Countries	Institutions	Common Module	ECTS
Romania **Poland** **Greece** **France** **Bulgaria**	Military Technical Academy "Ferdinand I" Military University of Technology Hellenic Air Force Academy French Air Force Academy "Vasil Levski" National Military University	**Propulsion systems** *European Common Technical Semester for Defence and Security*	**3.0**

Service	**Minimum Qualification of Instructors**
Technical/ALL	• **Officers or civilian Lecturers:** ○ English: Common European Framework of Reference for Languages (CEFR) Level B2 or min. NATO STANAG 6001 Level 3. ○ Expertise in relevant topics. ○ Relevant academic publications.
Language **English**	

Prerequisites for international participants	**Goal of the Module**
• English: Common European Framework of Reference for Languages (CEFR) Level B1 or NATO STANAG Level 2. • At least 1 year of national (military) higher education. • Basic knowledge in technical systems for security and defence	• To broaden the knowledge on Propulsion Systems for Aircraft, gun design and ballistics. • To gain sufficient insight to comprehend the working principles of the aforementioned fields • To acquire knowledge and understand the thermodynamic principles of air breading/fossil-derived fuel powered systems. • To identify different types of engines, • To engage in a multi-national course where all students are expected to bring their knowledge and contribution to the lectures and teaching sessions

Learning outcomes		
	Know-ledge	• To foster the interest of young cadets in the topics of propulsion and ballistics • To gain technical knowledge on mechanical and thermodynamics principles of propulsion systems • To acquire in-depth knowledge on the main factors affecting engine selection and ballistic systems design.
	Skills	Technical • To identify different types of engines, • To identify the basic principles of ballistic systems design. Transversal • Develop a multi-cultural awareness; • Improve team spirit, in heterogeneous, multi-cultural environment; • To improve English level and skills; • To develop communication skills;
	Respon-sibility and autonomy	• To foster propulsion systems for aircraft and ballistic applications.

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Verification of learning outcomes:

- **Observation**: Students are evaluated during each session, in order to document their understanding of the basic concept of propulsion applied in defence and security technology applications
- **Project**: Teamwork project and project defence.
- **Test**: Final examination at the end of the module.

Module details		
Main Topic	**Recom-mended WH**	**Details**
Energy balance and equations of state	10	**Lecture (4h) and Applications (10h)** Thermodynamic systems. The first law of thermodynamics. Thermodynamic functions and potentials. Equation of state of ideal gas. Equations of state of real gases.
Bernoulli equation - conditions for critical flow and flow through the nozzles	10	**Lecture (4h) and Applications (10h)** Nozzles. Mass and energy conservation equations. Conditions for critical flow.
Basic construction of aircraft engines	10	**Lecture (4h) and Applications (10h)** Types engines and applications
Propulsion in ballistic systems	6	**Lecture (2h) and Applications (4h):** - Types of ballistic systems. - Types of propellants. - Ballistic characteristics. - Experimental determination of impulse and covolume for a small calibre propellant
Solving the fundamental problem of interior ballistics for classical artillery systems	6	**Lecture (2h) and Applications (4h):** - General consideration regarding fundamental problem of interior ballistics. - Energy losses. - Necessary equations for a 0D IB model. - Solving the differential equations system in Mathcad/Matlab.
Total WH	**42**	
Additional hours (WH) to increase the learning outcomes		
Self-Studies and syndicate work	33	• Enhancing knowledge by studying specific documents. • Preparation for the group project. • Teamwork for the group project. • Those hours comprise the work of students in laboratories and exercises to improve skills and consolidate knowledge.
Total WH	**75**	

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1. Carlucci D. E., Jacobson S. S. *Ballistics: Theory and Design of Guns and Ammunition*, CRC Press, 2007.
2. Corner J. *Theory of the interior ballistics of guns*. New York : John Wiley & Sons Inc.; 1950.
3. Hazell, P.J. . *How Guns Work. In: The Story of the Gun*. Springer Praxis Books. Springer, Cham. 2021
4. Kubota N., *Propellants and Explosives: Thermochemical Aspects of Combustion,* John Wiley & Sons: Weinheim, Germany, 2015.
5. Serebriakov, M. E., *Vnutrenniaia ballistika stvolnâh sistem i porohovâh raket*, Gosudarstvenoe naucino-tehniceskoe izdatelstvo, oboronghiz, Moskva, 1962.
6. Sutton G. P., Biblarz O., *Rocket Propulsion Elements*, 9th ed.; John Wiley & Sons: Hoboken, NJ, USA, 2016; pp. 491–524.ISBN 978-1-118-75391-0.
7. **** STANAG 4115 LAND (EDITION 2) – *Definition and Determination of Ballistic Properties of Gun Propellants*, 1997.
8. **** STANAG 4367 – *Thermodynamic Interior Ballistic Model with Global Parameters*, 2000.
9. Individual materials of the lecturer

List of Abbreviations:

B1, B2 ..... CEFR Levels

CEFR ..... Common European Framework of Reference for Languages

ECTS ..... European Credit Transfer and Accumulation System

GUI ..... Graphical User Interface

ODE ..... Ordinary Differential Equations

WH ..... Working Hour

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