Loughborough, Surrey, Strathclyde and Cardiff (LSSC) Consortium

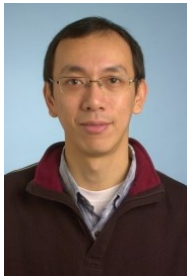
Signal Processing Solutions for the Networked Battlespace

Director: Jonathon Chambers FREng CEng FIET FIEEE

Sensor Signal Processing for Defence: Strand Palace Hotel, Wednesday 4th December 2013

Academic Team










Professors John McWhirter FRS FREng and Ian Proudler have over 50 years of defence signal processing experience at RSRE, DERA and QinetiQ

Research Associates Team

Fran

Ioannis

Anastasia

Carmine

Cemre

Miao

Swati

Keith

Seven PhD students supported by LSSC universities started in October 2013

Industrial Supporters

QinetiQ Ltd., Malvern	**Prof. M. Macleod**
Selex ES, Edinburgh	**Dr. A. Colquhoun**
Thales UK, Reading	**Prof. C. Firth**
Texas Instruments, Europe	**Dr. I. Hunter**
PrismTech Group Ltd., Stirling	**Dr. K. Steele**
Mathworks, Glasgow	**Dr. J. Bowman**

PDRAs and PhDs will spend secondments with these companies to extend the scope of data set generation, algorithm evaluation and real-time realization.

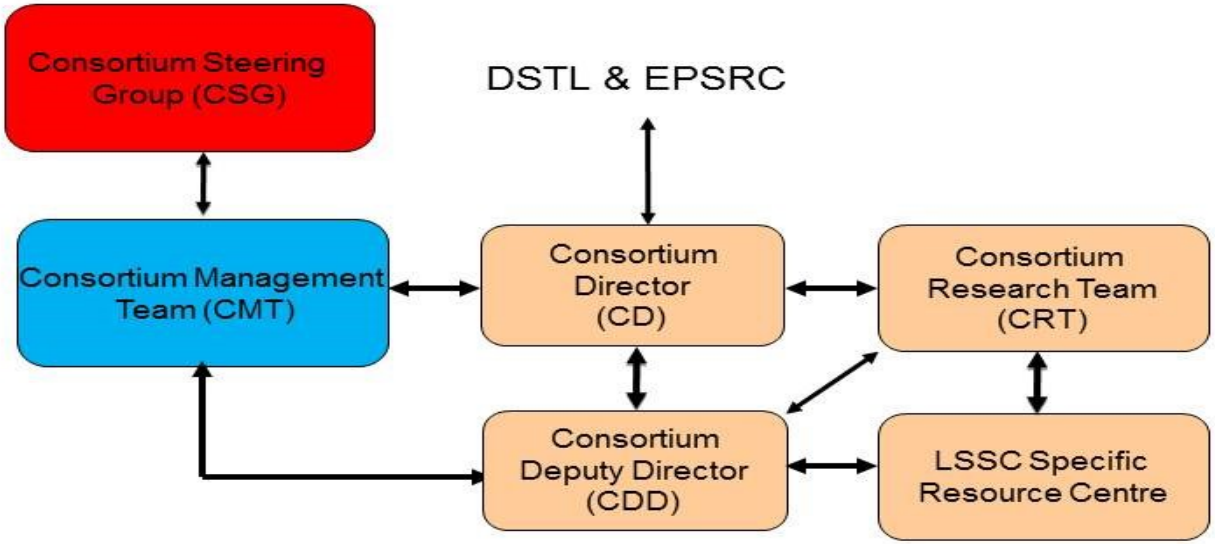
Research Office Team

Arif Syed

Jeanette Guida

To maximise industrial engagement we have in place a “Supporters Engagement Agreement”

Management and Operation



LSSC-Consortium Management Structure

CSG Members: CD, CDD, PIs, EPSRC, Industry, DSTL, Independent Experts
CMT Members: CD, CDD, PIs, CIs

Management and Operation

Six-monthly CSG meetings:-

CD	-	Jonathon Chambers
CDD	-	John Soraghan
WPLs	-	Work Package Leaders
EPSRC	-	Matthew Lodge
Dstl	-	Andrew Baird, Paul Thomas, Bob Elsley
PSs	-	Project supporters/industrialists

Independent experts

Alan Gray	Ex-Military, DERA & Dstl
Andrew Middleton	Director Malvern Labs, Ex Technology Strategy Director QinetiQ

First CSG Meeting – October 2013

Professor Robert Allison, Vice Chancellor, Loughborough University thanks EPSRC & Dstl.

Technical Context:-

Future battlespace will be a complex environment characterised by known and unknown threats, modern and legacy sensor systems, a congested RF spectrum, and mobile and static forces.

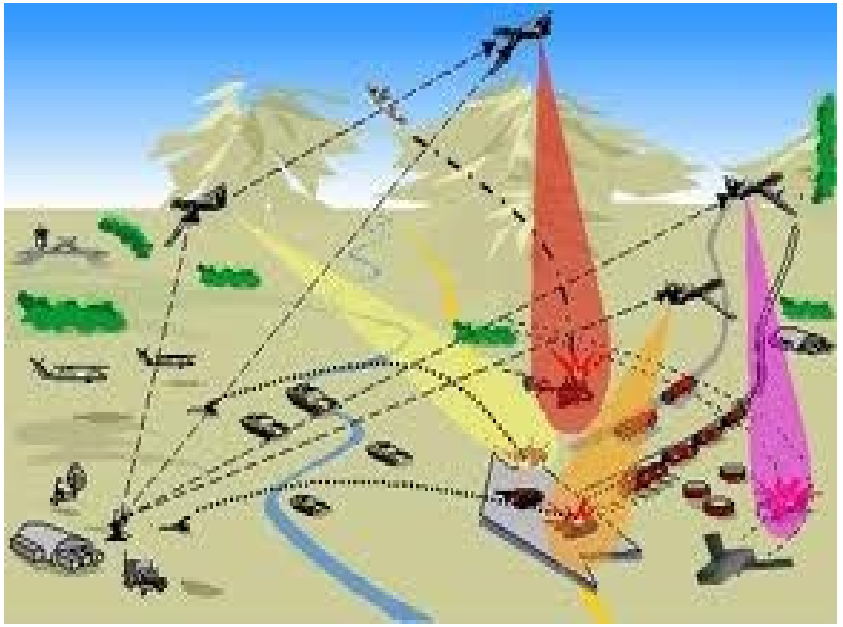


Image source: www.cds.caltech.edu

To Support UK Forces in this Environment there is a need to Exploit a Heterogenous Mix of Sensors

Challenges to signal processing include to

- Maximize the amount of information on hostile activity
- Transport this information to the people who need it
- Take due notice of the available communications bandwidth
- Cope with a high density of signals, and signals hard to detect & classify
- Reduce the work load of operators and interact with coalition forces
- Be able to execute the operations in shortest possible time
- Meet power and cost constraints

LSSC aims to

- advance the state-of-the-art in fundamental signal processing for the networked battlespace.

- publish and present work in the foremost international conferences and journals.

- transfer knowledge and skills to UK industry in defence and other sectors.

- provide the foremost training to its research staff and students.

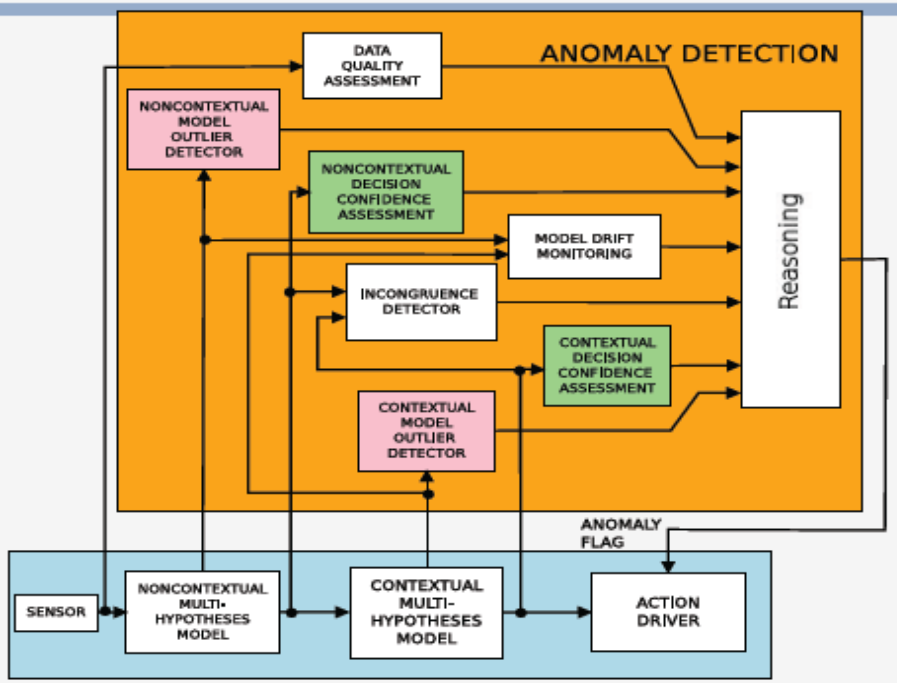
- work with the Edinburgh consortium to establish a community of practice in signal processing in the UK.

Wor

WP
stati
dete
class
dim
netw
(Lea
Thal
Academics: Profs Kittler and Parish)

UNIVERSITY OF SURREY

Proposed anomaly detection system

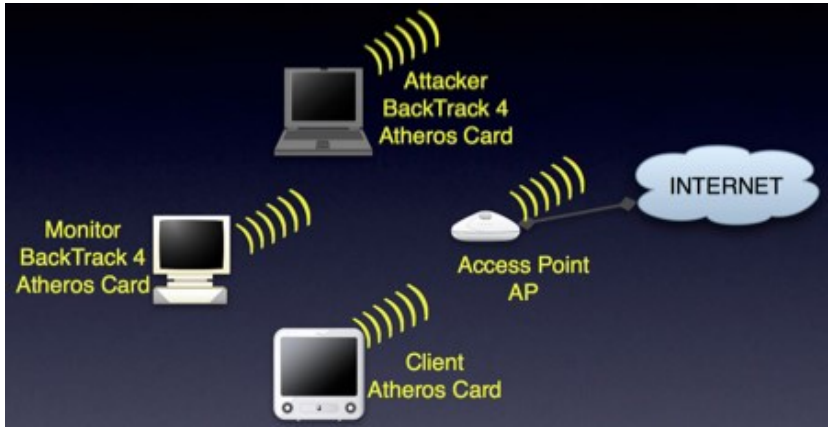


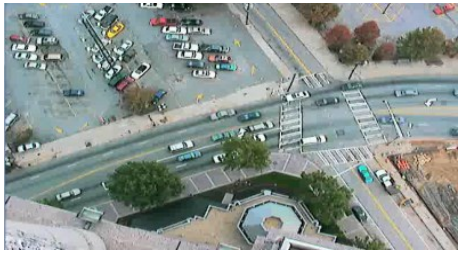
Loughborough University

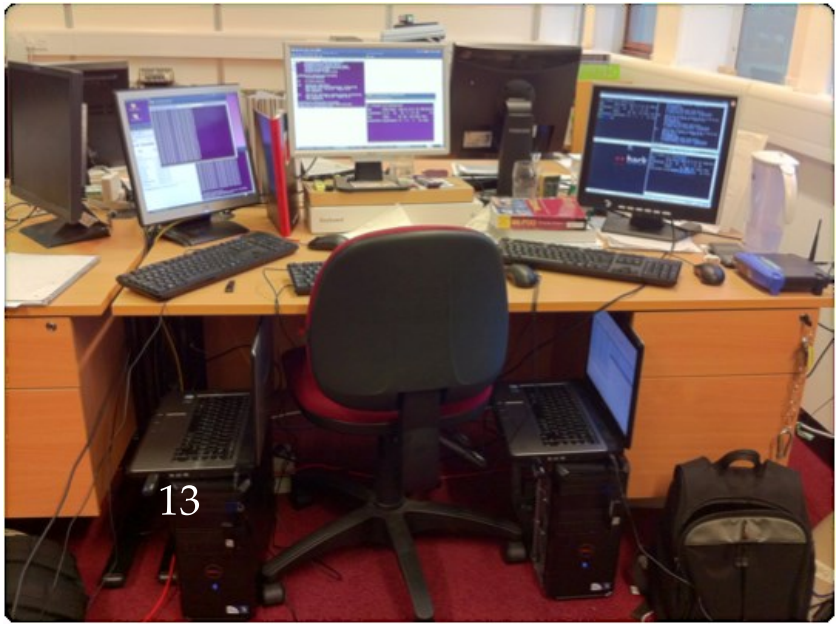
CARDIFF UNIVERSITY

6

Anomaly Detection - Communication Networks and in Video

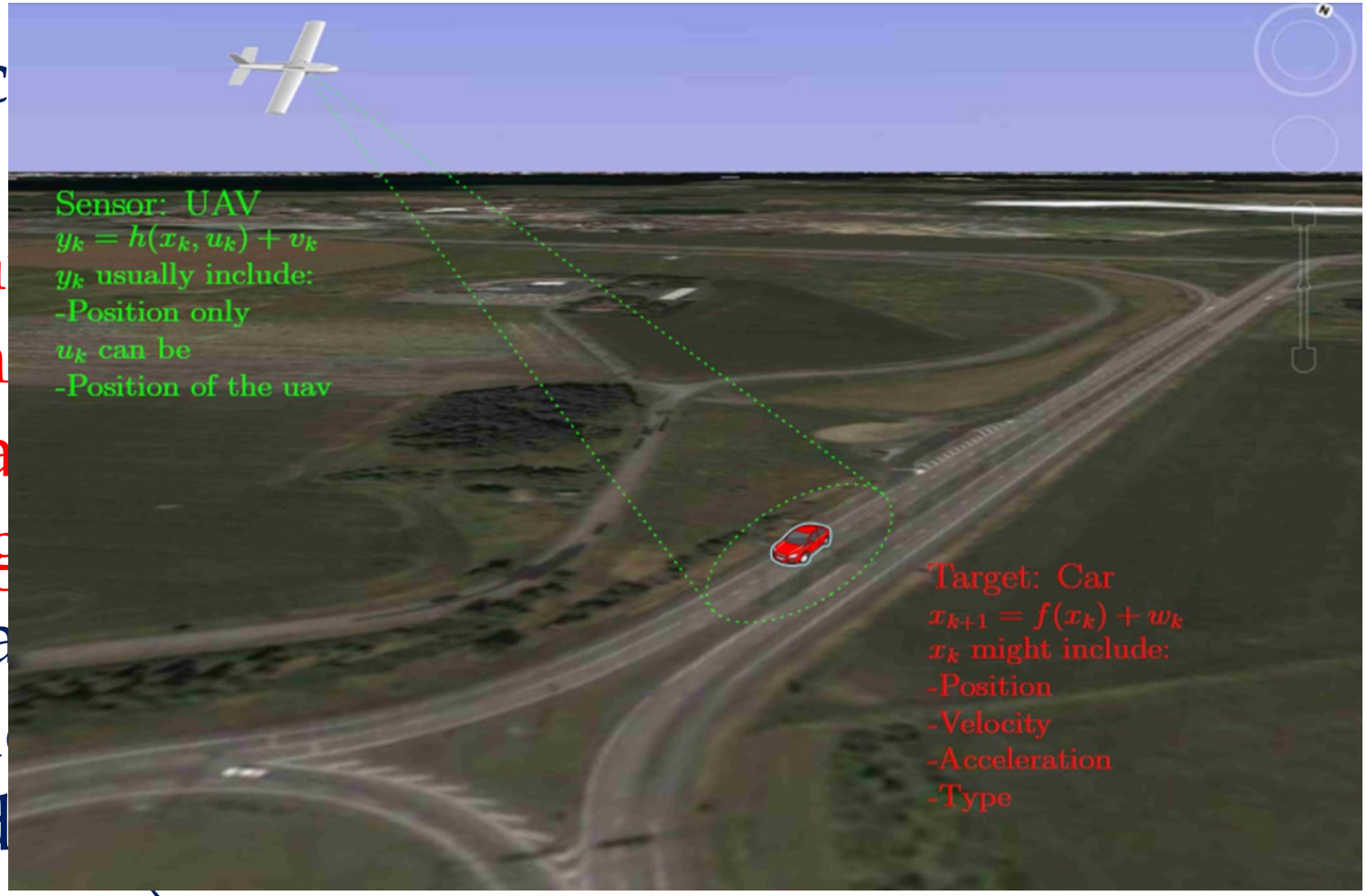




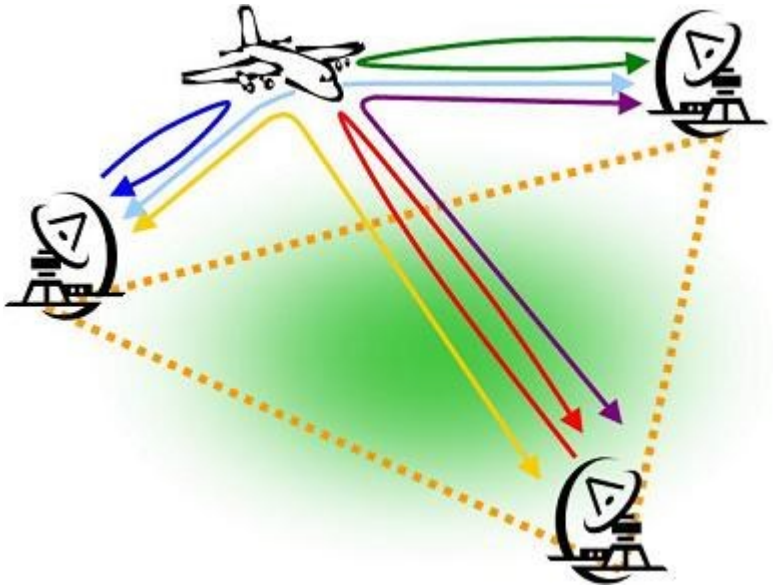


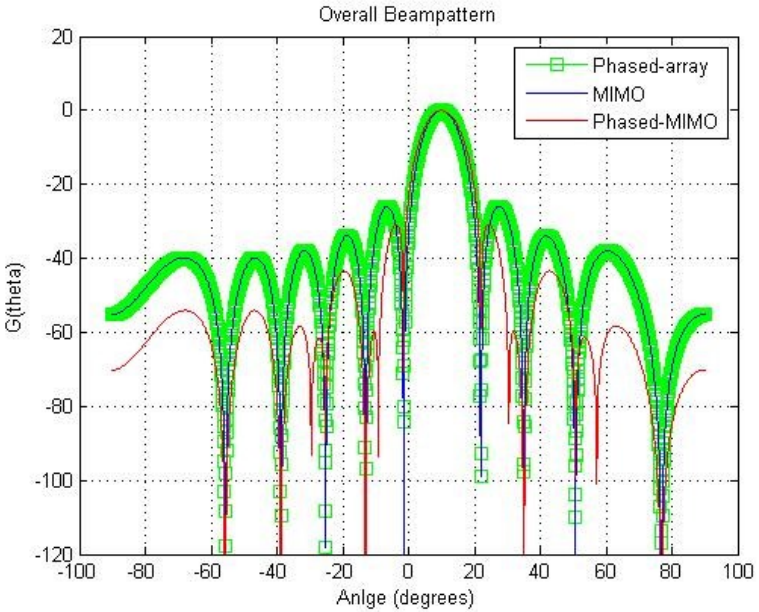
Work Pac

WP2: Ha
uncertain
incorpora
knowledg
Project Pa
Lead Aca
Chen and
Lambotharan)



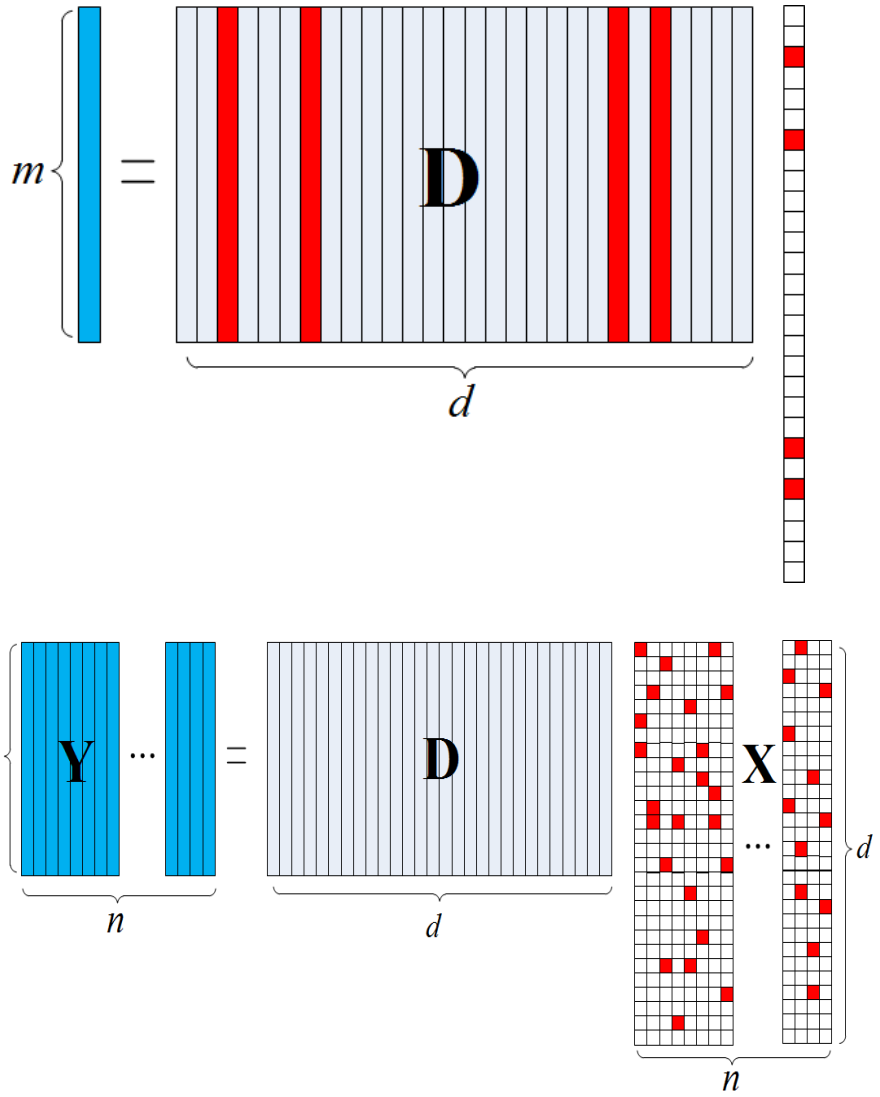
Game Theoretic Approach to Distributed MIMO Radar Waveform Design



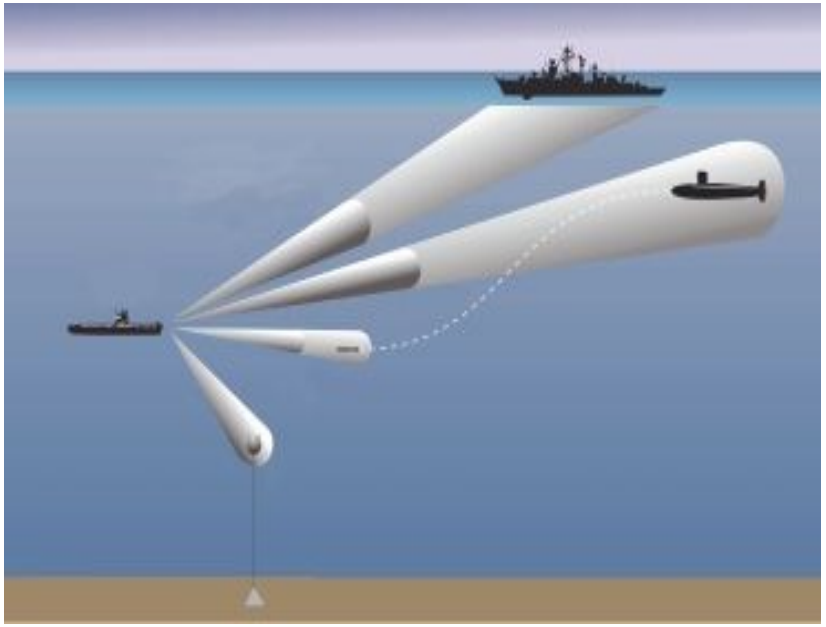


Work Package 3

WP3: Signal separation and broadband distributed beamforming (Lead Project Partner: QinetiQ; Lead Academics: Dr Wang and Prof. McWhirter)



Mitigating interference and multipath channels (polynomial matrices)



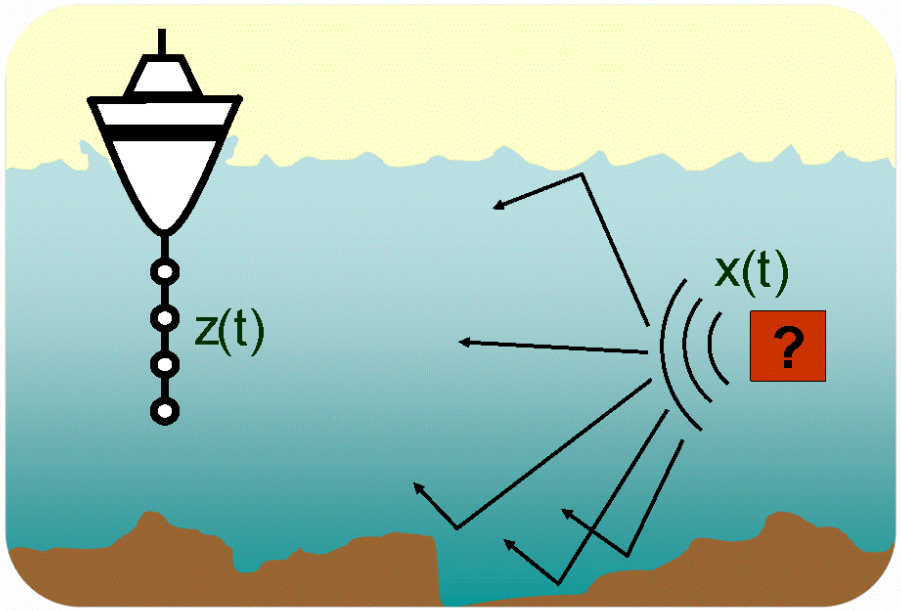


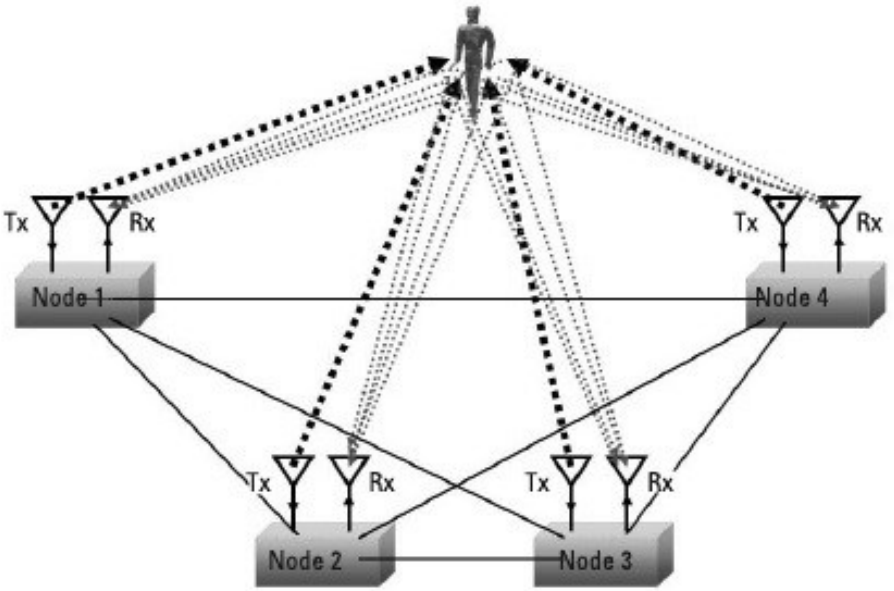
Image Sources: www.maritime.com; cnx.org

$$\Lambda(z)=\begin{bmatrix} 2+(z^{-1}+2+z)^{1/2} & 0 \\ 0 & 2-(z^{-1}+2+z)^{1/2} \end{bmatrix}$$

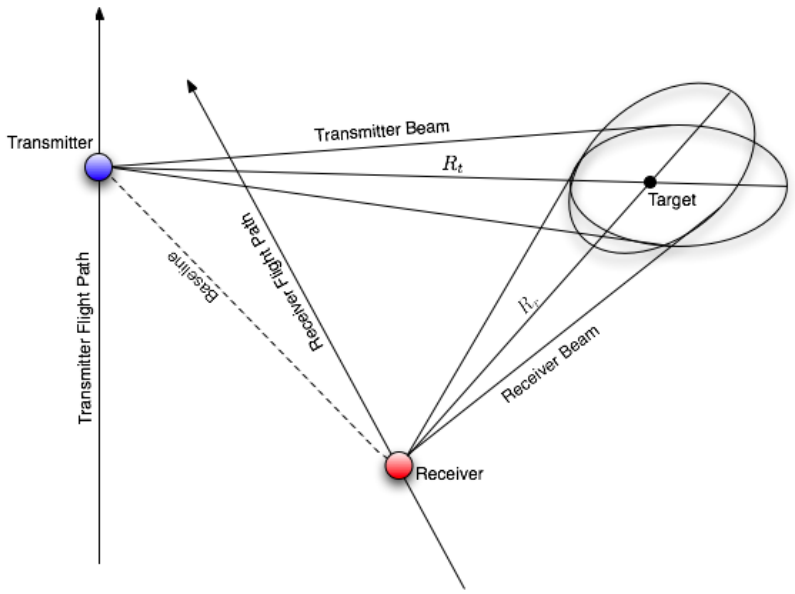
$$\mathbf{U}(z)=\frac{1}{\sqrt{2}}\begin{bmatrix} (z^{-1}+1)(z^{-1}+2+z)^{-1/2} & z^{-1} \\ 1 & (z^{-1}+1)(z^{-1}+2+z)^{-1/2} \end{bmatrix}.$$

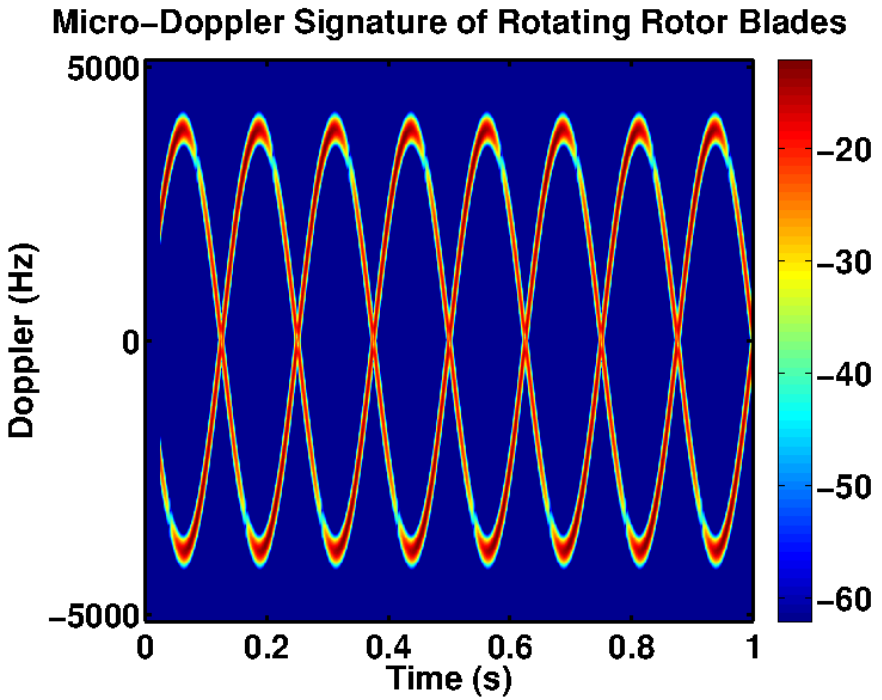
Work Package 4

WP4: MIMO and distributed sensing (Lead Project Partner: Selex ES; Lead Academics: Profs. Soraghan and Proudler)



Bistatic Radar and Micro-Doppler Analysis

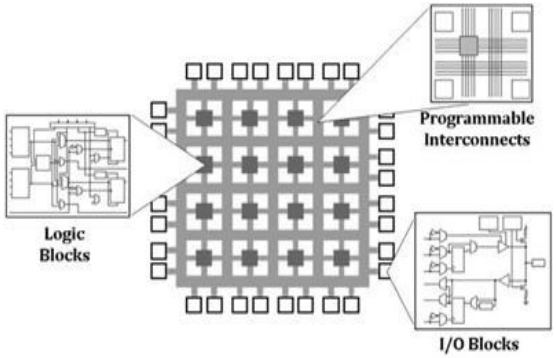


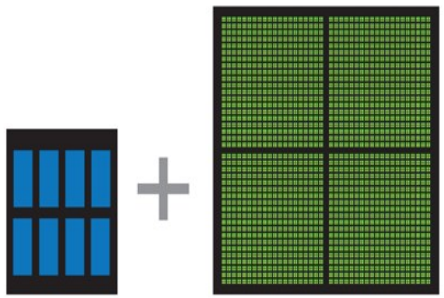


Work Package 5

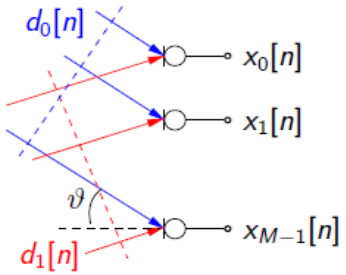
WP5: Low complexity algorithms and efficient implementation (Lead Project Partners: Mathworks, Prismtech and TI; Lead Academics: Dr. Weiss and Prof. Proudler)

MathWorks®
Accelerating the pace of engineering and science



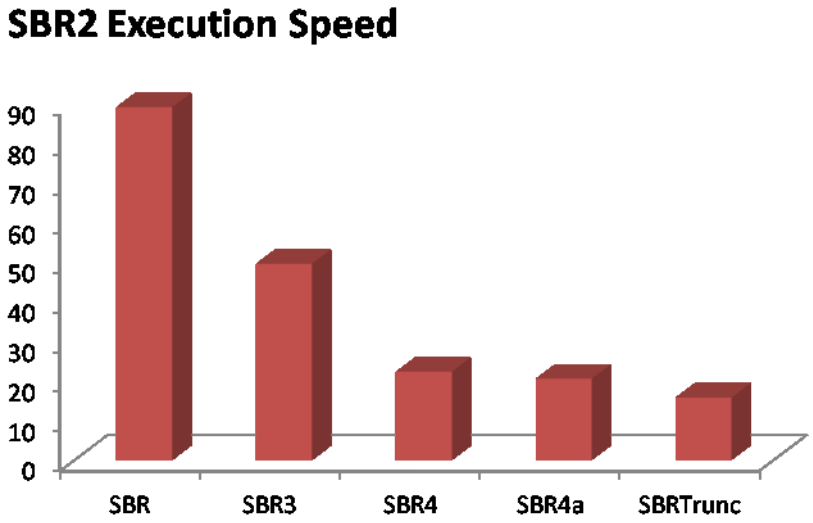


SBR2 approximates PEVD of R(τ) Space-Time Covariance Matrix

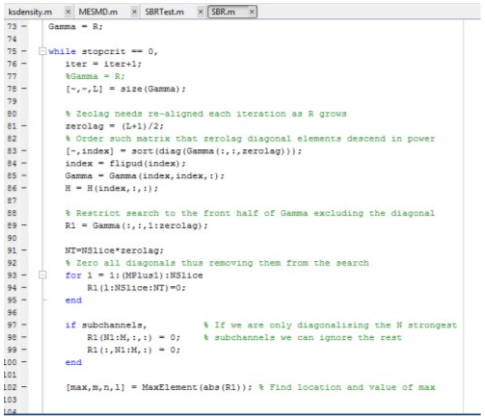


$$\mathbf{x}_n = \begin{bmatrix} x_0[n] \\ x_1[n] \\ \vdots \\ x_{M-1}[n] \end{bmatrix} = \sum_i \mathbf{s}(\vartheta_i)[n] * d_i[n] + \mathbf{v}[n]$$

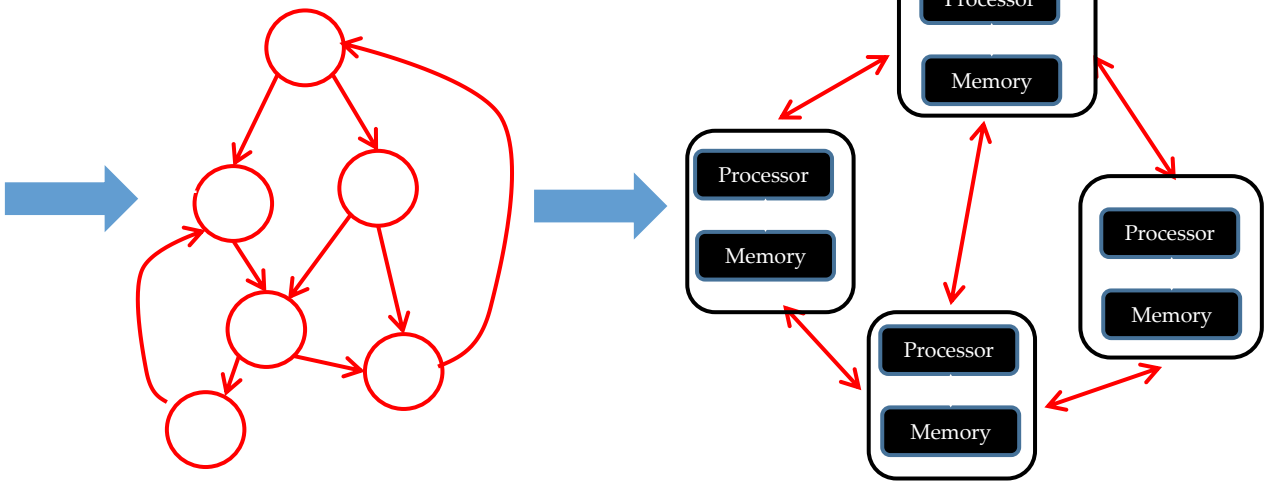
$$\mathbf{R}[\tau] = \mathcal{E}\{\mathbf{x}_n \mathbf{x}_{n-\tau}^{\mathrm{H}}\}$$



Mapping algorithms with Statistical/Graphical models (e.g. Bayesian Networks)



```
Gamma = R;

while stopcrit == 0,
    iter = iter+1;
    %Gamma = R;
    [~,~,L] = size(Gamma);

    % Zeolag needs re-aligned each iteration as R grows
    zerolag = (L+1)/2;
    % Order such matrix that zerolag diagonal elements descend in power
    [~,index] = sort(diag(Gamma(:,:,zerolag)));
    index = flipud(index);
    Gamma = Gamma(index,index,:);
    H = H(index,:,:);

    % Restrict search to the front half of Gamma excluding the diagonal
    R1 = Gamma(:,:,1:zerolag);

    NT=NSlice*zerolag;
    % Zero all diagonals thus removing them from the search
    for l = 1:(MPlus1):NSlice
        R1(1:NSlice:NT)=0;
    end

    if subchannels,          % If we are only diagonalising the N strongest
        R1(N1:M,:,:) = 0;    % subchannels we can ignore the rest
        R1(:,N1:M,:) = 0;
    end

    [max,m,n,l] = MaxElement(abs(R1)); % Find location and value of max
```



Thank you for your attention...

Questions???

Please attend our posters marked L-WPx and Prof Soraghan's talk.