Ministry of Defence

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University Defence Research Collaboration in Signal Processing, Phase 3 Application Theme in Electromagnetic Environment

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This document should be read in conjunction with the EPSRC/MOD call document, available on the EPSRC website (https://epsrc.ukri.org/funding/calls/udrcphase3appthemes/).

Technical Challenges

The following are examples of challenges that the research outputs may seek to address. The list is non-exhaustive and not specific, but the statements provide tangible motivating examples of problems for which MOD is seeking solutions. It is not necessary to address all of these Technical Challenges, and other relevant problems may be presented during the course of the award.

1. Rapid Waveform Analysis

The challenge is to be able to rapidly discriminate signals of interest from interfering signals in order to identify potential hostile intent. As opposed to benign or interfering signals, signals of interest may track in frequency or time or may be used in a manner different to similar signals in the same environment. Examples of signals of interest include: previously uncharacterised signals that appear only fleetingly or immediately prior to a hostile event; these signals may appear anomalous but have hostile intent. These signals may be used to track own system response or behaviour.

2. Simultaneous Transmit and Receive (STAR)

This challenge is to develop software, analogue and digital techniques to simultaneously transmit and receive. This is best achieved as part of an overall layered design for potential full, unhindered use of the required spectrum. This means achieving the ability to constantly monitor and characterise, with the freedom to transmit as required. To illustrate the complexities of this challenge beyond that being investigated for civilian applications, consider a case study of wide-frequency range systems operating at frequencies in the HF, VHF and UHF bands with an instantaneous sensing / characterisation bandwidth of 100 MHz and indicative dynamic range of 130dB in a 25 kHz bandwidth.

3. Congested RF environment

In an environment of multiple threat signals, multiple jammers and multiple radio systems, how can the total system responses be optimised, while minimising electromagnetic interference? This may involve spatially distributed coherent processing for sense and attack. AI / machine learning techniques for instance could be useful for optimisation of effects options selection. Optimisations may be weighted differently for different applications such as dynamic spectrum management, mission planning or system efficiency.

4. Increased dimensionality of information extraction from spatiotemporal signals

The challenge is to exploit opportunities for increased information extraction from non-stationary signals across time, frequency and space including vector processing and using advanced processor technologies. Various techniques could give improvements over brute force processing methods, including (but not limited to) parallelisation in new and emerging electronic processors, optical processing and polarisation vector processing.

5. Signal Subspace Methods

The challenge is to explore the utility of subspace techniques for classification of complex signals, but have potentially key subtle differences, due to how the individual hardware components produce the signals, for instance analogue and digital systems may have a characteristic fingerprint. A case study is discrimination of radar target returns from hostile jamming signals. Use of these techniques may allow the exploitation of readily available, commercial, processors to reduce computational complexity.

6. Precise spatiotemporal delivery of energy

To extend research for precise energy delivery in time and space where the environment may not always be well characterised or where process feedback may be more challenging to achieve compared to that reported in academic press for digital network optimisation or controlled applications. The aim is to evaluate and demonstrate improved delivery of Electronic Warfare effects by employing techniques to focus and enable the precise delivery and or reception of radio energy in time and space.

7. Signal Pre-distortion

The challenge is to understand how signal pre-distortion can be used to overcome the non-linear effects of the electromagnetic and physical environments and or electromagnetic coupling physics in order to deliver a desired response in a target or at a point in space or to improve quality of service metrics.

8. Efficient signal disruption

The challenge is to develop novel techniques for signal disruption that are surgical, energy efficient and require the minimum amount of information on the host waveform. Covert techniques are desirable.

9. Response to Tracking Waveforms

The challenge is to understand signalling and system implications of interfering with signals designed to track the radio system being protected, including adaptive / iterative optimisation of own response to detected changes in not-previously-encountered tracking signals. Given that tracking signals may not have been encountered previously, dynamic, computationally efficient techniques are likely to be required. Response optimisation is of interest including in response to detected changes in the tracking signals.