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| **Country**  **GR** | **Institution**  **HNA** | **Course title:**  **NAVAL COMMUNICATIONS** | **ECTS**  **2** |

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| Service  **Navy** | **Minimum Qualification for Lecturers**   * PhD degree in Electrical Engineering * English: Common European Framework of Reference for Languages (CEFR) Level B1 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. * Elements of real, complex and vector calculus, electromagnetics and wave physics, and basic circuit theory. | | **Goal of the Module:**   * Understand the principles of operation and design and the underlying physics of communication systems and components * Familiarize with the concepts, techniques and measurement principles of wave propagation, wireless transmission and signal processing |

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| Learning outcomes | Knowledge | * Knowledge of characteristics of radio-communication systems and devices. * Basic understanding of spectral concepts and techniques * Understanding of principles of analog and digital modulation * Understanding of fundamental electromagnetic wave phenomena, basic propagation mechanisms and characteristics. * Understanding of antennas and wireless links * Understanding of satellite links and systems (ground / space segment) for various applications * Basic knowledge of GMDSS systems |
| **Skills** | * Organize a frequency plan taking into consideration the skills and restrictions of naval training * Utilize appropriate propagation techniques for each use case * Organize and use terrestrial and satellite communication systems and the associated multiple access techniques to the satellite resource * Use GMDSS systems according to Radio Legislation and subsystems technical specifications * Perform basic frequency and link budget calculations |
| **Competence** | * Recognize and solve the main communication problems * Prepare the naval force communication plan * Transmit and receive correct and timely information, using GMDSS subsystems and equipment in accordance to ITU Radio Regulations and other conventions and international regulations (SOLAS, STCW, etc.) |

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| **Verification of learning outcomes** |
| * **Observation**:   + The theoretical part will be uploaded as prerequisite on eClass platform, as well as simulation programs in GNU Octave. * **Tests**:   + The assessment strategy is based on pre-post assessment method and a personal interview in laboratory premises. * **Evaluation**:   + The observation and the practical exercises in the lab result in the overall grading of the module. Qualified individual feedback will be provided to participants. |

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| **Module details** | | |
| **Main Topic** | **Recom-mended**  **WH** | **Details** |
| Spectral analysis and discretization of signals | 4 | * Fourier transform and related techniques (convolution, FFT). Application to LTI systems. * A/D conversion – sampling and quantization; The sampling theorem. * Frequency bands and spectrum allocation; Classification of emissions |
| Laboratory exercise 1 | 2 | * Spectrum analyzer: principle of operation and use * Spectral analysis of RF signals and characterization of frequency generators |
| Fundamentals of analog and digital transmission | 7 | * AM modulation (DSB, DSBSC, SSB) * Frequency (up-/down)conversion and the superheterodyne principle * FM modulation; FM spectrum and the Carson rule * Digital networks; Protocol hierarches * Baseband signaling and line coding * Basic digital modulation schemes (ASK, FSK, BPSK, QPSK, QAM) |
| Laboratory exercise 2 | 2 | * Computer simulations of analog signals and modulators / demodulators by use of FFT and other programming blocks |
| Electromagnetic waves and propagation | 4 | * Maxwell equations in differential and time-harmonic form * Fundamentals of planar electromagnetic waves: field calculation, phase velocity and intrinsic impedance; Polarization; Spherical waves * Power flux: The Poynting vector |
| Antenna radiation | 5 | * Far-field and near-field region; Radiated power * Radiation intensity – Radiation Pattern; Directivity and Gain * Antenna input impedance – Equivalent circuit for transmission * Application to dipoles: Current distribution, Radiation pattern, Directivity, Input impedance. |
| Wireless links | 3 | * Reciprocity theorem for antennas; Equivalent circuit for reception – Self impedance * Antenna effective aperture and relation to directivity * Friis transmission equation and radar range equation * Link budget |
| Laboratory exercise 3 | 2 | * Antenna pattern and gain measurements |
| Final evaluation | 1 | Pre-Post Assessment and Laboratory evaluation |
| **Total lecture WH** | **30** |  |
| **Additional hours (WH) to increase the learning outcomes** | | |
| Random signals and noise | 5 | * Stochastic processes; Properties of random signals: stationarity, ergodicity, average power and the Wiener-Khinchin theorem * Classification and sources of noise; Thermal noise: power spectral density and the concept of white noise * Effective noise bandwidth, noise temperature and noise figure; S/N ratio and analog system performance; Noise in cascaded systems and the Friis formula |
| Fundamentals of digital coding / decoding | 3 | * Basic digital decoding schemes; The matched filter; BER analysis. * The concept of information and the Shannon-Hartley theorem |
| Laboratory exercise 4 | 4 | * Computer simulations of digital signals, noise and coding / decoding by use of FFT and other programming blocks |
| Microwave components and systems | 7 | * Transmission lines and the telegrapher’s equations; Fundamental transmission line parameters * Standing waves and SWR; Special cases and applications (Heaviside condition, Quarter wave impedance transformer, Stubs, Matching techniques) * Guided waves and waveguide modes; TE modes in orthogonal waveguides: Field equations and cutoff frequencies; Propagation constant, wavelength, phase and group velocity; Practical considerations * Introduction to fiber optics |
| Laboratory exercise 5 | 3 | * Reflection and SWR measurement in waveguides * Measurement of attenuation in optical fibers |
| Fundamentals of terrestrial and satellite wireless links | 7 | * Wave propagation mechanisms * Surface and volume waves * Fundamentals of tropospheric and ionospheric propagation * Satellite links; The space segment; Transponders; The ground segment; VSAT components * GMDSS and commercial maritime satellite systems |
| Evaluation | 1 | * Final Assessment |
| **Total WH** | **60** | 30 residential hrs (23 teaching hrs + 6 lab exercises + 1 final assessment); or 60 residential hrs (45 teaching hrs + 13 practical exercises + 2 final assessment) |

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| **List of Abbreviations:** |
| GR…………………………………………………………...…………………………... Greece  HNA…………….………………………………………….………… Hellenic Naval Academy  CEFR……………………………. Common European Framework of Reference for Languages  B2…………………………………………………………………. Common Reference Levels  ECTS……………………………………. European Credit Transfer and Accumulation System  NATO…………………………………………………….. North Atlantic Treaty Organisation  ITU…………………………………………………… International Telecommunication Union  STANAG…………………………………………………………... Standardization Agreement  WH………………………………………………………………………………. Working Hour  LTI……….……………………………………………………………… Linear Time Invariant  ΙΜΟ……………………………………………………..…International Maritime Organisation  SOLAS……………………………………………………….…………. Safety of Life at Seas  GMDSS………………………………………… Global Maritime Distress and Safety System  STCW…………………………………. Standards of Training Certification and Watchkeeping  VSAT………………………………….……………………….. Very Small Aperture Terminal |