Specific Emitter Identification (SEI) Research

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Electronic Support SEI Research

- Context of SEI within EW
- Why do we do SEI?
- Research project
- Proof of concept
- Proof of SEI
- Issues related to SEI
- Future work

Context of SEI within EW

Electronic Warfare (EW)

"use EM and directed energy to control the EM spectrum"

Electronic Support (ES) *[ESM]*	Electronic Attack (EA) *[ECM]*	Electronic Protection (EP) *[ECCM]*
"search for, intercept, locate, classify sources of intentional and unintentional radiated EM energy"	"use EM and directed energy to attack facilities and equipment in order to degrade, neutralise or destroy enemy activity"	"actions taken to protect facilities and equipment from any effects of friendly or enemy EW"
•SIGINT •ELINT •COMINT	•ECM •DEWs •ARMs	•ECCM •EMCON •COMSEC

Adopted from *Electronic Warfare in the Information Age*, (1999), D.C. Schleher

CSIR
our future through science

Signals Intelligence

Electronic Warfare (EW)

"use EM and directed energy to control the EM spectrum"

Electronic Support (ES) *[ESM]*

"search for, intercept, locate, classify sources of intentional and unintentional radiated EM energy"

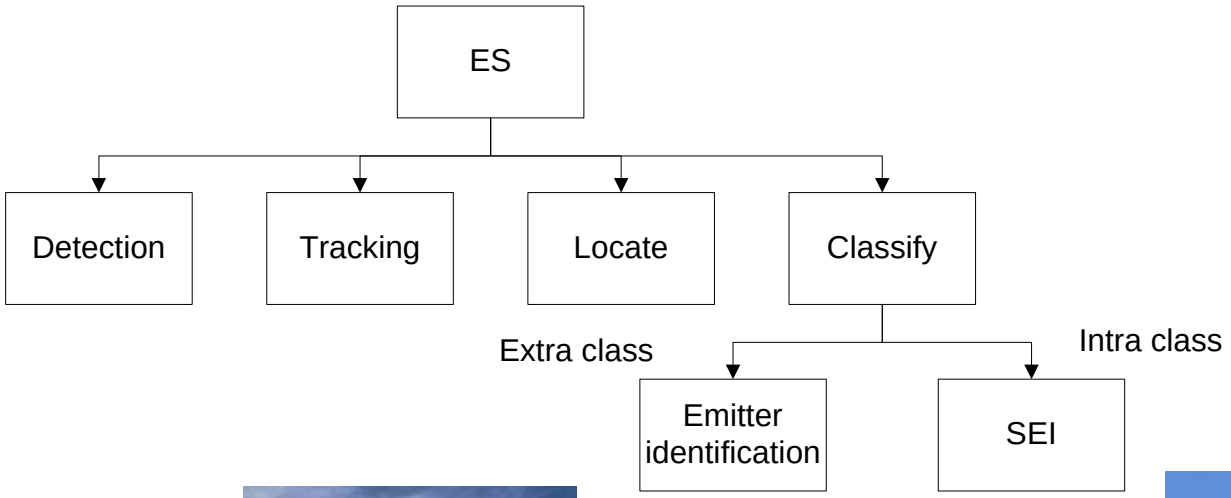
- SIGINT
  - ELINT
  - COMINT

Signals Intelligence (SIGINT)

- Electronic Intelligence (ELINT). Concerned with the characterisation of emitter signal parameters e.g. pulse width and carrier frequency
- Communications Intelligence (COMINT). Concerned with information content e.g. sms

"ES Techniques refer to the development of signal processing algorithms in order to develop an ES capability for the EDERI"

Context of SEI within EW

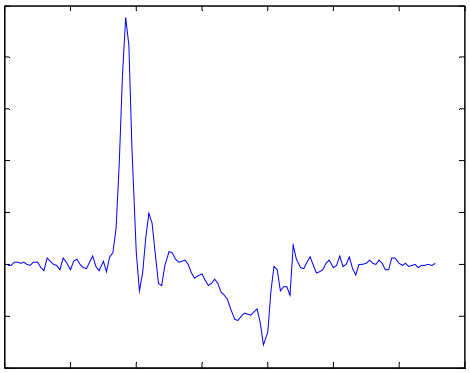


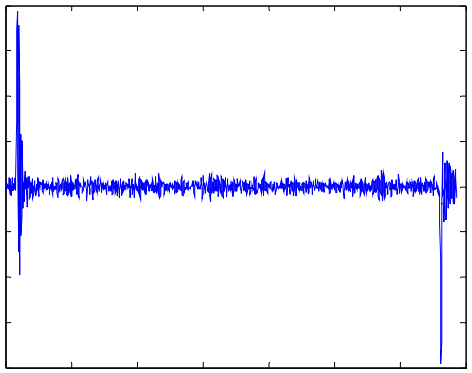
Why do SEI?

- Identity a particular Radio Frequency (RF) emitter
  - Cooperative or non- cooperative
  - Adds a further dimension to emitter classification
- Useful in Radar, EW and Communications
  - Situational awareness of friend or foe
  - Emitter performance management over time

Research project (1)

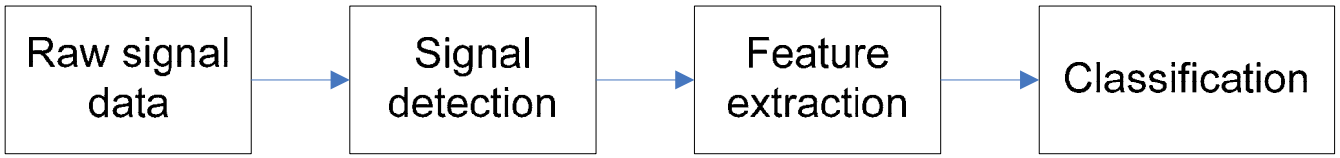
- WdP studied possible techniques for SEI on radars
- MC – similar research project at GEW on radio transmitters
- Research done is not to develop a product
- Development of signal processing algorithms (detection and feature extraction)
- Classification algorithm





Research project (2)

- Technical aspects:
  - Detection – determine presence of signals
  - Feature extraction – calculation of values representing a specific feature
  - Features are calculated from waveform statistics and amplitude-scale transform (DWT)
  - Effectively, process performs data rate reduction on received signals



Proof of concept – Emitter Classification

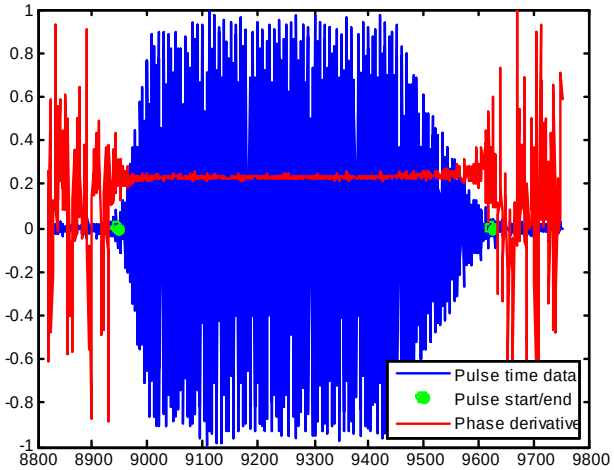
- “Can we classify emitters based on their SIGINT description?”
- “Can we do this automatically?”
- “Can we reuse emitter data already captured?”
- “Can we identify EA?”

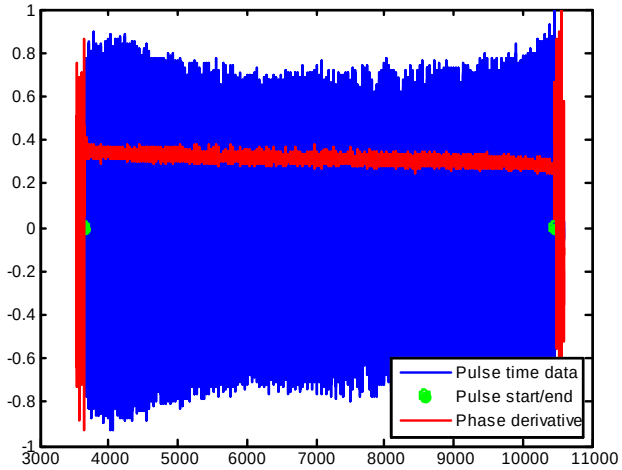


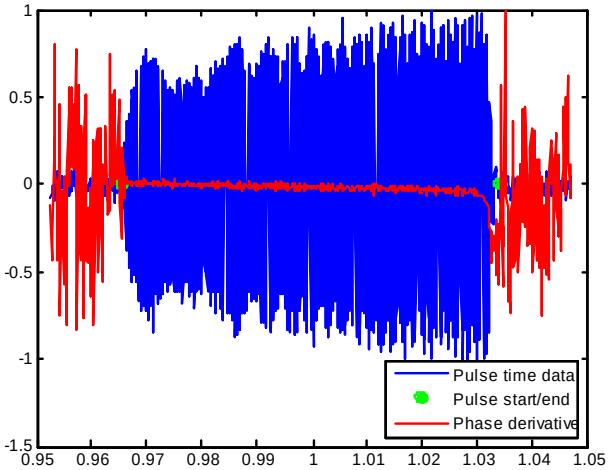


Proof of concept – Emitter Classification

- Analysis of measured data
- Pulse detection

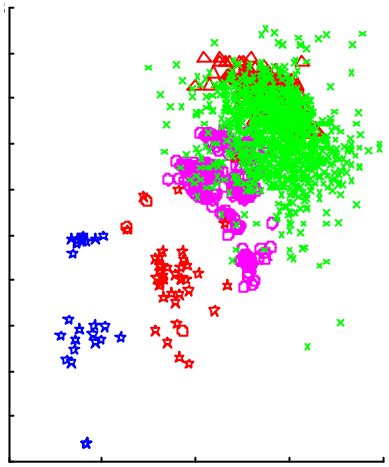


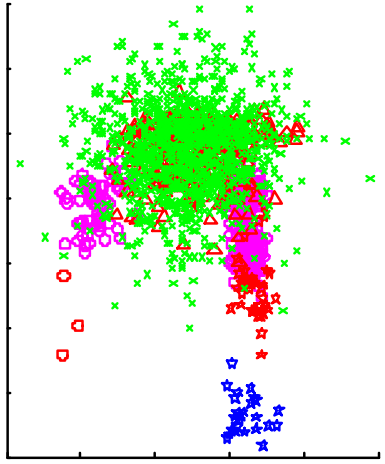


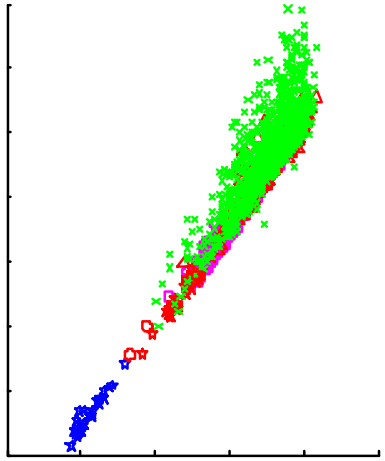


Proof of concept – Emitter Classification

- Overlapped features of units
- High correlation between features







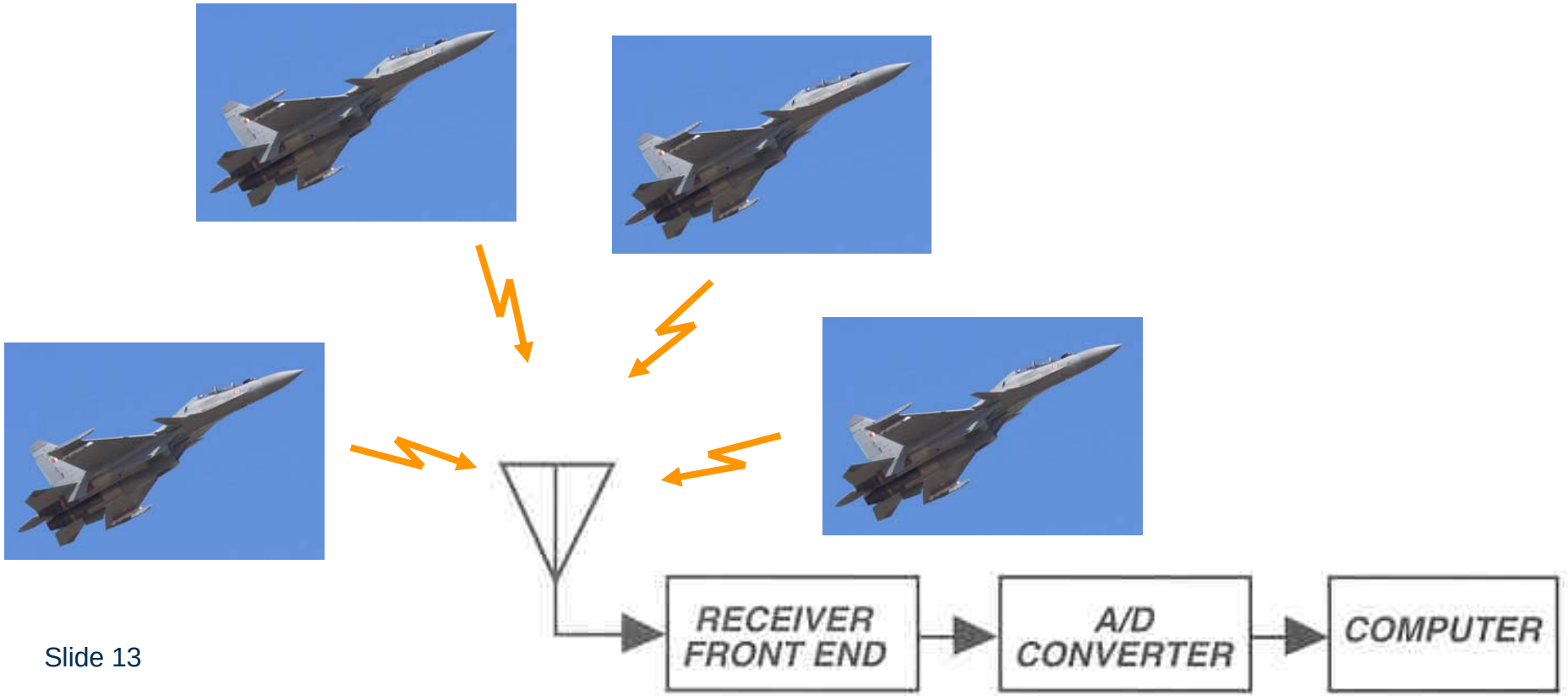
Proof of concept – Emitter Classification

- Results show feasibility of SEI

Normalisation	Percentage Training Data [%]	CCD [%]
Global	5	78.91
	10	79.22
Individual	5	83.03
	10	83.33

Proof of SEI (1)

- Extends emitter classification to identify emitters of the same type
- Here we explore the subtle differences in emitter parameters
  - Usually originates from analogue emitter subsystems

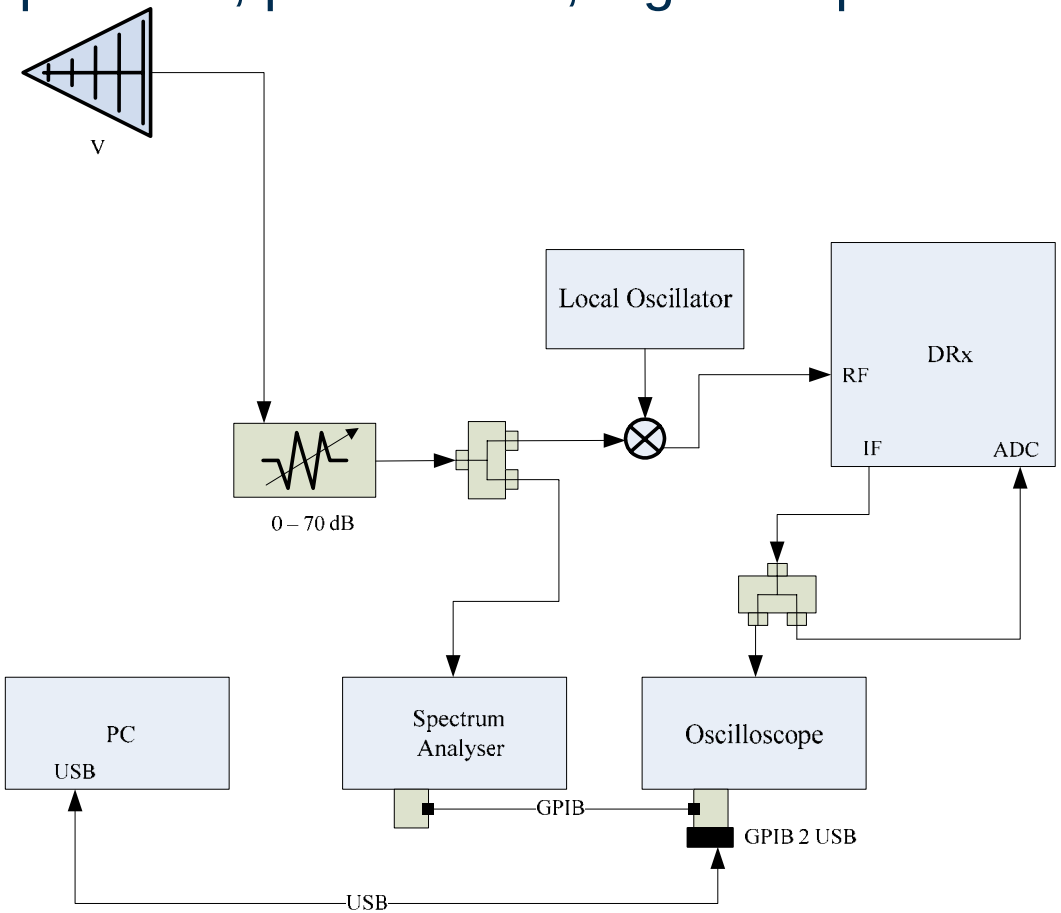


Proof of SEI (2)

- Emitter parameters tend to be severely overlapped
  - Emitters are fundamentally the same
- It is usually required to fully characterise an emitter for accurate classification
  - Many parameters require an intensive characterisation effort
- Need for an adaptable emitter database
  - Own systems are easily characterised
  - Enemy systems are generally quite difficult or impossible to characterise

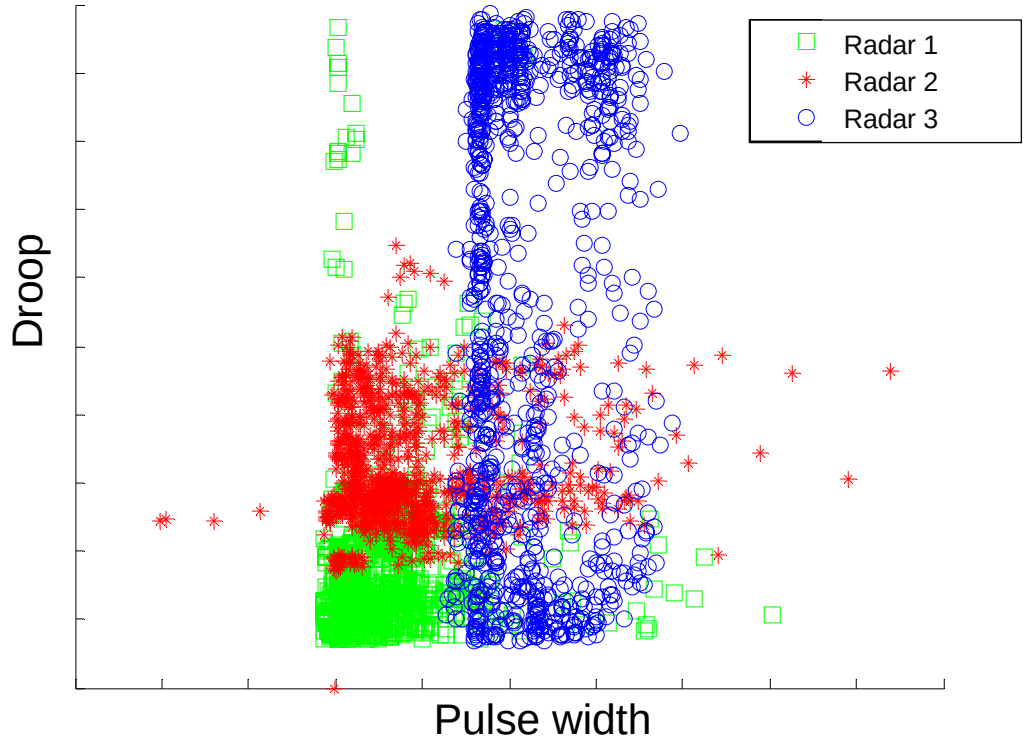
Proof of SEI (3)

- Time and frequency measurement setup
- Antenna patterns, polarisation, high sample rate



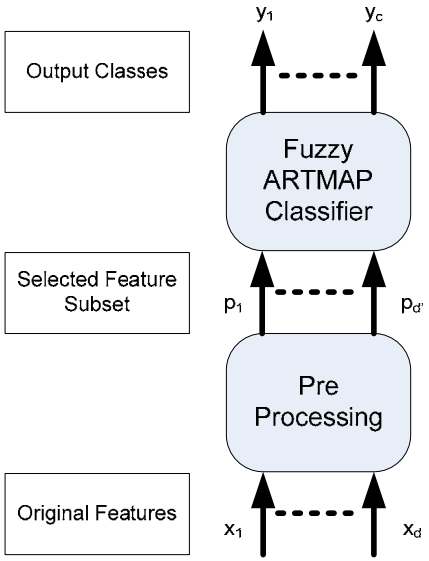
Proof of SEI (4)

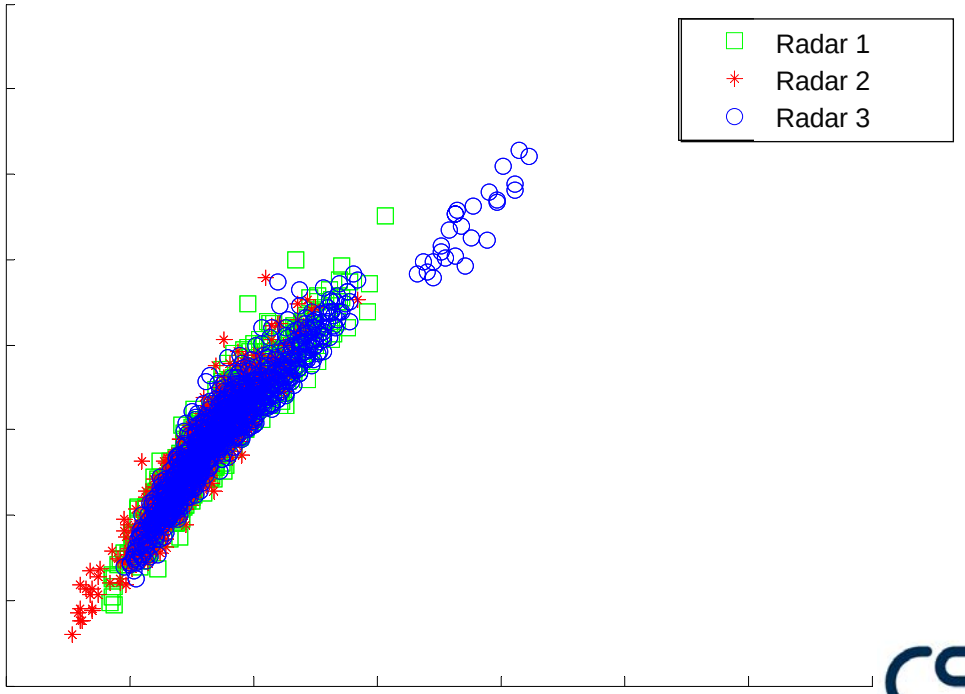
- Results from feature calculation show distinction between radars
- Scatter plot of 2 features – Droop and Pulse width



Dimensionality reduction

- Redundant features clutter the feature vector, has an influence on the classification
- Three different methods were used to reduce the dimensionality of the input feature vector (Correlation method, LDA, Gamma test)
- Successful reduction of features



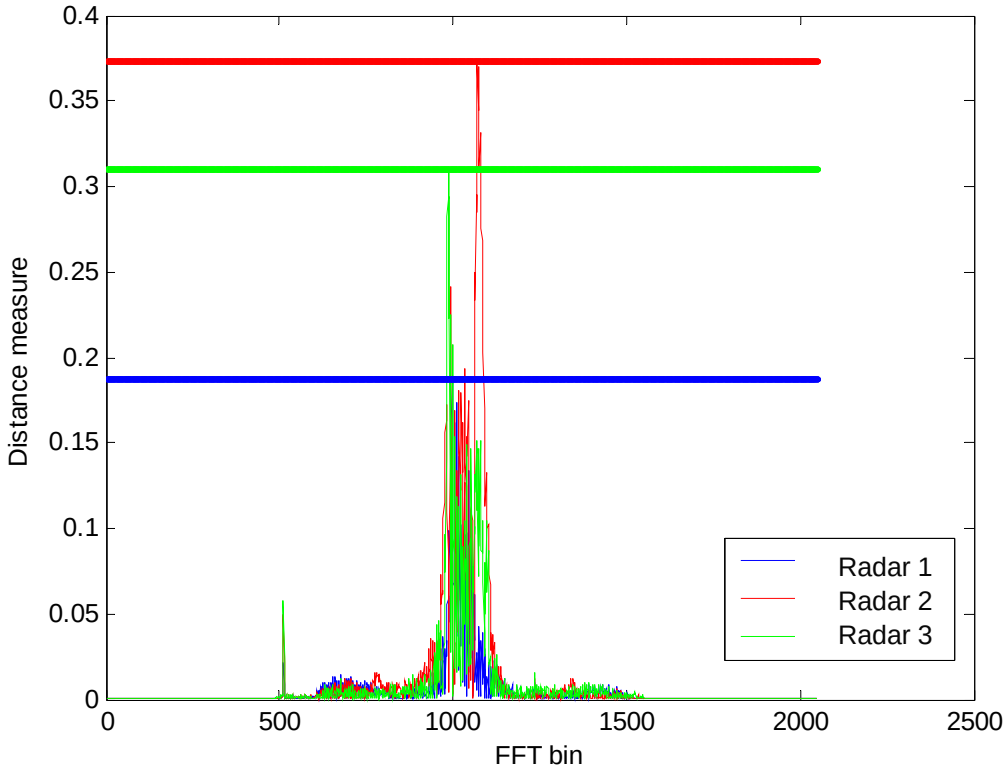


Spectral information (1)

- Compare spectrum of unknown transmitter with set of reference spectra (computed through averaging)
- Either only the magnitude response or the magnitude and phase responses
- Only magnitude response comparison was done
- Included in future work, design of a matched filter is a possibility – this will consider both magnitude and phase responses
- Exact alignment (in time and frequency) is very important for accurate calculation of the average

Spectral information (2)

- Results of comparing an unknown radar pulse magnitude response with 3 reference magnitude responses



Classification

- A fuzzy ARTmap classifier was used
- Results are shown for different sets of features

Combination of features	**CCD (%)**
All 19 features	82.32
13 features as selected using the correlation method	85.42
2 features (transmitted frequency and droop)	92.15
7 features as selected using the Gamma test	84.97
4 features as selected using LDA	77.74
6 features as selected using LDA	74.93
8 features as selected using LDA	73.95

Issues related to SEI

- Incomplete data
- Complete characterisation required of own equipment for effective identification of friendly forces

Conclusion and Future work

Conclusions

- Current research shows that classification is possible on radars of the same make and model
- There are many methods that can be implemented to do SEI (feature vector, spectral information, other possible methods yet to be discovered)

Future work

- High sampling rate measurements for more detailed features
- Polarisation measurements and analysis
- Design of matched filter for magnitude and phase response comparison
- Further trials to record more of the same, including radio transmitters

Questions?