Imperial College London

UCL

Signal Sensing, Design and Delivery for Electronic Warfare

University Defence Research Collaboration

Application Theme in Electromagnetic Environment

Project Background

Joint Imperial-UCL consortium - 3 year (April 2019-March 2022)

- In collaboration with underpinning UDRC consortium (UEDIN) and DSTL

Challenge

- Information extraction and delivery of signals in EM environment
- Accounting for specificities of Electronic Warfare:
  - high dimensionality, complex and congested EM environment, mix of threat and benign signals, wide range of platforms, systems and applications, lack of cooperation, covert transmission, demand of extremely high reliability

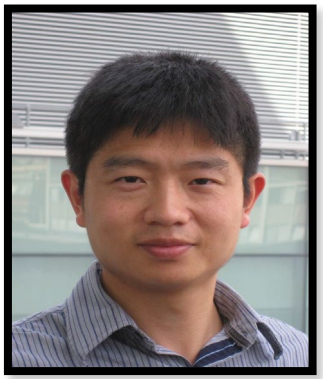
Aims

- Addresses signal extraction and delivery *jointly* as integral parts of a single, coherent research programme
- Brings together state-of-the-art expertise in signal processing for civilian and military RF applications

Imperial-UCL Consortium

Imperial College London

Bruno Clerckx
Wireless Comms



Wei Dai
Signal Processing

Kin Leung
Comms networks

UCL

Hugh Griffiths
Radar

Matthew Ritchie
Radar

Christos Masouros
Wireless Comms

Project Goals

Analyse, separate and characterise signals across time, frequency, and space and extract useful information from those signals

- develop and leverage novel super-resolution, subspace and deep learning methods

Design signals and system responses for sensing and signaling in congested EM environments

- Waveform for sensing, for precise spatiotemporal signaling and for joint sensing and signaling

… with the design of sensing (signaling) techniques being informed by signaling (sensing) approaches

Project Novelty

Joint signal extraction and delivery through the “double” lenses of

(1) new blind and computationally-efficient *super-resolution framework*,

(2) new *network-wide optimisation* with spatially distributed nodes, *robust* to imperfect/partial channel state and process feedback, under nonlinear channel responses

to capture four modes of information from signals (namely time, frequency, space and waveforms) and enable high precision in spatiotemporal sensing and signalling

WP1 Sensing Signals and Extracting Information

Develop a unified framework to seamlessly extract *four modes of information* from signals: time, frequency, space, and waveform

T1.1. Super-resolution with Unknown Waveforms

- Detect and locate threat signals in spectrum, time, and space, even when we don't know what they look like
- If waveforms are unknown, correlation based localisation does not work
- New blind super-resolution framework

T1.2. Low-probability-of-intercept (LPI) Signal Detection/Classification

- Specific instance of the framework
- Develop a flexible RF chain model, generate example datasets, test super-resolution and subspace methods

T1.3. Learning for the Super-Resolution Framework

- DNN to track the relationships among the four modes of information
- Provide new insights and enhance the super-resolution framework

WP2 Signal Designs and Delivery

Study a *network-wide* and *robust* optimization of waveforms for sensing, signaling and joint sensing-signaling purposes

T2.1. Waveform Design for *Sensing* beyond the Ambiguity Function

- Characterize the dependence of the Ambiguity Function on waveform and bistatic geometry (spatially distributed nodes)
- Network-wide processing with spatially distributed nodes: optimal transmit receive pair, dynamic emitter selection, single/multi-target tracking

T2.2. Waveform Design for Precise Spatio-Temporal *Signaling*

- Enabling precise spatiotemporal signaling and energy delivery while dynamically managing EM interference
- Network-wide and robust optimisation of waveforms with imperfect knowledge of the channel state, with spatially distributed nodes
- Time-reversal (TR) waveforms to enable high energy focusing

WP2 Signal Designs and Delivery

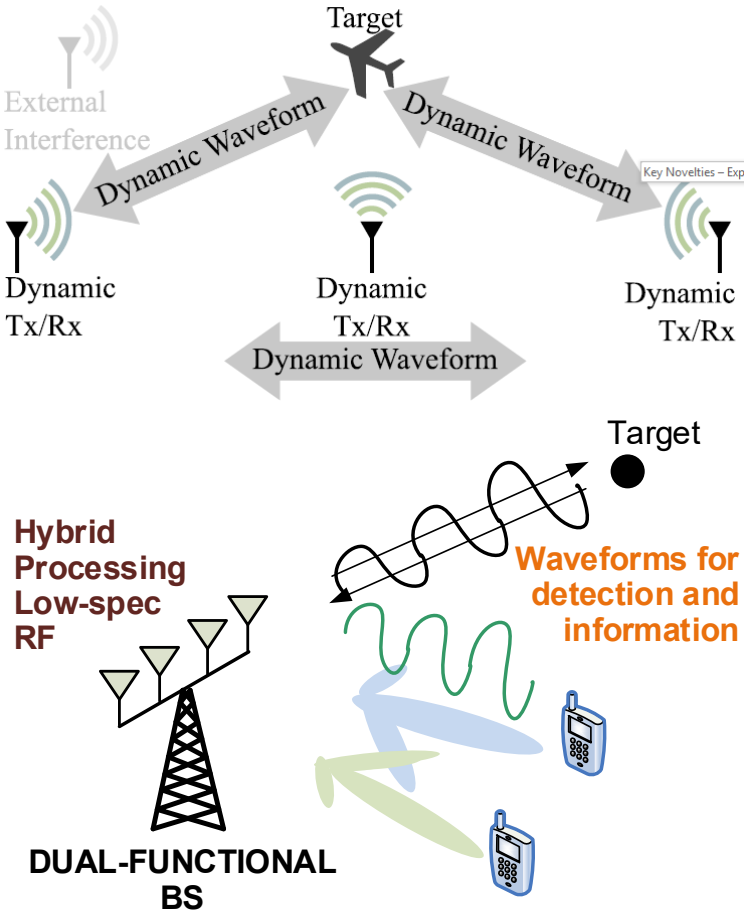
T2.3. Joint Waveform Design for *Sensing and Signaling*

- Decongesting the spectrum: Waveforms for remote sensing that carry covert/non-covert information

T2.4. Hardware and Nonlinearity *Resilient* Waveform Design

- Hardware limitations: low-resolution ADCs, power amplifiers with low dynamic range and other low-spec circuits;
- Nonlinear hardware and EM channel responses;
- Constant Modulus (CM) waveforms.

Dual Comms-Radar Transmission



Work Plan

	Tasks	M1-6	M7-12	M13-18	M19-24	M25-30	M31-36
WP1	T1.1	PDRA 1 (M1-12), PhD student (M1-24)					
	T1.2	PDRA 2					
	T1.3		PDRA 3				
WP2	T2.1	PDRA5					
	T2.2			PDRA4		PhD student (M25-36)	
	T2.3			PDRA5			
	T2.4					PDRA4, PDRA5	

Partners

- IBM Research
- University of Kansas
- US Army Research Laboratory
- Thales Group (UK)
- Fraunhofer Institute of Communications