A student perspective into ESA Academy Space Systems Engineering Training Course

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Abstract
The ESA Academy's Space Systems Engineering Training Course is a unique educational opportunity offered by the European Space Agency's Education Office. It allows Bachelor, Master and PhD students to learn about the fascinating world of Systems Engineering and its applications within the space sector, while bringing this captivating framework of challenges and satisfaction to life for the participants of the Training Course. During this course, the whole life-cycle of a space project is explored from a System Engineering viewpoint, and students can learn about the challenges of Space Systems Engineering. Moreover, the Systems Engineering process is explored in detail [1]. Taught by ESA experts, the Training Course is delivered through formal lectures, with a heavy emphasis on the interaction with the students. During the course, students take part in group exercises aimed at putting the theory learnt into practice. This paper purposes at giving an overview of the training course, as it took place online on the 12th-20th of July 2021, and at addressing the benefits of the Author's participation into the Training Course for his studies and future space career.

Keywords
Systems Engineering, ESA Academy, Training Course

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Acronyms/Abbreviations

ARCADIA *Architecture Analysis & Design Integrated Approach*

ASEP *Associate Systems Engineering Professional*

INCOSE *International Council on Systems Engineering*

MBSE *Model-Based Systems engineering*

1. Introduction

Nowadays, System Engineering plays a crucial role in all space missions, as the inherent complexity of such projects is extraordinary suitable to be addressed by it. Systems Engineering approach has proved to be capable of reducing the costs of late design changes by a 50x factor [2].

The International Council on Systems Engineering (INCOSE) defines Systems Engineering as “an interdisciplinary approach and means to enable the realization of successful systems” [3], while for ESA it is “an interdisciplinary approach governing the total technical effort to transform requirements into a system solution” [4].

When it comes to space projects, Systems Engineering is a powerful approach which aids the development of the mission along its whole lifecycle, from Phase 0 to Phase F. Thus, the System Engineer must have interdisciplinary knowledge related to all subsystems and in general they must have a comprehensive view of the entire mission, needs and activities.

However, the aforementioned background knowledge is not sufficient to qualify somebody as a skillful Systems Engineer. A lot of experience in the field is required, in order to master the extensive methodology related to the Systems Engineering domain.

Therefore, the ESA Academy’s Space Systems Engineering Training Course explored in this paper, has the two-fold objective of providing students not only with the theoretical notions necessary to understand the framework in which Systems Engineering takes place, but also to allow them to take part in group exercises in which these notions are put in practice, by means of the application of Systems Engineering practices to a Mars Sample Return Mission.

2. Training course overview

All lectures were delivered online in real time to 30 University students from ESA Member and Associate States. Moreover, students could count on a single website which gathered all useful links and information, such as general communications and training material.

Table.1 Training Course Schedule

Day 1	Introduction, scope and context of Space Systems Engineering, tasks of a System Engineer, how to represent a system
Day 2	System Engineering process and system requirements, requirements capture and specifications
Day 3	Concurrent Engineering, system options and trade-offs, mission architecture
Day 4	Budget and margins, mission timeline and system modes, system design loop
Day 5	Development and verification approach
Day 6	Project, engineering and quality management
Day 7	Risk management and LEOP

The course covered all aspects of Systems Engineering applied to space missions, extensively going through the processes of requirements definition, architecture definition, budgets and margins management, system design, quality assurance, verification and validation, operation and lifecycle management. It also gave students valuable insight into Concurrent Engineering design and model-based systems engineering as well as the interactions with project management, including project planning and risk management.

Apart from theoretical lectures, participants were divided in small groups of five and took part into group exercises aimed at getting them familiar with Systems Engineering practices and some real-world problems faced by space systems engineers. The numerous group sessions were part of a unique exercise which challenged students in the preliminary sizing of the subsystems needed to perform a Mars Sample Return Mission, and went through the processes of requirements capture, mission architecture definition and trade-offs, preliminary system design, launcher selection and budget finalisation.

After completion of the Training Course, the link to the Evaluation Questionnaire became available for the students. The test was mandatory in order to get the participation certificate, and consisted of several multiple-

choice questions. The students had 30 minutes to complete it.

3. Educational benefits

The Training Course provided participating students with an overview of the scope and context of Systems Engineering in general, then it proceeded outlining the role of a system engineer. It also gave extensive explanation of the Systems Engineering practices which are usually implemented in a space mission. The Training Course allows participating students to unlock the path for a career in a new domain, which they only heard about at University. In fact, further ways to be involved in the role of System Engineer and learning opportunities are described during the Training Course.

For example, the Author decided to take up further educational opportunities related to the field of Systems Engineering. In particular, he prepared and passed INCOSE ASEP Certification, completed an online course regarding Model-Based Systems Engineering (MBSE), and became acquainted with relevant software such as Capella MBSE Tool. This ESA course boosted his interest in learning more about the methodologies used to perform Systems Engineering in space missions, so he discovered ARCADIA approach and was motivated to acquire proficiency in using Capella MBSE Tool to implement all Systems Engineering practices in an MBSE environment for a space mission, including requirements management, Operational Analysis, System Analysis, Logical Architecture, Phyisical Architecture, but also modes management, mission Phases definition, Concept of Operations and AIV/AIT plan development. The Training Course played a key role in bringing these additional opportunities to the attention of students, and to boost their ambition to further develop the knowledge acquired through the Training Course.

Thanks to his participation in the Training Course, the Author has received many inputs for the development of his future career in the Space sector. Moreover, he has been exposed to intense interaction with the other participating students coming from other institutions and professionals such as the ESA Education organisers and ESA experts. Getting in contact with students from several universities enabled the participants to enrich their network and to share their educational paths.

The possibility of accessing the trainers and organisers' biographies has been of great value for collecting essential information regarding different backgrounds that bring someone to work in the Space sector, especially in the Systems Engineering domain.

Thus, taking part in the ESA Academy's Space Systems Engineering Training Course the Author got more familiar with Space initiatives and gained important knowledge and experience for his future Space career.

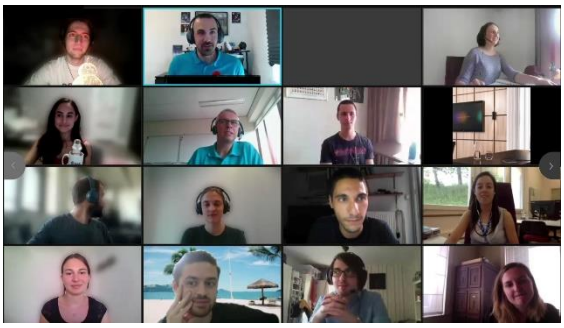

Fig. 1 (Partial) Group photo

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