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| **Country**  **ITA** | **Institution**  **Naval Academy** | **Course title:**  **NAVAL SENSORS** | **ECTS**  **2** |

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| Service  **Navy** | **Minimum Qualification for Lecturers**   * PhD degree in Communications Engineering * English: Common European Framework of Reference for Languages (CEFR) Level B2 or NATO STANAG Level 2+. | |
| Languages  **English** |
| **Prerequisites for international participants:**   * English: Common European Framework of Reference for Languages (CEFR) Level B1 or NATO STANAG Level 2. * Minimal knowledge of electronic physics. | | **Goal of the Module:**   * Understand the principles of radar systems and relevant operational performances * Understand the principles of EW systems and relevant operational performances * Understand the principles of electro-optical systems and relevant operational performances * Acquire the necessary knowledge on sound propagation in water and familiarize with the main underwater system applications |

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| Learning outcomes | Knowledge | * Understand the principles of radar, radar equipment (transmitters, antennas, receivers, etc.). * Review of military radar applications with practical case studies (Navigational radar, Early Warning radar, CW radar, Multistatic radar, Over the Horizon radar, Phased Array radar). * Description and analysis of the operation and performance of military radar systems for detecting, tracking and locking on targets in the operational area. * Knowledge of basic electronic warfare doctrine. * Understand the principles of EW systems and equipment (receivers, jammers, etc.). * Review of principles and applications of Electro-optical Systems as key sensors in the Aeronautical Warfare. * Knowledge of the sound propagation in water. |
| **Skills** | * Recognize the constructive type of equipment and integrated system by various specific criteria. * Describe and identify the parts of integrated C.I.C. systems. * Interpret and correlate the provided data by the integrated C.I.C. systems. |
| **Competence** | * Understand different techniques applied to modern sensors. * Ability to evaluate sensors main performances and cost. * Ability to make correct tactical decisions exploiting information from different systems. * Manage on-board sensors in different warfare and scenarios. * Take advantage of the maximum potential of on-board sensors, also in relation to the operational environment. |

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| **Verification of learning outcomes** |
| * **Observation**: * Class time is primarily assigned to lecturing. Educational materials such as slides or videos may be used in order to illustrate some of the basic points in the lecture in order to encourage discussions and debates about focus points. * Methods of teaching/lecturing are: lecturing, heuristic conversation, explanation, discussions/debates, case study, simulation of situations. * **Tests**:   Final exam (written test).   * **Evaluation**:   The final exam will consist in examination based on a multiple-choice test and applications of the taught subject. |

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| **Module details** | | |
| **Main Topic** | **Reco-mmended**  **WH** | **Details** |
| Pulsed radars | 4 | * Principles and performances * 2D, 3D, OTH, Phased Array radar overview * E.M. propagation effects * Block diagram * Clutter |
| CW radars | 1 | * Principles and performances * Block diagram * FM-CW radar |
| Secondary radars | 2 | * SIF modes * S mode |
| Fire control radars | 1 | * Target acquisition * Angular tracking techniques * Range tracking technique |
| Electronic warfare (EW) | 1 | * Terminology and principles of operation * Doctrine overview and outlooks |
| Passive EW | 3 | * Operational parameters * Interceptors and different types of receivers * Goniometric techniques |
| Active EW | 2 | * Operational parameters * Jamming techniques * Deception techniques * Chaffs and decoys |
| Electro-optical Systems | 3 | * Principles and performances * Main operational applications |
| Sound propagation in water | 4 | * Principles and performances * Behavior at different frequencies |
| Underwater sensors | 3 | * Active/passive transducers * Main operational applications |
| Final evaluation | 1 | Final Assessment |
| **Total lecture WH** | **25** |  |

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| **Additional hours (WH) to increase the learning outcomes (4 ECTS total)** | | |
| Radar equation | 4 | * Basic form of radar equation in free space * Probability of Detection and Probability of False Alarm * Multipath effect * RCS and Swerling models |
| High power RF components | 2 | * Magnetron * Klystron * TWT * Solid State amplifiers |
| Anti-clutter techniques | 4 | * STC * CFAR * MTI * MTD |
| RCS reduction methods | 2 | * Structure shaping * Absorbing materials |
| Radars (in-depth analyses) | 1 | * Pulse compression technique * Side lobe interrogation, garbling and fruiting |
| Evaluation | 2 | * Final Assessment |
| **Total WH** | **39** | 26 residential hrs (24 teaching hrs + 1 final assessment); or 39 residential hrs (37 teaching hrs + 2 final assessment) |

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| **List of Abbreviations:** |
| ITA…………………………………………………………...…………...………… …………Italy  CEFR…………………………..……. Common European Framework of Reference for Languages  B2………………………………….……………………………………. Common Reference Levels  ECTS…………………………………………. European Credit Transfer and Accumulation System  NATO……………………………………………………………North Atlantic Treaty Organisation  STANAG……………………...………………………………………... Standardization Agreement  WH…………………………...………………………………………………………. Working Hour  CIC……………………...…………………………………………...…. Combat Information Center  OTH……………………...………………………………………………………. Over The Horizon  RF…………………………...……………………………………… ……………. Radio Frequency  FM-CW…………………………...…… …………… ….Frequency Modulated – Continuous Wave  RCS ……………………...……………………………………… …………. Radar Cross Section  SIF ……………………...…………………………………………. Selective Identification Feature  STC………………...……………………………………… ………… …. Sensitivity Time Control  MTI/MTD………………...……………………… ……………. Moving Target Indicator/Detector  TWT……………… ...……………………………………… ……………. Travelling Wave Tube |