

# EEE5114Z - MIMO and New concepts of Radar

## 1 Prerequisites

This course requires students to have a good background in radar techniques, radar signal processing, antenna theory and phased array processing and computer programming (MATLAB)

## 2 Course Format and Dates

The course is given in a two day, intensive format, [followed by a project...](#) [shall we describe here?]

## 3 Staff

Convener Prof. M.R. Inggs UCT mikings(a)gmail.com

Lecturer: Prof. Marc Lesturgie, Supelec and ONERA

[marc.lesturgie@supelec.fr](mailto:marc.lesturgie@supelec.fr), [marc.lesturgie@supelec.fr](mailto:marc.lesturgie@supelec.fr)

## 4 Course description:

This course is composed of two parts. The first part addresses the principles and techniques related to the operation of a MIMO radar system. The second part investigates a selection of new radar concepts for which the performances are improved by the use of MIMO techniques; several applications, GMTI/STAP, Foliage penetration radar, low frequency long range radar, multistatic and passive radars, will be illustrated in order to show the benefiting MIMO configurations. The course gives also the opportunity to review most of the techniques widely used in modern radar such as phased array electronically scanning antenna (ESA), adaptive processing, generalized likelihood detector (GLRT), moving target indicator (MTI), passive coherent location (PCL), waveform design and ambiguity function.

### 4.1 Overview , introduction and definitions

- How MIMO works in communication and Navigation
- MIMO in radar (starting from RIAS, the first MIMO radar)
- Definition of a MIMO radar configuration
- Statistical and Coherent MIMO

*The lecture will also bring a reminder on the target radar signature phenomenology, which is essential to understand the statistical and coherent MIMO configurations*

### 4.2 Signal Model for MIMO

- Define the signal model and study the properties of the transmitted pattern
- Average transmitted power and comparison with the conventional ESA
- Examples of codes and array transmitted patterns

*The lecture also contains a reminder on the phased array techniques and signal processing applied to radar*

### 4.3 Signal processing at reception

- Estimation of the steering vector
- MIMO signal chain
- Detection based on GLRT
- MIMO steering vector and Virtual array
- Range-Doppler processing and high resolution techniques

### 4.4 MIMO Waveform design

- Classification of codes, fast time and slow time coding
- The ambiguity and cross-ambiguity function of MIMO waveform

#### **4.5 Application in GMTI ground surveillance**

- Principles of and GMTI STAP
- FoPen Radar
- Benefit of MIMO (examples, results..)

#### **4.6 Low frequency ground-based Radar**

- Skywaves radar
- HF surface waves radar
- Benefit of MIMO (examples, results..)

#### **4.7 Multistatic Radar and Passive Radar**

- Bistatic radar principles
- PCL (passive coherent location) principles & examples
- Netted passive radar applications

#### **4.8 Other applications of MIMO**

- Mono-pulse for active antenna
- Shared antenna / time modulated array
- Adaptive transmitting array

#### **4. 7. Project description / discussion (1h)**

#### **4.8 Software Expertise**

Students must be proficient in tools such as Simulink/Matlab, spreadsheets (OpenOffice, Excel), as they are used extensively in the analysis and design examples.

Students will use the tools most familiar to themselves.

#### **5 Learning outcomes:**

Having successfully completed this course, students should be able to:

##### **5.1 Knowledge Base:**

1. Understand the fundamental operation of a MIMO radar and its real benefits vs. conventional radar
2. Be able to identify which kind of radar sensor or application can support and benefit a MIMO mode
3. Identify the key problems and practical challenges in MIMO

##### **5.2 Engineering ability:**

1. Describe a MIMO chain and specify the waveforms and kind of processing
2. Have a correct understanding of important parameters relating to the MIMO radar components

##### **5.3 Practical skills:**

1. First, to be able to simulate a MIMO radar mode, under a simple assumption of orthogonal waveform transmission
3. Second, to deal with the design or selection of MIMO waveforms of a practical use.

#### **6 Textbook**

Only copies of presentation material are given for this course.

#### **7 Lecture Programme**

The first day of lecturing will be Monday May 27<sup>th</sup>, 2013.

The second day of lecturing will be Tuesday May 28<sup>th</sup>, 2013

The detailed schedule is:

| Lecture nr                                    | Subject (Monday May 27 <sup>th</sup> , 2013)   |
|---|--|
| 1   | Structure of the course, MIMO and New Concepts of Radar<br>Introduction and definitions of MIMO (1h) |
| 2   | Signals Model for MIMO (2h)  |
| 3   | Signal processing in MIMO radar (2h)   |
| 5   | MIMO Waveform design (1h)  |
| Subject (Tuesday May 28 <sup>th</sup> , 2013) |  |
| 6   | GMTI and STAP (2h)   |
| 7   | LF ground-based Radar (2h)   |
| 8   | Passive multistatic Radar (2h)   |
| 9   | Other applications of MIMO (1h)  |
| 10  | Project description / discussion (1h)  |
|   |  |

Half hour tea breaks are included in the schedule after the second morning lecture, and the third afternoon lecture, while a one hour lunch break is scheduled after the fourth morning lecture. Daily time of start will be 08h, while closing will be at 18h.

### 8 Course Assessment and Examination

develop some simulation tool, e.g. Monopulse antenna under Matlab, to extend the conventional monopulse to MIMO, simulate signals, the monopulse rate, and the accuracy. Students will need to provide the simulation code + ppt presentation + 30mn oral defense (by Skype, 3rd or 4th week of June).

### 11 Course Load

|  | number | hrs/per | hours     | grading effort needed | Rel. weight in final grade |
|--|--------|---------|-----------|-----------------------|----------------------------|
| Lectures                                       | 15     | 1       | 15        |                       |                            |
| assimilation                                   | 15     | 1       | 15        |                       |                            |
| seminar attendance<br>(to present the project) | 1      | 3       | 3         |                       |                            |
| exam preparation                               | 1      | 17      | 17        |                       |                            |
| <b>Total</b>                                   |        |         | <b>50</b> |                       |                            |