Universidad Politécnica de Cartagena

Centro Universitario de la Defensa

**General Air Force Academy**

# Course unit description:

## Electromagnetic Exploration Systems

**Degree/s: Industrial Organization Engineering**

**Course: 2016-2017**

## 1. Subject data

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|---|---|---|---|---|---|
| **Name** | Electromagnetic Exploration Systems | | | | |
| **Subject area** | Electromagnetic Exploration Systems | | | | |
| **Module** | 511103011 | | | | |
| **Code** | Industrial Organization Engineering Degree | | | | |
| **Degree programme** | 2009 (Decreto 269/2009 de 31 de julio) | | | | |
| **Curriculum** | University Centre of Defense at the Spanish Air Force Academy | | | | |
| **Centre** | Elective | | | | |
| **Type** | Electromagnetic Exploration Systems | | | | |
| **Length of subject** | Four-month course (1 semester) | **Semester** | 2nd | **Course** | 4th |
| **Language** | English | | | | |

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|---|---|---|---|---|---|
| **ECTS** | 7.5 | **Hours / ECTS** | 25 | **Total workload (hours)** | 187.5 |

## 2. Lecturer data

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|---|---|---|---|
| **Lecturer in charge** | Nina Skorin-Kapov | | |
| **Department** | Integrated Areas | | |
| **Knowledge area** | Telecommunications | | |
| **Office location** | Office 7 @ CUD building | | |
| **Telephone** | +34 968 189 911 | **Fax** | +34 968188780 |
| **email** | nina.skorinkapov@cud.upct.es | | |
| **URL / WEB** | Aula Virtual UPCT | | |
| **Office hours** | To be defined | | |
| **Location** | Office 7 @ CUD building | | |

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|---|---|
| **Teaching and research profile** | Doctor of Electrical Engineering, Field Telecommunications. Associate Professor of Telecommunications. |
| **Teaching experience** | >10 years: teaching at the Universidad de Zagreb (10 years) and at CUD in San Javier (1.5 years)<br>Courses taught: Electromagetic Exploration Systems, Informatics, Heuristic Optimization Methods, Information Theory, Photonic Telecommunication Networks, Photonic Communication Technologies, Algorithms and Optimization Methods, Computer Science, Teletraffic Theory, Transmission Systems, Logical Algebra, Information Networks, Reliability of Telecommunications Systems, Digital Logic, Telecommunication Systems and Networks |
| **Research lines** | Optimization and planning in telecommunications, WDM wide-area optical networks, (meta)-heuristic algorithms, network security and attack management |
| **Work experience** | Member of the Advisory Board of the Institute of Telemedicine of the Republic of Croatia, (2009 – 2012)<br>Associate Editor of the CIT - Journal of Computing and Information Technology |
| **Other** | ECTS coordinator (Coordinating exchanges for international programs Erasmus, Double Degree, Erasmus Mundus) at the Faculty of Electrical Engineering and Computing, University of Zagreb, Croatia (2010- 2013) |

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|---|---|---|---|
| **Lecturer** | María Teresa Martínez Inglés | | |
| **Department** | Integrated Areas | | |
| **Knowledge area** | Telecommunications | | |
| **Office location** | Office 2 @ CUD building | | |
| **Telephone** | +34 968 189 916 | **Fax** | +34 968188780 |
| **email** | mteresa.martinez@cud.upct.es | | |
| **URL / WEB** | Aula Virtual UPCT | | |
| **Office hours** | Tuesday and Thursday at 12:50-14:25 (after prior appointment by email) | | |
| **Location** | Office 2 @ CUD building | | |

| | |
|---|---|
| **Teaching and research profile** | Doctor of Telecommunication Engineering, Field Telecommunications. Associate Professor of Telecommunications. |
| **Teaching experience** | 3 years<br>Courses taught:<br>Optic Communications, Telecommunication Systems and Services, Spatial and terrestrial Radiocommunications, Electromagetic Exploration Systems |
| **Research lines** | Characterization and Modeling of the radio channels for systems with large bandwidth in the millimeter frequency band<br>Experimental study of multiple Diffraction phenomenon in the millimeter band |
| **Work experience** | 3 years<br>AQUILINE: Software engineer<br>UPCT: Engineer. Studies about the viability of cognitive systems |

# 3. Subject description

## 3.1. General description

The course "*Electromagnetic Exploration Systems (EES)*" is an elective course in the 4th year of the undergraduate program in Industrial Organization offered at the University Centre of Defence (CUD) as part of the formation of future Air Force officers at the Spanish Air Force Academy (AGA). Specifically, the main objective is for students to learn the basic theoretical and practical concepts of radar and radionavigation systems, and thus, develop the skills needed to apply them in their future professional practice.

Radar systems apply the concepts of electromagnetic wave propagation to detect objects (targets) and determine their distance (range). Modern radar systems can be used to track, identify, and image targets, and have numerous military and civilian applications, such as aircraft and missile detection and tracking, fire control, weather radar, and airport surveillance. The first part of this course covers the basic elements of radar systems, their underlying principles of operation, design issues and applications. It develops upon the basic concepts on radar systems introduced in course Security and Defense Technology.

In addition to the aforementioned radar applications, exploiting the properties of electromagnetic wave propagation is widely used in navigation systems to determine the position of moving objects with respect to a reference, referred to as radionavigation. The second part of this course covers a wide range of air radionavigation aids, including both terrestrial systems (point source systems, aircraft landing systems, and hyperbolic systems) and satellite systems.

The complex and practical character of the course will also be aimed at developing skills such as teamwork, independent learning, quality concern and critical thinking.

## 3.2. How the subject contributes to a professional career

Radar systems have extensive military applications, including target tracking, surveillance, and reconnaissance missions, as well as military and civilian applications in air traffic control and weather detection. Thus, knowledge of the underlying principles of operation of radar systems is critical for military officers with direct responsibilities in the areas mentioned. Furthermore, understanding the foundations of various radionavigation systems, specifically air navigation aids, including both terrestrial and satellite systems, form an integral part of the formation of future Air Force officers. This course is meant to provide the fundamental knowledge needed to understand the theoretical workings and design of radar and radionavigation systems, and thus prepare the students with a solid theoretical background to face their practical training within the Spanish Air Force.

## 3.3. Relationship with other subjects in the programme

The course further develops concepts introduced in course Security and Defense Technology (3rd year), Block II, and also complements the course Networks and Communications Services (3rd year).

## 3.4. Incompatibilities defined in the programme

Nonexistent.

## 3.5. Recommendations to do the subject

It is recommended that students have basic knowledge of electromagnetism and Fourier analysis. These topics are covered in first year subjects Physics and Calculus, respectively. Furthermore, it is recommended that students have basic knowledge of electromagnetic wave propagation, signal modulations, and antenna basics, covered in course Security and Defense Technology in the 3rd year of the degree.

## 3.6. Special provisions

Special measures will be taken to allow for successful completion of the students´ military & aeronautical training activities which run in parallel to the course. Specifically, working groups will be formed to promote cooperative learning for students with limited availability; scheduled tutoring activities will be available and lecture notes will be provided on the course website.

# 4. Competences and learning outcomes

## 4.1. Basic curricular competences related to the subject

BC1. Students must know and understand a field of study that has its basis in secondary education for which advanced textbooks are used. In addition, students must also be acquainted with avant-garde knowledge of their field of study.

BC2 Students must know how to professionally apply their knowledge to their work or vocation and have the skills to make and defend arguments and solve problems in their field of study.

BC3 Students must have the ability to collect and interpret important data (normally within their area of study) in order to make judgements considering relevant social, scientific or ethical issues.

BC4. Students must be able to transmit information, convey ideas, and describe problems and solutions to a specialised and non-specialised audience.

BC5. Students must have developed the learning abilities needed to undertake subsequent studies with a high degree of autonomy.

## 4.2. General curricular competences related to the subject

## 4.3. Specific curricular competences related to the subject

PROFESSIONAL COMPETENCES
E 2.8."Ability to organize, control, protection and use of units responsible for force protection, control systems, control and operational support to air operations"

## 4.4. Transversal curricular competences related to the subject

INSTRUMENTAL COMPETENCES
- ☒ T1.1 Analytical and summary skills
- ☒ T1.3 Oral and written communication skills in their mother tongue
- ☒ T1.7 Problem solving skills

PERSONAL COMPETENCES
- ☒ T2.2 Teamwork

SYSTEMIC COMPETENCES
- ☒ T3.1 Ability to apply theory to practice
- ☒ T3.2 Learning ability
- ☒ T3.7 Ability to work autonomously

## 4.5. Subject learning outcomes

The main objective of the course is to understand the underlying principles of operation and capabilities of modern radar and radionavigation systems. Specifically, the student should be able to:

1. Explain the principles of electromagnetic wave propagation and radio detection
2. Enumerate the basic elements of radar systems
3. Explain the workings of radar subsystems and the influence of external factors
4. Identify the problematics associated with radar system design
5. Distinguish between different types of radar and modern radar applications and identify their capabilities and limitations
6. Explain positioning methods used in radionavigation
7. Explain the basic principles of operation of terrestrial navigation systems (hyperbolic radionavigation systems, point-source systems and aircraft landing systems)
8. Explain the basic principles of satellite navigation systems
9. Describe the capabilities and limitations of terrestrial radionavigation systems and global satellite navigation systems

## 5. Contents

### 5.1. Curricular contents related to the subject

Radio determination. Air navigation aids. Ground equipment. Onboard equipment. Radar.

### 5.2. Theory syllabus (teaching modules and units)

**BLOCK I. RADAR SYSTEMS**

Unit 1: Introduction to radar systems
- Lecture 1: Introduction and Basic Concepts
- Lecture 2: The Radar Range Equation

Unit 2: Radar Subsystems and External factors
- Lecture 3: Propagation effects
- Lecture 4: Radar Cross Section
- Lecture 5: Detection of Signals in Noise
- Lecture 6: Pulse Compression
- Lecture 7: Radar antennas
- Lecture 8: Clutter
- Lecture 9: Signal Processing - MTI and Pulse Doppler Techniques
- Lecture 10: Tracking and Parameter Estimation
- Lecture 11: Transmitters and Receivers

Unit 3: Selected Radar Applications
- Lecture 12: Air Traffic Control Radars

**BLOCK 2. RADIONAVIGATION SYSTEMS**

Unit 4: Introduction to radionavigation systems
- Lecture 13: Introduction and Basic Concepts

Unit 5: Terrestrial systems

Hyperbolic Systems:
- Lecture 14: Hyperbolic Systems; Loran C

Point source systems:
- Lecture 15: Direction Finding: Nondirectional Beacons (NDB), Automatic Direction Finding (ADF), VHF Direction Finding (VDF)
- Lecture 16: VHF Omnidirectional Range (VOR), Distance Measuring Equipment (DME), Tactical Air Navigation (Tacan)

Aircraft Landing Systems:
- Lecture 17: Aircraft Landing Systems: Instrument Landing System (ILS), Microwave Landing System (MLS)

Unit 6: Satellite Systems
- Lecture 18: Satellite Systems: Global Navigation Satellite Systems (GNSS); fundamentals of satellite navigation; Global Positioning System (GPS); Global Orbiting Navigation Satellite System (GLONASS), Galileo, Compass

## 5.3. Practice syllabus (name and description of every practical)

**Laboratory sessions:**

Four lab sessions will be realized to familiarize the students with the basic technologies used in radar systems.

The learning objectives are to:

- Apply the theoretical knowledge acquired in the lectures to practical problems
- Gain knowledge of the main aspects of laboratory work and acquire the capacity to organize, plan and solve problems
- Understand the need for numerical simulations and experiments
- Understand the difficulties encountered when dealing with real problems.
- Learn to work in a team and prepare project/lab reports

## 5.4. Theory syllabus in english (teaching modules and units)

**BLOCK I. RADAR SYSTEMS**

Unit 1: Introduction to radar systems

Lecture 1: Introduction and Basic Concepts

Lecture 2: The Radar Range Equation

Unit 2: Radar Subsystems and External factors

Lecture 3: Propagation effects

Lecture 4: Radar Cross Section

Lecture 5: Detection of Signals in Noise

Lecture 6: Pulse Compression

Lecture 7: Radar antennas

Lecture 8: Clutter

Lecture 9: Signal Processing - MTI and Pulse Doppler Techniques

Lecture 10: Tracking and Parameter Estimation

Lecture 11: Transmitters and Receivers

Unit 3: Selected Radar Applications

Lecture 12: Air Traffic Control Radars

**BLOCK 2. RADIONAVIGATION SYSTEMS**

Unit 4: Introduction to radionavigation systems

Lecture 13: Introduction and Basic Concepts

Unit 5: Terrestrial systems

Hyperbolic Systems:

Lecture 14: Hyperbolic Systems; Loran C

Point source systems:

Lecture 15: Direction Finding: Nondirectional Beacons (NDB), Automatic Direction Finding (ADF), VHF Direction Finding (VDF)

Lecture 16: VHF Omnidirectional Range (VOR), Distance Measuring Equipment (DME), Tactical Air Navigation (Tacan)

Aircraft Landing Systems:

Lecture 17: Aircraft Landing Systems: Instrument Landing System (ILS), Microwave Landing System (MLS)

Unit 6: Satellite Systems

Lecture 18: Satellite Systems: Global Navigation Satellite Systems (GNSS); fundamentals of satellite navigation; Global Positioning System (GPS); Global Orbiting Navigation Satellite System (GLONASS), Galileo, Compass

## 5.5. Detailed description of learning goals for every teaching module

### BLOCK 1: Radar Systems

**Unit 1: Introduction to  Radar Systems**

❖ **TOPIC 1 (BLOCK 1, UNIT 1): RADAR SYSTEMS: INTRODUCTION AND BASIC CONCEPTS**
The objective is to introduce the students to radar systems, outlining the basic concepts and design issues of modern radar.

❖ **TOPIC 2 (BLOCK 1, UNIT 1): THE RADAR RANGE EQUATION**
The objective is to teach the students to interpret and calculate Radar Range Equation (RRE) which one of the basic and most important topics in radar systems, tying together all the radar subsytems and external factors.

**Unit 2: Radar Subsystems  and External factors**

❖ **TOPIC 3 (BLOCK 1, UNIT 2): PROPAGATION EFFECTS**
The objective is to teach the students the individual propagation effects affecting electromagnetic radar signals as they travel to and from the target.

❖ **TOPIC 4 (BLOCK 1, UNIT 2): RADAR CROSS SECTION**
The objective is to familiarize the students with the basic concepts  of the The Radar Cross Section (RCS)  which is a measure of power scattered in a given spatial direction when a target is illuminated by an incident wave

❖ **TOPIC 5 (BLOCK 1, UNIT 2): DETECTION OF SIGNALS IN NOISE**
The objective is to teach the students the basic concepts of detection of a target, a detection threshold, and the probabilities of false alarm and detection. These concepts will then be tied together in a description if the radar detection problem.

❖ **TOPIC 6 (BLOCK 1, UNIT 2): PULSE COMPRESSION**
The objective is to teach the students the basic concepts and motivation behind Pulse Compression, including a discussion on range resolution, bandwidth and pulsewidth.

❖ **TOPIC 7 (BLOCK 1, UNIT 2): RADAR ANTENNAS**
The objective is to familiarize the students with the fundamentals of radar antennas, such as field regions, radiation patterns (with a main focus on beamwith, gain and sidelobes), and polarization.

❖ **TOPIC 8 (BLOCK 1, UNIT 2): CLUTTER**
The objective is to familiarize the students with the concepts of *radar clutter*, the differences between clutter and noise, and the main measure used for clutter backscatter (called the scattering coefficient).

- **TOPIC 9 (BLOCK 1, UNIT 2): SIGNAL PROCESSING - MTI (MOVING TARGET INDICATOR) AND PULSE DOPPLER TECHNIQUES**

The objective is to teach the students the basics of radar signal processing, i.e. Moving Target Indicator (MTI) and Pulse Doppler Techniques, beginning with a review of clutter characteristics from the previous topic, a review of the Doppler effect, techniques for measuring Doppler shifts in pulsed waveforms, Doppler velocity ambiguity, and finally the differences between MTI and Pulse Doppler Techniques.

- **TOPIC 10 (BLOCK 1, UNIT 2): TRACKING AND PARAMETER ESTIMATION**

The objective is to familiarize the students with radar tracking, including Single Target Tracking and Multiple Target Tracking in Track-while-Scan (Automatic Detection and Tracking) and Phased Array Tracking radars.

- **TOPIC 11 (BLOCK 1, UNIT 2): TRANSMITTERS AND RECEIVERS**

The objective is to familiarize the students with aspects relating to radar transmitter and receivers and transmitter/receiver architectures used in radar systems.

**Unit 3: Selected Radar Applications**

- **TOPIC 12 (BLOCK 1, UNIT 3): AIR TRAFFIC CONTROL RADARS**

The objective is to familiarize the students with Air Traffic Control (ATC) radars such as Primary Surveillance Radars (En-route and Airport Surveillance Radars) and Secondary Surveillance Radars (SSR).

## BLOCK 2: Radionavigation Systems

**Unit 4: Introduction to Radionavigation Systems**

- **TOPIC 13 (BLOCK 2, UNIT 4): INTRODUCTION AND BASIC CONCEPTS**

The objective is to give a general introduction to radionavigation systems and associated Term. Common position fixing methods will be covered, as well as overview of the main navigation system performance parameters.

**Unit 5: Terrestrial Systems**

- **TOPIC 14 (BLOCK 2, UNIT 5): HYPERBOLIC SYSTEMS**

The objective is to teach the students the basic principles of operation of hyperbolic radionavigation systems.

- **TOPIC 15 (BLOCK 2, UNIT 5): POINT SOURCE SYSTEMS I (DIRECTION FINDING)**

The objective is to teach the students the basic principles of operation of point source systems based on direction finding (NDB, ADF, VDF), as well as their capabilities and limitations.

- **TOPIC 16 (BLOCK 2, UNIT 5): POINT SOURCE SYSTEMS II (VOR, DME, TACAN)**

The objective is to teach the students the basic principles of operation of point source systems DME, VOR, and TACAN, as well as their capabilities and limitations.

- **TOPIC 17 (BLOCK 2, UNIT 5): AIRCRAFT LANDING SYSTEMS**

The objective is to teach the students the basic principles of aircraft landing systems, as well as their capabilities and limitations.

**Unit 6: Satellite Systems**

- **TOPIC 18 (BLOCK 2, UNIT 6): SATELLITE SYSTEMS**

The objective is to teach the students the basic principles of satellite systems, as well as the characteristics, capabilities and limitations of different global satellite navigation systems.

# 6. Teaching method

## 6.1. Teaching method

| Teaching activity | Teaching techniques | Student workload | Hours |
|---|---|---|---|
| **Lectures** | Presentation and explanation of the course material. Resolving doubts. Special emphasis will be made on the fundamental and more complex theoretical aspects of the course. | In-class: Active attendance and class participation. Taking notes. Questions. | **55** |
| | | Self-study: Individual study. | **45** |
| **Problem solving classes** | Solving problems in the classroom and/or presenting case studies. | In-class: Active attendance. Questions and problem solving. | **10** |
| | | Self-study: Individual study. Problem solving. | **15** |
| **Laboratory sessions** | Explaining the laboratory exercises. Supervising and leading the laboratory classes. Evaluating student knowledge and participation. | In-class: Individual and/or cooperative work in the laboratory under lecturer supervision. Active participation. | **10** |
| | | Self-study: Cooperative and individual pre-lab preparation; Lab report preparation. | **20** |
| **Continuous assessment/Midterm** | Preparing an individual, partial written examination covering the first part of the course (Block 1) | In-class: Attending and taking the midterm exam | **1,5** |
| | | Self-study: Attending and taking the midterm exam | **10** |
| **Individual and/or group consultation and tutorials** | Resolving student questions and doubts related to the course | In-class: Actively participating in resolution of their questions/doubts. | **4,5** |
| **Course assessment/Final Exam** | Preparing a final individual written examination at the end of the term consisting of 2 parts covering Blocks 1 and 2, respectively. | In-class: Attending and taking the final exam. | **2,5** |
| | | Self-study: Individual or group study and exam preparation | **14** |
| | | | **187.5** |

## 6.2. Learning outcomes (4.5) / teaching activities (6.1) (optional)

| Teaching activities (6.1) | Learning outcomes (4.5) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Theory Classes | x | x | x | x | x | x | x | x | x |
| Solving exercises and case studies | x | x | x | x | x | x | x | x | x |
| Laboratory classes | x | x | x | x | x | | | | |
| Office Hours (tutorials) | x | x | x | x | x | x | x | x | x |
| Continuous assessment | x | x | x | x | x | x | x | x | x |

# 7. Assessment method

## 7.1 Assessment method

| Assesment activity | Type: Summative | Type: Formative | Assessment methods and criteria | Percentage (%) | Assessed learning outcomes (4.5) |
|---|---|---|---|---|---|
| **Midterm Exam** | x | x | A written exam consisting of theoretical and theoretical-practical questions and problems will be given at the end of Block 1 (Radar systems, Units 1-3) to evaluate the acquired knowledge | 70%(*) | 1-5 |
| **Final Exam Part B1** | x | | Part B1 of the final written exam will consist of theoretical and/or practical questions and problems aimed at evaluating the acquired knowledge of the material covered in Block 1 (Radar systems, Units 1-3), i.e. pre-Midterm content | 70%(*) | 1-5 |
| **Final Exam Part B2** | x | | Part B2 of the final written exam will consist of theoretical and/or practical questions aimed at evaluating the acquired knowledge of the material covered in Block 2 (Radionavigtion systems, Units 4-6), i.e., Post-Midterm content | 30% | 6-9 |
| **Laboratory work** | x | x | Participation and successful completion of the laboratory classes is compulsory for passing the course. Evaluation based on participation, oral questioning and/or lab reports. | PASS/FAIL | 1-5 |

(*) There will be an individual written Midterm examination at the end of Block 1 which will cover the first part of the course (Block 1: Radar Systems, Units 1-3). Students that obtain a global score greater or equal to 5 out of 10 have the option to skip Part B1 of the final exam.

The Final examination will consist of two parts: Part B1 covering pre-Midterm content (i.e., Block 1: Radar Systems, Units 1-3) and Part B2 covering post-Midterm content (i.e., Block 2: Radionavigation Systems, Units 4-6), each carrying a maximum of 10 points. The final exam will be held as follows: Part B1 of the final exam covering pre-Midterm material (Block 1) will be taken by those students who did not pass the Midterm exam (received a grade <5) or by students who wish to try to improve upon their Midterm grade. Part B2 of the exam covering post-Midterm material (Block 2) will be taken by all of the students.

Note: Students who decide to take Part B1 the final exam to try to improve upon their Midterm grade, permanently renounce the grade received on the Midterm, irrespective of the result they obtain on the final exam.

The final grade is based on the grades received for each Part (Part B1 and Part B2). To pass the course it is necessary to obtain a minimum score of 4 out of 10 for Part B1 and a minimum score of 3 out of 10 for Part B2), and obtain an overall minimum score of 5 out of 10 for the Final Grade. The grade for Part B1 can be obtained either though the Midterm (if the grade is >=5) or Part B1 of the Final Exam as outlined above. The grade for Part B2 can only be obtained via the Final Exam.

The final grade will then be calculated as:

**Final grade= 70%(Part B1 grade)+30%(Part B2 grade)**

**To pass the course the student must obtain a Final grade >= 5.0, such that Part B1 grade >= 4.0 and Part B2 grade >=3.0**

## 7.2. Control and monitoring methods (optional)

Learning process monitoring will be realized through the following activities:
- Posing questions/problems and monitoring student participation in the classroom.
- Monitoring student work in the laboratory sessions.
- Individual and/or group tutorials
- Individual written midterm and final examinations

# 8. Bibliography and resources

## 8.1. Basic bibliography


- M. Skolnik*, Introduction to Radar Systems*, New York, McGraw-Hill, 3rd Edition, 2001

- M. Richards, J. Scheer, W. Holm, *Principles of Modern Radar: Basic Principles*, SciTech Publishing, 2010

- B. Forsell, *Radionavigation Systems*, Artech House, Inc., 2008


## 8.2. Supplementary bibliography


- *J. C. Toomay, Paul J. Hannen, Radar Principles for the Non-Specialist, 3rd Edition*, SciTech Publishing, 2004.

- G. W. Stimson, *Introduction to Airborne Radar*, 2nd *and 3rd Editions*, SciTech Publishing, 1998, 2014

- *Radio Navigation, JAA ATPL Training Edition 2*,Jeppesen Sanderson Inc, 2007

- B. Hofmann-Wellenhof, K. Legat, M. Wieser, *Navigation, Principles of Positioning and Guidance*, Springer-Verlag, 2003

- M. Kayton, W.R. Fried, *Avionics Navigation Systems*, John Willey & Sons, Inc., 1997

- L.C. Peña Morán, *Ayudas a la Navegación Aérea*, Diego Marin Librero Editor, 2000


## 8.3. On-line resources and others

- All material used during the development of this course will be available online in the Virtual Classroom
- O'Donnell, Robert M. *RES.LL-001 Introduction to Radar Systems, Spring 2007*. (Massachusetts Institute of Technology: MIT OpenCourseWare), http://ocw.mit.edu License: Creative Commons BY-NC-SA