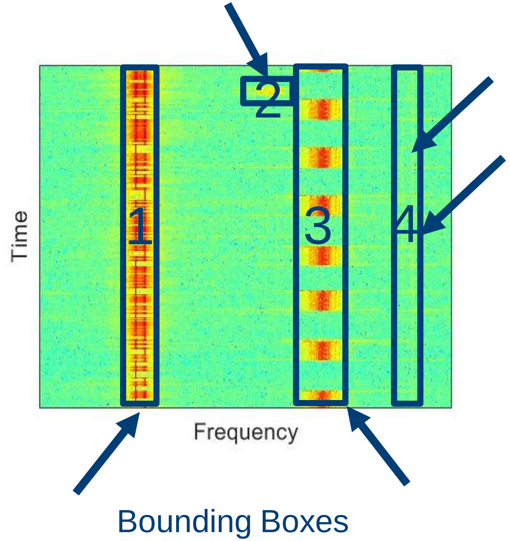
DEEP LEARNING FOR DETECTION

- Deep learning: Feature extraction and classification using deep neural nets (DNNs)



- State of the art technology especially in object detection and image classification problems

- Starting point: spectrogram data (waterfall)
  - Realize the existence of signals
  - Identify the exact quantity
  - Localize each signal in time and frequency

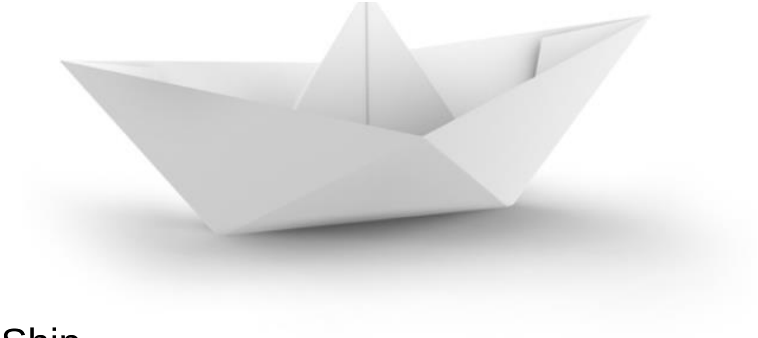


SIGNAL CLASSIFICATION IN SPECTRUM

Customer Requirement	Possible Solution	Technical Feasibility
• Increase early-warning time through faster classification	• AI methods for classification based on spectrum data	• Quality depends on a-prior knowledge (test sets) • High labeling effort • Current publications cover only small parts of entire challenge • Scan solution (low resolution; only spectral data available)

WHAT IS THE DIFFERENCE?

An Aircraft

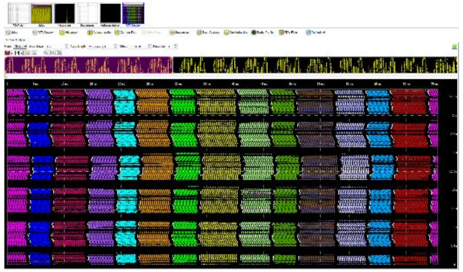


A Ship

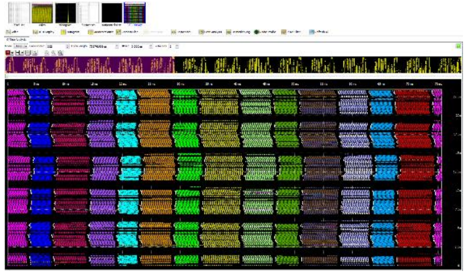
- For our Machine Learning we need:

- An Algorithm ✓
- Training ✓
- Samples (huge amounts of data) ✓

WHAT IS THE DIFFERENCE?



Radar A



Radar B

- For our Machine Learning we need:
- An Algorithm ✓
- Training ?
- Samples (huge amounts of data) ✗

SIGNAL CLASSIFICATION IN BASEBAND

Customer Requirement

- Improved classification performance and reliability
- Automatic determination of modulation type

Features

- Determination of modulation type based on IQ data

Technical Feasibility

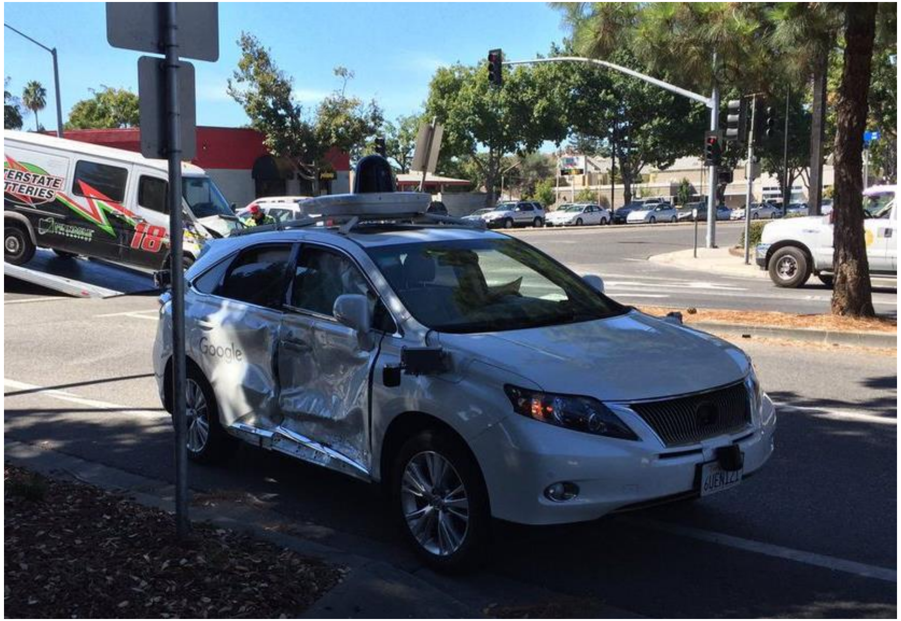
- Quality depends on prior knowledge (test sets)
- High labeling effort
- Computational efforts exceed system capabilities

WHY APPLY AI TO THE ELECTROMAGNETIC SPECTRUM

- We need to defeat the enemy in the electronic warfare domain
- Traditional EW ‘superpowers’ have fallen behind potential adversaries.
- Offensive cognitive electronic warfare technologies are the future
- Historically enemy systems have to be developed before any countermeasures
- Autonomously counter adversary systems without preprogramming

WHY NOT AI

- The military insists on having a person to blame if a mistake is made.



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