R3.4 Guidelines for Education & Training Programme Prototype

Dissemination level: CO (Confidential)

Grant Agreement Number:	**612678-EPP-1-2019-1-IT-EPPKA2-SSA-B**
Project acronym:	ASSETs+
Project full title:	Alliance for Strategic Skills addressing Emerging Technologies in Defence
WP number and tittle:	Work Package 3 - Implementation
Tittle of the deliverable:	Guidelines for Education & Training Programme Prototype
Deliverable number:	R3.4
Responsible partner:	University of Bordeaux
Contributing partners / fellows:	Aerocampus Aquitaine, Rzeszów University of Technology, European Welding Federation, University of Pisa, University Polytechnic of Madrid, Leonardo Technical Training, Aalborg, University University Carlos III de Madrid, University of Seville, Mercantec
Document's status	Final version

Document's development track:

	Version of the document	Organisation	Name, Surname	Date
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** Note from the Project coordinator: draft document is expected from the task leader and can involve other partners; the review of the document is performed by the task fellows, the validation of the document is expected from the WP leader and, when relevant, by the Project coordinator.*

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Introduction

ASSETs+ aims to build a sustainable human resources supply chain for the European Defence Industry, that boosts innovation by both attracting highly-skilled young workers and upskilling its employees. Complementary education & training programmes address the following main technologies: Artificial Intelligence, Robotics, C4ISTAR[1] and Cybersecurity.

After a first phase dedicated to the analysis of data to identify job profiles and targeted skillsets (Work Package 1) and a second phase devoted to the translation of these needs into pedagogical training programmes for workers and students (Work Package 2), the third phase tests and evaluates the designed programmes through prototyping across several institutions (HEI and VETs) and countries. The third phase also comprises the replication of these programmes in other contexts, including a "training the trainers" step (Work Package 3). Figure 1, below, describes the different steps and tasks of Work Package 3.

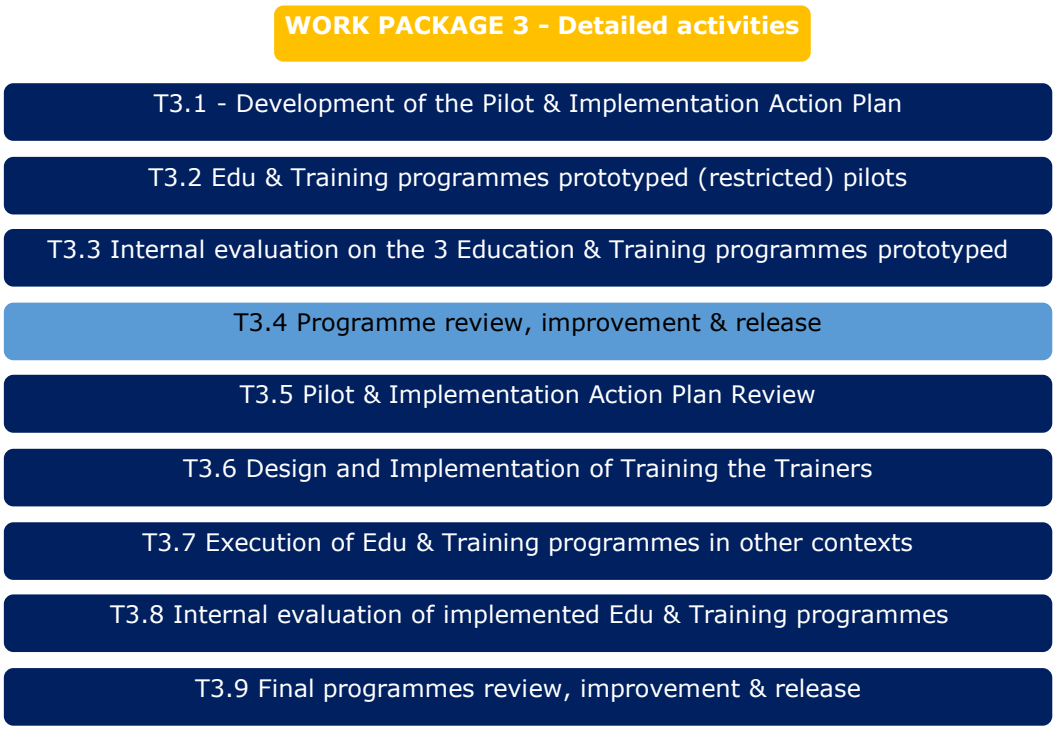

Figure 1 : Prototyping and replication phase of WP3

The first activity run by WP3 leader and fellows was the construction of the guidelines for course implementation (R3.1 "Education and Training Programmes Prototypes Pilot Action Plan"). Then, taking into account the industrial needs collected in Work Package 2, *("Education and Training design")*, 17 programmes were initially considered relevant to be implemented: 11 programmes at the EQF 4 and 5 level, 2 for EQF6, and 4 for EQF7. However, two of these courses: 4.2 "Computer hardware and software" and 4.10 "Identifying operating problems techniques" were cancelled due to the lack of registrations and trainers, (as explained in R3.2 "Technical Report of the Education and Training Programme Pilot". In the end, 15 programmes have been successfully implemented, which include: 9 programmes at the EQF 4 and 5 level, 2

[1] **C4ISTAR** is an acronym for Command, Control, Communications, Computers, Information/Intelligence, Surveillance, Targeting Acquisition and Reconnaissance

for EQF6, and 4 for EQF7. These 15 programmes are listed in Appendix 1. The course providers (academics and VETs) in charge of the identified prototype programmes have implemented them in their own institutions during the end of 2021 and the first semester of 2022 (specifically, from November 2021 to June 2022) following the guidelines provided in R3.1.

The current document R3.4 "Guidelines for Education & Training Programme Prototype" gathers the results collected within the deliverables R3.2 "Technical Report of the Education and Training Programme Pilot", R3.3 "Recommendations for improving Education and Training Programmes Prototype" and R8.5 "Evaluation of prototype implementation guidelines" to propose improvements and adjustments on the pilot programs in order to prepare the replication as part of Task 3.7. This is described visually in Figure 2, below.

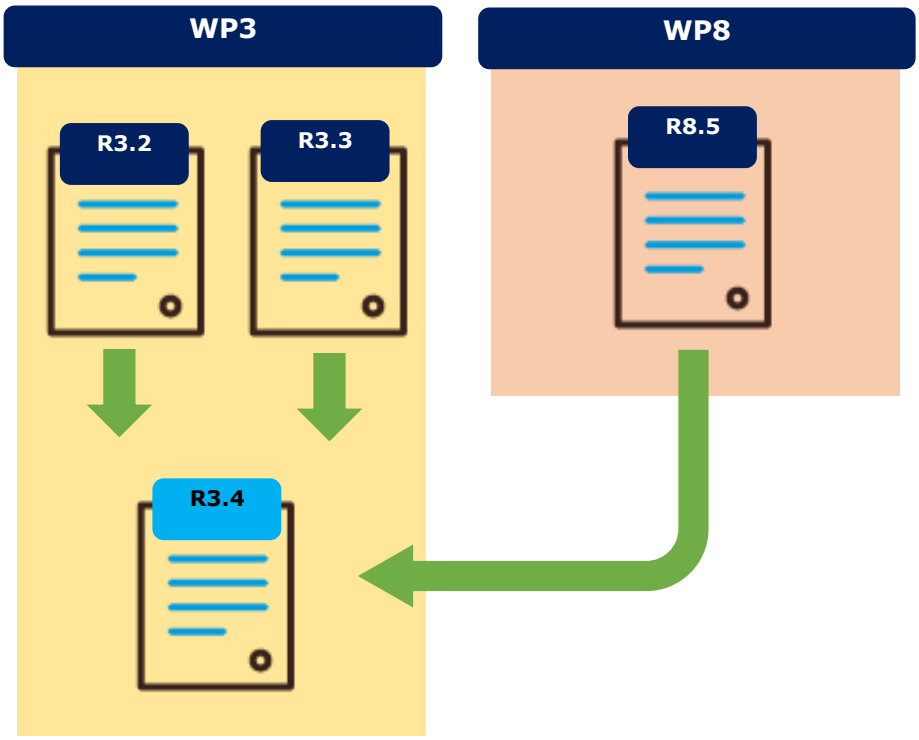

Figure 2. Inputs reports to construct R3.4

The document R3.4 is organized as follows: an introduction, three main sections making up the body of the report, and a conclusion. The first main section is dedicated to programmes at the EQF levels 4 and 5, the second to EQF level 6, and the third to EQF level 7. In each of these sections, observations leading to suggested improvements and modifications are proposed for each programme. Each programme description follows the following format, addressing four main aspects of the course:

1. Content of the programme
   a. *Technical content*
   b. *Pedagogical content*
2. Pedagogical activity proposed
3. Overall presentation of the programme and organisation
4. Additional comments

Only aspects which are the subject for commentary or potential are included for each programme description. In cases where no suggestions or modifications are offered for a

particular aspect (for example, if no improvements are suggested for *pedagogical activity*), this aspect is not included in the programme description.

At the end of each of the three main sections covering the different EQF levels (EQF 4/5, EQF 6, and EQF 7), a summary chart is proposed which sums up the main improvements suggested for each programme in terms of their technical content, pedagogical content, pedagogical activity, overall presentation and organisation, and any additional comments or suggestions offered. A template for this chart format is given below.

Table 1. Course Improvement Summary Chart

Course ID – Course name	**Technical content** – Main points →Sub-points **Pedagogical content** – Main points →Sub-points **Pedagogical activity proposed** – Main points →Sub-points **Overall presentation and organisation** – Main points →Sub-points **Additional comments** – Main points →Sub-points

Revision of the programmes EQF4/5

This section will detail the observations and suggested improvements for the 7 courses implemented at the EQF4 and EQF 5 levels. Namely, it will give feedback received regarding prototypes:

- 4.3 - Types of technical reports
- 4.4 - Circuit boards Processors Chips Electronic equipment
- 4.5 - Unit of measurement and Errors
- 4.6 - Analytical tools
- 4.7 - Controlling operations of processes to solve problems
- 4.8 - Records of maintenance and equipment documentation
- 4.9 - Instructions into machine control units to start operation
- 5.1 - Performance calculation
- 5.2 – Programming

At the end of this section, a summary chart will be provided which sums up the improvements outlined for each course point by point.

Prototype Programme 4.3 - Types of technical reports

1. Content of the programme

a. Technical content

The programme addresses drone security vulnerabilities that can be exploited to launch dangerous attacks, with potentially drastic consequences on critical infrastructures. Such attacks are possible due to the lack of security by design of robotic systems and the reliance on open wireless communication channels. The course begins with an overview of the cybersecurity problem and recommended countermeasures. Then, two solutions are studied in detail:

- The first one is a low-cost solution based on of RFID modules.
- The second one is a strong authentication scheme adopted by Parrot to design its last drone named "ANAFI Ai" which embeds a Secure Element compliant to the highest level of security.

Knowledge acquired by the students during the course must include risk assessment reports, safeguard solutions, common communication protocols between an embedded computer and electronic devices such as I2c and SPI, as well as cybersecurity of a flying drone ANAFI Ai.

External experts pointed out the need to clarify the title and abstract of the course and the lack of information on the content of the lessons in the design phase.

Internal evaluation of industrial partners inside the consortium after execution recommended that the target of this course should be graduate students instead of professionals. They also highlighted that more cybersecurity issues could be covered during the course and that it could more oriented to the defence sector.

Taking into consideration those comments, here are the changes that could be made:

- The course should target undergraduate students instead of professionals.
- Change the title and abstract of the course to:

- Title: "The cybersecurity of drones"
- Abstract: Drone security vulnerabilities that can be exploited to launch dangerous attacks, with potentially drastic consequences on critical infrastructures. Such attacks are possible due to the lack of security by design of robotic systems and the reliance on open wireless communication channels. The general cybersecurity problem must start with an assessment of the risks. Then, in accordance with this assessment, specifically tailored solutions must be proposed. In particular, the case of the internet of things (IoT), in particular drones, is analysed. As an introduction to the understanding of a more advanced technique named Near Field Communication (NFC) used in identification, e-payment, utility services like energy, and e-ticketing solutions, the MIFARE Classic variant which is used in contactless smart cards and proximity cards is analysed. At last, a strong authentication scheme adopted by Parrot to design its last drone named ANAFI Ai is studied. This drone embeds a Secure Element compliant to the highest level of security.

- Specify the content of the lessons and the syllabus:

  - Module 1 (4h): Risk assessment reports

This course gives the process to establish a risk assessment which is an important part of any information security process. It is used to understand the scale of a threat to the security of information and the realistic probability of that threat. The result of a risk assessment can be used to prioritize efforts to counteract the threats.

  - Module 2 (4h): Safeguard solutions

This course starts with the enumeration of methods to reduce cybersecurity risks. Then, it provides solutions to prevent cybersecurity risks. It ends with the case of IoT, particularly drones.

  - Module 3 and 4 (8h): Communication techniques

In these two courses, low-level communication techniques, I2c and SPI, commonly used by the embedded computer of a drone to communicate with its electronic devices, are studied. Various display screens and sensors are presented theoretically and then through various practical activities. Contactless smart cards which contain a cybersecurity module are explained and are also shown in practical activities.

  - Module 5 (4h): Cybersecurity of a flying drone Anafi Ai

The strong authentication scheme adopted by Parrot to design its last drone named ANAFI Ai is studied in this course. This solution embeds a Secure Element attached physically to the motherboard of the drone which is compliant to the highest level of security The Secure Element, VAULTIC184 protects the integrity of the embedded software, provides a unique identity to the drone for 4G pairing and strong authentication, and features a unique digital signing of the pictures taken by the drone. Increasing cybersecurity issues treated and focusing on defence sector issues would incorporate the following themes: Securing the communication between the remote computer and the drone has been realized using an asymmetric cipher based on RSA and the OAEP padding described in RFC8017 (where it is called RSAES-OAEP). A course has been written in detail and practical activities are operational. This could substantially increase the importance of the cybersecurity part of this course.

- Specify the job profiles targeted by the course:
    - This skillset acquired and developed are in accordance with the following market positions: computer hardware engineering technician, computer numerical control machine operator, computer-aided design operator, electronics engineering technician, instrumentation engineering technician, robotics engineering technician, and sensor engineering technician

b. Pedagogical content

The course is made of 5 slots of 4 hours, with 5 lectures, practical activities included and 1 exam online (multiple-choice questions) accessible online after the course. The execution of the course highlighted a lack of interaction between the teacher and the participants, (increased maybe by the heterogenous level of English of participants), and the format of the course (live videoconferences). The participants did not finalize the course with an exam.

External experts pointed out the lack of information about the level of homework needed for the course and questioned the evaluation format. They also highlighted the lack of bibliography.

Taking into consideration those comments, here are the changes that could be made:

- Develop interactive activities with the participants in each slot of 4 hours to facilitate interactions (classpoint): Replacing the long multiple-choice questionnaires at the end of all the modules by shorter, more interactive ones over the course of the different modules. As an example:
    - Proposing different ways to store private keys
    - Proposing different definitions for an asymmetric encryption
    - Proposing different keys to decrypt a drone message from a remote computer
    - Proposing different first steps for a cybersecurity risk assessment
    - Proposing different distributions of keys to realize a crypted communication between a computer and a raspberry pi 4
    - Proposing different ways to describe the cybersecurity approach used by the Parrot company to secure the drone Anafi Ai
- Ask for a minimum level of English to access the course or organise the course on-site in the official language, as was done by some course providers when for courses offered to student participants instead of professionals, as it is difficult to organise for professionals coming from all over Europe.
- Develop the bibliography of the course, to include the documents available at this link, here.
- Specify the amount of homework required at the end of each day (which could be used to prepare the next session and/or exercises). The participant could prepare for the next course by reading any recommended materials and its attached documentation.
- Organise the exam during the course and not after.

2. Pedagogical activity proposed

The activities proposed in this course are lectures and practical demonstrations online. Internal evaluation highlighted the necessity of a greater involvement of the industry. The lack of participation of industrial partners was also pointed out during the execution phase (also, the availability of the professionals attending the courses). If industrial partners could participate in the design and the development phase of the courses, use cases from the industry could be

proposed which tackle specific defence-related issues in the domain using project/problem-based learning.

Targeting professionals concerned by the course would be easier for industrial partners if they could express their current needs on a given topic and give practical example for the trainees during the design phase. However, the organisation of the project does not facilitate a direct exchange between industrial partners and course providers.

Despite the lack of comments, a similar complaint could be expected as in course 4.4 "Circuit boards Processors Chips Electronic equipment", since the fully online classes do not allow the participants to manipulate any devices or data. The same solutions could thus be proposed: organise the practical activities on-site or use a simulation software developed for the course. However, the cost of these solutions for either industrial partners or the course provider cannot be implemented within the current scope of the project.

3. Overall presentation of the programme and organisation

The programme was presented by e-mail to the partners with all EQF4-5 courses at the end of March (2022) and was published on ASSETS+ website at the beginning of April (2022), with the course starting in June (2022). The common registration form was accessible through ASSETS+ website. The course was shortened and organised 100% online in concordance with industrial feedback.

The execution phase, pointed out the necessity to communicate early on the programme to facilitate registration, especially if professionals need to be involved at levels EQF4-5 (technicians, operators, etc.) because they would need to be taken out of production.

What could be improved in this field is:

- Organising communication on the programme at least 3 months before the beginning of the course. However, as the timeline of the project being very tight, with certain tasks being dependant on others, it is not possible in the current scope of the project.
- Being more precise in the description of the programme (modifying the title and abstract, skills and knowledge, learning outcomes, targets) – see suggestions above.

4. Additional comments

Restructuring the course on more numerous but shorter time slots could be a solution to improve industrial professionals' participation in the course. However, in the frame of the project, the availability of the teachers or experts participating to the course must also be taken into consideration. AEROCAMPUS only had one teacher for all the courses with only 2 timeslots of 4 hours available from April to June (2022). Therefore, this suggestion could not be applied for the course as the timeframe of the project had to be respected.

Prototype Programme 4.4 - Circuit boards Processors Chips Electronic equipment

1. Content of the programme

a. Technical content

The programme addresses drones electronic devices connected to an embedded computer programmed to be remotely controlled or to act autonomously. The embedded computer works with an operating system which must be installed and updated. To restore it or to clone it, it is necessary to create an image.

To connect electronic devices more easily or add functionalities, it is common to plug in a shield over the main board. Then, it becomes possible to display a message on various screens, to control different types of motors and to acquire sensor data. A camera directly connected to the embedded computer streams the video to a remote computer. The drone is first programmed to work independently. Then, server applications allow a wireless communication with a computer by Wi-Fi. A key pair is used to encrypt and decrypt the exchanged data.

RFID cards are often used to access to a safe location. The principle of the technology followed by the process of reading and writing are studied. Each theoretical study is followed by a practical activity which illustrates how to concretely use each electronic device.

Knowledge acquired by the students during the course must include embedded computer management, adding functionalities with shields, displaying messages, acquiring data from logical sensors, digital and analogue sensors, acquiring video from a camera, controlling servomotors, stepper motors and dc motors, as well as safe communication between a computer and an embedded computer-based drone.

Internal evaluation of industrial partners inside the consortium after execution pointed out several observations concerning the course:

- The programme covers almost all the methods needed for Circuit boards Processors Chips Electronic equipment, with a focus on the domains of ASSETS+.
- Received great matrix skills score 38/112.
- The programme covers the main skills and knowledge expected.
- The inclusion of Raspberry pi board and its many applications was very useful.
- There was lack of regulatory aspects in the course.

External experts pointed out the need to clarify the title and abstract of the course and the lack of information on the content of the lessons in the design phase. Taking into consideration those comments, here are the changes that could be made:

- Change the title and abstract of the course to:
  Title: “Drones electronic devices - Technology and programming”
- Abstract: The programme addresses drones electronic devices connected to an embedded computer programmed to be remotely controlled or to act autonomously. The embedded computer works with an operating system which must be installed and updated. To restore it or to clone it, it is necessary to create an image. To connect electronic devices more easily or add functionalities, it is common to plug in a shield over the main board. Then, it becomes possible to display a message on various screens, to control different types of motors and to acquire sensor data. A camera directly connected to the embedded computer streams the video to a remote computer. The drone is first programmed to work independently. Then, server applications allow a wireless communication with a computer by Wi-Fi. A key pair is used to encrypt and decrypt the exchanged data. RFID cards are often used to access to a safe location. The principle of the technology followed by the process of reading and writing are studied. Each theoretical study is followed by a practical activity which illustrates how to concretely use each electronic device. The principle of the technology followed by the process of reading and writing are studied.

Each theorical study is followed by a practical activity which illustrates how to concretely use each electronic device locally and remotely optionally with encrypted data.

- Specify the content of the lessons and the syllabus for the course:
  - Content of the lessons:
    - ⇒ Module 1 (4 hours): Install, update, clone and restore an operating system on the embedded computer. Discover the main available shields to plug in on the embedded computer to add functionalities such as the connection of motors or screens.
    - ⇒ Module 2 (4 hours): TCP client/server communication with optional cyphering. Display messages on various types of display screens such as a LCD screen, a LED Matrix Display, a I2C 7 Segments LED Display and an OLED screen.
    - ⇒ Module 3 (12 hours): Acquire data from logical sensors such as key inputs, a button matrix, a sound sensor, a touch sensor, an external motion sensor, a line detector, a tilt sensor and an ultrasonic sensor. Acquire data from digital sensors such as a temperature, humidity sensor, a light sensor, an inertial sensor and a RFID module. Acquire data from analog sensors such as a sliding potentiometer, a rotary potentiometer, a XY Joystick and a magnetic Hall sensor. Acquiring and manage the quality of the video from a camera.
    - ⇒ Module 4 (8h): Control different types of motors such as a stepper motor, a vibration motor, a servomotor and a dc motor.
- Syllabus:
  - Knowledge acquired by the students during the course must include embedded computer management, adding functionalities with shields, displaying messages, acquiring data from logical sensors, digital sensors and analog sensors, acquiring video from a camera, controlling servomotors, stepper motors and dc motors, safe communication between a computer and an embedded computer-based drone.
- Specify the job profiles targeted by the course:
  - This set of acquired knowledge and developed skills are in accordance with the following market positions: computer hardware engineering technician, computer numerical control machine operator, computer-aided design operator, electronics engineering technician, instrumentation engineering technician, robotics engineering technician, and sensor engineering technician.
- Address regulatory aspects in the course using a European map of encryption laws and policies.

b. Pedagogical content

The course is made up of 7 slots of 4 hours, with 7 lectures and 1 exam online (multiple choice questions are accessible online after the course).

The execution of the course highlighted a lack of interaction between the teacher and the participants, increased maybe by the heterogenous level of English of the participants and the format of the course (live videoconferences). Some participants did not finalize the course with the exam.

External experts pointed out the lack of information about the level of homework needed for the course and questioned the evaluation format. They also highlighted the lack of bibliography. Taking into consideration those comments, here are the changes that could be made to improve the course:

- Develop interactive activities with the participants in each slot of 4 hours to facilitate interactions (classpoint): replacing the long multiple-choice questionnaires at the end of all the modules by shorter, more interactive ones over the course of the different modules. For example:
    - Proposing different connections of electronic devices according to a specific code.
    - Proposing different streams with different addresses for a specific i2c electronic device given with its default address.
    - Proposing different accuracies for a specific analog sensor used in combination with a specific analog to digital converter.
    - Proposing different numbers of coils powered at the same time for a stepper motor in the half mode.
    - Proposing different setups to create a specific video stream.
    - Proposing different addresses to acquire a specific video stream remotely.
    - Proposing different algorithms to acquire the state of a button matrix connected to a raspberry pi 4.
    - Proposing different distributions of keys to realize a crypted communication between a computer and a raspberry pi 4ask for a minimum level of English to access the course.
- Develop the bibliography of the course to include the documents available at this link here.
    - Specify the amount of homework required at the end of each day (which could be used to prepare the next session and/or exercises). The participant could prepare for the next course by reading any recommended materials and its attached documentation.
    - Organise the exam during the course and not after.
    - Include more information from the lectures in the attached PDF files as it could help to refer back to specific course-related knowledge
    - Include in the PDF files the code to be used for those who do not know the language, or provide material beforehand about the language used during the course.

2. Pedagogical activity proposed

The activities proposed in this course are lectures and practical demonstrations online.

The internal evaluation pointed out that the trainees could not practice with physical elements which is very important at EQF4-5 level.

Taking into consideration this comment, a solution could be to organise the practical activities on-site or to use a simulation software developed for the course. However, the cost of these solutions for either industrial partners or the course provider cannot be implemented within the current scope of the project.

3. Overall presentation of the programme and organisation

The programme was presented by e-mail to the partners with all EQF4-5 courses at the end of March (2022) and was published on ASSETS+ website at the beginning of April (2022). The course starting on June (2022). The common registration form was accessible through ASSETS+ website. The course was shortened and organised 100% online in concordance with industrial feedback.

The execution phase, pointed out the necessity to communicate earlier on the programme to facilitate registration especially if professionals need to be involved at EQF4-5 (technicians, operators, etc.) because they would need to be taken out of production.

What could be improved in this field is:

- Organising communication on the programme at least 3 months before the beginning of the course. However, as the timeline of the project is very tight, certain tasks dependant on others, it is not possible within the current scope of the project.
- Be more precise in the description of the programme (title and abstract, skillsets and knowledge, learning outcomes, targets).

4. Additional comments

Restructuring the course on more numerous but shorter time slots could be a solution to improve industrial workers participation in the course. However, given the frame of the project, the availability of the teachers or experts participating in the course must also to be taken into consideration. There was only one teacher for the courses with only 2 timeslots of 4 hours available from April to June (2022). This is why the suggestions for the course could not be applied as the timeframe of the project had to be respected.

Prototype Programme 4.5 - Unit of measurement and Errors

1. Content of the programme

a. Technical content

The course deals with methods to assess the state of electronic devices attached to the embedded computer of a drone. Two important protocols, I2c and SPI, used for the communication between the embedded computer and electronic devices are studied through several examples. A cybersecurity element, the RFID module, using the SPI protocol takes part of these examples. Then, an entire course deals with logical sensors commonly found in robotics. Each theoretical study is followed by a practical activity showing how to acquire and understand the exchanged digital signals displayed on the screen of an oscilloscope. Through this understanding, it is possible to detect errors or failures. Knowledge acquired by the students during the course must include digital signal analysis, I2c and SPI protocols, RFID modules.

External experts pointed out the need to clarify the title and abstract of the course and the lack of information on the content of the lessons in the design phase.

Internal evaluation of industrial partners inside the consortium after execution recommended that the course was more specified to the defence sector issues and expand to other types of sectors and professional profiles. The regulatory aspects were not addressed but it turned out to be an opportunity for the participants to improve their skills.

Taking into consideration those comments, here are the changes that could be made:

- Change the title and abstract of the course to:
  - Title: "Diagnostics of drone electronic devices"
  - Abstract: As part of the maintenance of drones, it is necessary to learn methods to assess the state of electronic devices attached to their embedded computer. Two important protocols, I2c and SPI, used for the communication between the embedded computer and electronic devices are studied through a lot of examples. A cybersecurity element, the RFID module, using the SPI protocol takes part of these examples. Then, an entire course deals with logical sensors commonly found in robotics. Each theorical study is followed by a practical activity showing how to acquire and understand the exchanged digital signals displayed on the screen of an oscilloscope. Through this understanding, it is possible to detect errors or failures. Each theorical study is followed by a practical activity in which each electronic device is controlled locally and remotely optionally with encrypted data in order to make measurement to predict possible trouble-shootings and to solve them.

- Specify the content of the lessons and the syllabus:
  - Content of the lessons would include:
    - ⇒ Module 1(8h): This course deals with the signal analysis of the communication between an embedded computer such as the raspberry pi 4 and I2c electronic devices such as an LCD screen (MCP23008), a 4 digits 7 Segments LED Display (HT16K33), an OLED screen, a light sensor (BH1750) and an inertial sensor (IMU6050). Through this study, it is shown how to enable the I2c interface of the raspberry pi and to detect if a specific I2c electronic device is correctly connected to the I2c bus and works well.
    - ⇒ Module 2(4h): This course deals with the signal analysis of the communication between an embedded computer such as the raspberry pi

4 and first a I2c analog to digital converter to acquire the output voltage of a sliding potentiometer, a rotary potentiometer and a XY joystick and then a power interface (PCA9685) to control servomotors. Through this study, it is shown how to acquire an analog voltage with a raspberry pi 4.

⇒ Module 3(4h): This course deals with the signal analysis of the communication between an embedded computer such as the raspberry pi 4 and SPI electronic devices such as a RFID module (MFRC522), a LED Matrix Display (MAX7219) and a 3-pixels tricolour Led. Through this study, it is shown how to enable the I2c interface of the raspberry pi and to detect if a specific I2c electronic device is correctly connected to the I2c bus and works well.

⇒ Module 4(4h): This course addresses the acquisition by an embedded computer such as the raspberry pi 4 of logical sensors data such as key inputs, a button matrix, a sound sensor, a touch sensor (TTP223B), a external motion sensor (LHI778), a line detector (TCRT5000), a tilt sensor (SW200D) and a ultrasonic sensor (HSC04). Through this study, it is shown through practical activities to find and solve troubleshooting.

- Syllabus:
  - Knowledge acquired by the students during the course must include digital signal analysis, I2c and SPI protocols, RFID modules.

- Focus on defence sector issues:
  - The encryption of the TCP client/server communication is operational and can be integrated into this course.

- Address regulatory aspects through a European map of encryption laws and policies

- Specify the job profiles targeted by the course:
  - This set of acquired knowledge and developed skills are in accordance with the following market positions: computer hardware engineering technician, computer numerical control machine operator, computer-aided design operator, electronics engineering technician, instrumentation engineering technician, robotics engineering technician, and sensor engineering technician.

b. Pedagogical content

The course is made up of 4 slots of 4 hours, with 4 lectures, with practical activities included and 1 exam online (multiple choice questions). The execution of the course highlighted a lack of interaction between the teacher and the participants, increased maybe by the heterogenous level of English of the participant and the format of the course (Live videoconferences). The participants did not finalize the course with the exam.

External experts pointed out the lack of information about the level of homework needed for the course and questioned the evaluation format. They also highlighted the lack of bibliography.

Taking into consideration those comments, here are the changes that could be made:

- Develop interactive activities with the participants in each slot of 4 hours to facilitate interactions (Classpoint): replacing the long multiple-choice questionnaires at the end of all the modules by shorter, more interactive ones over the course of the different modules. For example:
  - Proposing different solutions to solve a problem of connection to a server.

  - Proposing different distances for a specific pulse response of an ultrasonic sensor
  - Proposing different solutions to connect an i2c electronic device to a raspberry pi 4.
  - Proposing different duty ratios for a specific control signal of a servomotor.
  - Proposing different distributions of keys to realize a crypted communication between a computer and a raspberry pi 4.
- Require a minimum level of English to access the course.
- Develop the bibliography of the course to include the documents available at this link here.
- Specify the amount of homework required at the end of each day (which could be used to prepare the next session and/or exercises). The participant could prepare for the next course by reading any recommended materials and its attached documentation.
- Organise the exam during the course and not after.

2. Pedagogical activity proposed

The activities proposed in this course are lectures and practical demonstrations online. No particular comments were highlighted on pedagogical activities for this course, but despite the lack of comments, a similar complaint as made for 4.4 "Circuit boards Processors Chips Electronic equipment" could be expected since the fully online classes do not allow the participants to manipulate the devices and data. The same solutions could be proposed: organising the practical activities onsite or using a simulation software developed for the course. However, the cost of these solutions for either industrial partners or the course provider cannot be implemented within the current scope of the project.

3. Overall presentation of the programme and organisation

The programme was presented by e-mail to the partners with all EQF4-5 courses at the end of March (2022) and was published on ASSETS+ website at the beginning of April (2022). The course starting on June (2022). The common registration form was accessible through ASSETS+ website. The course was shortened and organised 100% online to fit industrial feedbacks.

The execution phase, pointed out the necessity to communicate earlier on the programme to facilitate registration especially if professionals need to be involved at EQF4-5 (technicians, operators, etc.) because they would need to be taken out of production.

What could be improved in this field is:

- Organising communication on the programme at least 3 months before the beginning of the course. However, the timeline of the project being very tight, and with certain tasks being related to others, it is not possible within the scope of the project.

- Be more precise in the description of the programme (title and abstract, skills and knowledge, learning outcomes, targets).

4. Additional comments:

Restructuring the course on more numerous but shorter time slots could be a solution to improve industrial workers participation in the course. However, the frame of the project, the availability of the teachers or experts participating to the course must also to be taken into consideration. There was only one teacher for all the courses with only 2 timeslots of 4 hours available from April to June (2022). This is why this suggestion could not be applied for the course in order for the timeframe of the project to be respected.

Prototype Programme 4.6 - Analytical tools

1. Content of the programme

a. Technical content

The topic on this course is cyber security awareness, and the purpose is to provide participants with an introduction to key cybersecurity concepts, to use this knowledge in analyzing and discussing publicized compromises, and to learn how to perform a basic threat analysis of valuable assets in order to mitigate the consequences of such events.

The following subjects are considered essential in respect to topic and purpose, and are thus considered indispensable to the course:

- Asset identification, prioritization, and protection
- Threat agents and vectors
- Common vulnerability exploits (CVE)
- Case studies of well-known compromises
- Threat analysis and compromise mitigation
- Cybersecurity frameworks

Because of this, the content for the programme was compressed to fit the short timeframe established, and thus the pilot course felt cramped. Following that experience, this three-day course has been replaced by a five-day course (5.8 “Cybersecurity”).

b. Pedagogical content

The course employs six distinct parts, each serving a specific purpose to facilitate effective learning and knowledge retention. To emphasize this, the course introductions set the tone for a collaborative and inclusive learning environment. The teacher takes the time to understand the participants' backgrounds and expectations, fostering a sense of community and support right from the start. This is, in part, hindered by accepting students with no practical experience to draw upon. Consequently, it is proposed that only skilled professionals are accepted as participants in future courses.

The next phase focused on introducing the key concepts of cybersecurity. Through lectures and interactive discussions, the course covers a wide range of topics, including the ever-evolving threat landscape, attack vectors, vulnerabilities, risk assessment, and security frameworks. The emphasis is on building a solid theoretical foundation that can serve as a framework for the rest of the course.

The course then moves on to practical exercises, allowing participants to apply the theoretical knowledge they have acquired. These exercises are based on real-world scenarios, enabling hands-on learning and providing participants with an opportunity to implement secure configurations, encryption protocols, and threat detection techniques. By actively engaging in these exercises, participants gain practical skills and a deeper understanding of cybersecurity principles.

Group discussions are meant to play a crucial role in the course, fostering collaboration and the exchange of ideas among participants. The intention with this interactive approach is to enrich the learning experience, and to encourage critical thinking and broadening participants'

perspectives. Again, however, the acceptance of undergraduate students hampers this activity, as they have no real-world experience to draw upon.

2. Pedagogical Activity Proposed

As mentioned in the previous section, a more homogenous group of participants, in terms of skill level, would be preferable. It is therefore proposed to restrict the participants to skilled professionals. As awareness is a cross-functional discipline, the participants would not have to be from a single function in the space/defence industry. In fact, a mixed group would be preferred, as long as they have actual experience from the industry. With that, the practical exercises could be made more dominant, which would enhance the hands-on feeling of the course.

3. Overall presentation of the programme and organisation

This course is the first of three proposed courses on cyber security for the space/defence sector. It is intentionally generic as it is the first "steppingstone" in a series. The follow up courses are centred on governance and technical matters. However, the timeframe for the work-package does not allow sufficient time for the development of these.

4. Additional comments

The evaluation of this course is hampered by the fact, that only two participants completed feedback questionnaires. Still, it has been possible to identify some points on which the course could be improved and further developed. Most notably, the course has been changed from a three-day format to a five-day format. It has also been given a less generic title as well for the second phase of implementation: 5.8 "Cyber security" instead of "Analytical tools".

Prototype Programme 4.7 - Controlling operations of processes to solve problems

1. Content of the programme

a. Technical content

The topic of the course was the principle of features and functionality of the main mechanisms behind any control system which regulate and control a process. The attention was focused on the analysis of machine/phenomenon of interest, in order to make the participant understand its behaviours and how to interface with it in order to solve any control problem in an efficient way. Notably, without external-expert comments and suggestions, the contents of the course were useful both for the aerospace and maritime defence industry because it taught how to design a controlling system/device able to assure a process is working on properly and autonomously without the need for a human operator.

The main aims of the course were to develop the following skills: signal equipment, predictive control strategy, types of tests for functionality and usability of process, systems and machine.

b. Pedagogical content

The pedagogical approach included live workshops performed at the begining of the addressed topics and a various mix of methodologies, such as videos and examples and exercises proposed to increase the interaction between trainers and participants. This aspect of high interaction and concrete approach has been highly appreciated from the participants. From the evaluations of the participants questionnaires the strength of the course was:

- It was a very good course overall. Perhaps a few more exercises could be proposed to assimilate the concepts, but all in all, it was very good and interesting. Interaction and experience sharing between participants was appreciated.
- The mix of course methodologies (audiovisual, interactions, case method, examples, etc.) was also appreciated.

2. Pedagogical activity proposed

For the future, according with the suggestions of trainer and favourable opinions of the participants, it could be useful to propose more exercises to improve overall comprehension and to have facilitate a more in-depth study of the topics. Additionally, perhaps a few more exercises could be proposed to assimilate the concepts, but all in all it was very good and interesting.

3. Overall presentation of the programme and organisation

This course focuses on basic concepts of Automatic Control, identifying and designing the main adaptive control techniques, and the main regulating mechanisms behind any control system. The course's contents are useful both for the aerospace and maritime defence industries as it teaches how to design a controlling system/device that is able to assure a process is working properly and autonomously without the need for a human operator.

For the future, a possible practical application can be the design of PID controllers for aerospace/defence applications. A case study for the synthesis and design of basic controllers for landing gear actuated by electrical drives could also be proposed.

The course, based on the need to reduce the hours of the main intended target audience, (industry professionals), consisted of 3 slots of 4 hours of lectures and a final online exam (1 hour) with a multiple-choice written text.

The external experts highly appreciated the guidelines for this course but suggested to modify the title and abstract in order to give a better description and understanding of the core topics. The average score for this programme is excellent, looking in depth at the assessment, the programme obtained:

- High scores (from 7,5 to 10) for the global comprehension of the course description, for the global completeness of course description, for the comprehension of the educational goals, for the clarity of the learning outcomes, for the clarity of the description of the target groups, for the comprehension of learning methods, for the description of the bibliography and course materials, for the description of hardware and software necessary in the implementation and for the diffusion of the information provided to be a support for future implementation.
- Average scores (5) only for the description of the access conditions.

Prototype Programme 4.8 - Records of maintenance and equipment documentation

1. Content of the programme

a. Technical content

The topics of the course were the principle of maintenance operations and data collection, types of maintenance logs/project logs, understanding the benefits of using equipment maintenance logs, processing operating parameters/estimators, tips for updating an equipment maintenance log template, the main software to record and update maintenance activities and documentation, warranty claim problems, and an introduction to cybersecurity.

The course aims to develop mainly these skills:

- Identifying and using the documentation related to operations of maintenance of computer/devices/communications systems.
- Understanding how to organize, manage and maintain all documents storage in accordance with regulatory requirements.
- Understanding how to maintain master log of all manuals, including electronic & troubleshoot.
- Understanding how to access FAA & EASA Website for Technical Information.
- Managing the activities of one scheduled or one unscheduled maintenance programme.
- Determining resource requirements.
- Demonstrating fault diagnosis techniques.
- Communicating maintenance progress and outcomes with designated personnel and authorities.
- Reviewing the compliance and effectiveness of maintenance activities undertaken.
- Determining resource requirements.

Intentionally, the course is mainly oriented to the targeted job profile "Aerospace Technical Engineer". However, in the future, according to the external-expert comments, since the general principles and methodology are exportable to other defence use cases, other job profiles could be considered, notably extracted from WP1 "ANNEX 1 -Data driven analysis for the Skills Blueprint". These include:

- Maintenance and repair engineer
- Telecommunications Engineering Technician
- Knowledge Engineer
- Engineering SATCOM (not applying)

According to the external experts, this course is missing some relevant technologies and applications, yet the trainer has suggested that incorporating Cloud/Cloud computing in the near future could be considered. Out of the Technologies and Applications Matrix, these are the more relevant missing Techs & Apps:

- IoT
- Cloud / Cloud computing
- Mobile & IoT Security
- Cloud and virtualization security

Concerning the standards identified from the external experts, it must be underlined that, except for ISO 20022, the other proposed standards are refer to the hardware/software

development and design, yet these topics are not aligned with the contents and objectives of the course.

These identified standards were not specifically covered:

- ISO 20022 Standard Maintenance Process
- ECSS-Q-ST-60-02C ASIC/FPGA DEVELOPMENT
- ARP4754A Guidelines for Development of Civil Aircraft and System
- RTCA-DO-178B, Software Considerations in Airborne Systems and Equipment Certification (should be removed as it is substituted by 178C)
- RTCA-DO-178C, Software Considerations in Airborne Systems and Equipment Certification

b. Pedagogical content

The pedagogical approach included live workshops performed along the beginning of the addressed topics, ILS standards, and use cases coming from aerospace & defence. This was done to be more in line with the expected industrial targets and with most of the participants' background and role within their companies. This aspect of high interaction and concrete approach was highly appreciated from the participants.

From the evaluations of the participant the strength of the course was:

- The general approach of the course, enabling the participants to deepen a specific development in their fields.
- The interaction and experience sharing between participants.
- The mix of course methodologies provided: audiovisual, interactions, case method, examples, etc.

2. Pedagogical activity proposed

For the next course, according to the suggestions of trainer and the favourable feedback from the participants, it could be useful to have access to a trial license of ILS system and, similarly, to have live exercises and simulations on the topics exposed in the course. Additionally, an Enterprise Architect trial license would allow the possibility to download and read EA diagrams provided with ASD standards. For the ASD standards, the ASD standard topic referred to in the training material must be balanced with the defence market needs.

Considering the suggestion from only one participant, it would be important, for the future execution of the course, to correct the initial and final exam at the *end* of the sessions in order to give them the right feedback and to give the tools to apply the topics in their field of activity. It is considered particularly important to give feedback to the participant about the final exercise, where the understanding of the methodologies is assessed (application of the technologies to their fields).

3. Overall presentation of the programme and organisation

The programme aims to provide the main concepts necessary to manage the technical manuals and documents related to the maintenance of Aerospace systems or equipment, as well as the continued demonstration of organisation compliance with regulatory requirements, which is of critical importance to the success of the organisation.

The course, based on the need to reduce the hours of the main intended target audience, (industry professionals), consisted of 3 slots of 4 hours of lectures and a final online exam (1 hour) with a multiple-choice written text.

The external experts highly appreciated the guidelines for this course but suggested to modify the title and abstract in order to give a better description and understanding of the core topics. Concerning the experts' comments, according to the first intention, "The course was perceived as a reference framework, either to upgrade the company maintenance processes to the ongoing defence standards, or as an introduction to this subject to the maintenance junior professional" and match with Skills Matrix for 79%.

The average score for this programme is excellent, looking in depth at the assessment, the programme obtained:

- High scores (7,5) for the global comprehension of the course description, for the global completeness of course description, for the comprehension of the educational goals, for the comprehension of learning methods, for the description of the bibliography and course materials, for the description of hardware and software necessary in the implementation, and for the diffusion of the information provided to be a support for future implementation.
- average scores (5) for the description of the access conditions, for the clarity of the learning outcomes and for the clarity of the description of the target groups.

4. Additional comments

Since the Technologies Matrix was not available to the trainer in time to be accounted for this course, according to the industrial experts and the ASSETs+ project leader, we'll make some adjustments to increase the specific examples for the best applications of the topics in different context, in order to address this specific comment: "For further editions of the course to be considered, with specific examples for maintenance records and ILS of referred items. This will be validated by the ASSETs+ project leader and ASSETs+ stakeholders".

Prototype Programme 4.9 - Instructions into machine control units to start operation

1. Content of the programme

a. Technical content

The topics of the course were acquiring familiarity with the key elements, the functionality, tools and parameters of control unit machine, as well as the introduction of the main software used to configure and start a machine working process.

Notably, without external experts comments and suggestions, the course's contents were useful both for the aerospace and maritime defence industry because it taught both the functionality of the machine control unit and how to write a set of instructions or programme and identify the process of automatic execution for a machine control unit.

The attention was focused on introducing participants to process control with few basic practical notions, developing mainly these skills:

- Understanding the applications of the automation systems (Machine control units and PLCs) and referred architecture.
- Using sensors and transducers.
- Managing the technical documentation.

b. Pedagogical content

The pedagogical approach comprised live workshops performed during the beginning of the addressed topics with a mix of methodologies (videos, examples, exercises, case studies, etc.) and was also Project Based Learning (PBL) oriented. Participants were asked to carry out a project where the goal was to design a simple manufacturing line that produces a centrifugal pump impeller, to perform supervision control, as well as simple quality control. This aspect of interaction and concrete approach was highly appreciated from the participants. From the evaluations of the participants questionnaires the strength of the course was that the lessons had examples which were "easy to understand."

2. Pedagogical activity proposed

Project Based Learning (PBL) gives a boost to the overall interest of the course, but students who miss the first few classes may feel isolated from the flow of the course.

The PBL proposed is aimed to design a simple manufacturing line that produces a centrifugal pump impeller, to perform supervision control and simple quality control. The line will be physically made up of:

- a CNC machine to manufacture the item,
- one or more conveyor belts to move the item to a simple quality control station,
- appropriate sensors to control the movement of the item,
- [optionally] sensors to check the item quality.

Moreover, the line will be modelled using tools such as finite state automata, and a programme to control the line will be developed, using languages such as SFC, to control a PLC.

3. Overall presentation of the programme and organisation

This course focuses on basic concepts of the functionality of machine control unit and to write a set of instructions or programme and essential elements of circuit boards, processors, chips, electronic equipment, and computer hardware and software. The course content is useful for both the aerospace and maritime defence industries, as the topics covered provide solutions to support manufacturers in the aerospace industry in making aerospace manufacturing and testing processes better and more accurate, and in maritime defence to increase accuracy and reliability, minimize maintenance costs, and simplify ship monitoring to avoid misjudgements or malfunctions. For the future, a possible practical application could be the process design via Sequential Function Charts (SFC) and PLC Programming for the creation and manufacturing of a piece for a plane.

The course, based on the need to reduce the hours of the main intended target audience, (industry professionals), consisted of 5 slots of 4 hours of lectures and a final online exam (1 hour) with a multiple-choice written text.

The external experts highly appreciated the guidelines for this course and had no remarks with respect to this course or suggestions for improving it.

The average score for this programme is excellent, looking in depth at the assessment, the programme obtained:

- High scores (7.5 to 8.8) for overall completeness of course description, comprehensibility of learning objectives, clarity of learning outcomes, clarity of description of target groups, description of access conditions only, description of bibliography and course materials, and extent of information provided to support future implementations.
- Average scores (6.3) for the overall comprehensibility of the course description, for the comprehensibility of the learning methods, and for the description of the necessary hardware and software.

Prototype Programme 5.1 - Performance calculation

1. Content of the programme

a. Technical content

The aim of the course is to give the participants a basic understanding of big data concepts, data sets and basic tools. The objective of this two-day course is to familiarize the participant with big data concepts and various tools for extraction, transformation, and analysis of data. This includes the following topics:

- Introduction to big data and definition of big data
- Big data concepts and terms
- The 3 to 10 V's of big data
- Structured, semi-structured and unstructured data
- Data lakes and data warehouse concepts
- ETL – Extract, transform and load model
- Handling and processing big data

This requires a tightly compressed programme. It would be preferable to extend the course length by an extra day.

b. Pedagogical content

Throughout the course, a variety of pedagogical concepts is used to ensure an engaging and comprehensive learning experience. Classroom sessions facilitate interactive discussions and knowledge sharing. Laboratory exercises provide hands-on experience, enabling participants to apply the concepts learned. Self-study materials support independent learning and exploration.

In conclusion, this two-day online course on Big Data technologies seeks to equip the participants with the knowledge and skills required to navigate the world of Big Data effectively. By employing a combination of online "classroom sessions", laboratory exercises and self-study materials, it strives to foster an engaging and immersive learning environment. This could be enhanced by a more generous timeframe.

2. Pedagogical activity proposed

Depending on the scope of the course, it could be developed further. In its current form, as an introductory/coursework course, the only suggested change would be a more generous timeframe. It should be a three-day course if it is being delivered generically, and if the generic part is to form the basis for diving into more specialized topics (the standards mentioned in section 4, additional comments), it should probably be four days. However, these extra days do not have to be immediately following the generic part, and the timeframe of the course could probably be even better in a 2+1+1-day format.

3. Overall presentation of the programme and organisation

The primary objective of this course is to provide participants with a comprehensive understanding of the immense potential inherent in Big Data, as well as a profound comprehension of the associated prerequisites. In order to effectively harness the capabilities offered by these technologies, it is recommended that individuals pursue courses at an advanced EQF level. Furthermore, they should also have the opportunity to apply these technologies within the context of their professional responsibilities.

4. Additional comments

The pilot course was very well received. Due to difficulties with the chosen language (English) some students did not get the full benefit of the course, and it should probably be offered in Spanish as well as English.

A few standards are proposed to be included in the syllabus by the evaluators. These are:

- RTCA-DO-178C
- Software Considerations in Airborne Systems and Equipment Certification
- ARP4754A Guidelines for Development of Civil Aircraft and System
- ARP4761 Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment

This seems very reasonable but would require the course to be even longer. As this would specialize the course even further (which might be beneficial), it may be possible that certain course providers may be at a disadvantage if there is no specialized space/defence industry in the immediate vicinity of the school.

Specialized or not, the title of the course is too generic and it is suggested to change it to "Introduction to Applied Computer Science and Engineering".

Prototype Programme 5.2 – Programming

1. Content of the programme

a. Technical content

The aim of the course is to introduce the participants to machine learning emphasising the need to understand models rather than data. For this purpose, the mathematics of neural networks is first introduced in spreadsheets, then in simple standardized C# programming and, lastly, in python. Only on the last day, when proper understanding of models has been established, does the course deal with the data itself.

The evaluation shows that the (very few) respondents felt that the technical content of the course was very well covered by the course. If anything should be added, a standardized introductory course to Python could be added to the course. However, this would affect the length of the course.

b. Pedagogical content

The pedagogical approach favours a detail-oriented approach rather than a holistic one. This is of course to attain proper understanding of ML models, and to focus the participants' mental energy and focus on this element. However, this puts some strain on the more holistic-oriented participants' patience, and this might be one of the reasons for a very poor rate of attendance on the last days of the course: only two of the participants stayed for all the lectures and submitted an evaluation. They were very appreciative of the course and its content, but with fifteen participants noted on the first day, some attention should be given to secure a higher rate of success. As proposed in the next section, this probably could be attained by a series of videos made by the teacher, explaining how each part of the course fits into the subject as a whole.

The course was online, and the participants did not turn on their webcams, although they were asked to by the teacher. The anonymity they thus granted themselves most likely lessened their feeling of commitment, and may explain in part the high rate of drop-outs.
Another probable explanation is the previously mentioned detail-oriented approach to teaching employed. It can be argued, that to some participants, the purpose of the course might be lost in tedious, repetitive exercises, which aims to establish a firm grasp of ML models, but also demands a relative high degree of self-discipline of the participants. To counter this, the course should emphasize more discussion-based learning and a wider variety of activities to keep participants engaged.

2. Pedagogical activity proposed

As mentioned, the course was online. As it was meant for employed, skilled workers rather than ordinary students, the online format dispenses from the need to travel or commute for on-site courses. For this reason, the course online should be kept online. However, the use of webcams should be mandatory to mitigate the participants' experience of anonymity and the resulting low feeling of commitment.

The online format might be explored further by allowing asynchronous participation based on recorded lectures for the synchronous participants and a written chat-function with the teacher. The chosen platform, (MS teams), would be well suited for such a modification.

The participants were welcomed to the course with a video message from the teacher, in which he explained the course contents and introduced himself. This could be developed further in order to accommodate holistic orientated participants by producing a new video for each topic on the course, explaining its place in the bigger picture, presenting the exercises for the specific topic, and explaining the main learning objectives for the topic.

The course used blended learning, where lectures, exercises and individual study were used alternately. These methods needed little modification to accommodate asynchronous learners.

3. Overall presentation of the programme and organisation

The bibliography for individual studying was not presented in a fittingly organized manner, and this should be remedied by a list of the recommended literature and websites for each topic on the course.

The high drop-out rate is probably in part because the course is online. This might be countered by doing the course on-premises. This, however, would result in other challenges, *e.g.* some potential participants might not be able to attend because of the required travelling activity. As programming is relatively well suited for online education, it is proposed to keep the course online, and instead develop further for that format by the activities proposed in section 2. (*Pedagogical activity proposed*) above.

4. Additional comments

The evaluation of this course is hampered by the fact, that only two participants completed it. To complicate matters further, the teacher who executed the course has left the organisation, and no external experts' comments are available. Still, it has been possible to identify some points on which the course could be improved and further developed.

However, the most important issue remains that while 39 participants signed up for the course, only 15 joined the first day and over the course that number dwindled to only two participants. It has not been possible to identify one specific reason for this. The teacher has long experience in the topic and is well respected as a teacher. The most probable cause for the huge drop-out rate may well be the title of the course, as the topic is machine learning, yet this is not suggested in or by the title. If the participants thought they signed up for a basic C# course, and then got a welcoming video in which the teacher explained that the real topic was Machine Learning, this might keep some of them from attending. The dropout rate during the course has probably been enhanced by this too, as well as by the factors mentioned in section 1b *Pedagogical Content*. Consequently, it is recommended that the title of the course be changed to "Introduction to Applied Machine Learning".

Improvement Summaries for EQF 4/5 Programmes

In Table 2 below the reader can find the list of the summarized improvements suggested for the seven prototype programmes implemented at the EQF4 and EQF 5 Level.

Table 2. Improvement Summary Chart at EQF4/5

4.3 - Types of technical reports	**Technical content** – Aim for undergraduate students instead of professionals. – Change the course title to "The Cybersecurity of drones. – Modify the abstract (*for specific examples, see R3.4*) . – Specify the content of the lessons and the syllabus (*for specific examples, see R3.4*) . – Develop the bibliography of the course (*for specific examples, see R3.4*) . **Pedagogical content** – Develop interactive activities with the participants in each slot of 4 hours to facilitate interactions. – Replace multiple-choice questionnaires at the end of all the modules by smaller, more interactive ones (*for specific examples, see R3.4*). – Ask for a minimum level of English to access the course or organise the course on-site in the official language. – Further develop the bibliography of the course. – Specify the amount of homework at the end of each day (which should be used to prepare the next course by reading it and its attached documentation). – Organise the exam during the course and not after. – **Pedagogical activity proposed** – Participation from industrials in the design and the development phase of the course would allow for industry-based use cases and more specific defence issues using project/problem-based learning. – Organise the practical activities on-site or using a simulation software developed for the course. **Overall presentation of the programme and organisation** – Organise communication on the programme at least 3 months before the beginning of the course. – Improve and specify the description of the programme (title and abstract, skills and knowledges, learning outcomes, targets). – Restructuring the course on more numerous but shorter time slots could improve industrial workers' participation.
4.4 - Circuit boards Processors Chips Electronic equipment	**Technical content** – Change the course title to "Drones electronic devices - Technology and programming" . – Modify the abstract (*for specific examples, see R3.4*). – Specify the content of the lessons and the syllabus (*for specific examples, see R3.4*) . – Develop the bibliography of the course (*for specific examples, see R3.4*). – Specify the job profiles targeted by the course (*for specific examples, see R3.4*). – Address regulatory aspects in the course. **Pedagogical content** – Develop interactive activities with the participants in each slot of 4 hours to facilitate interactions. – Replace multiple-choice questionnaires at the end of all the modules by smaller, more interactive ones (*for specific examples, see R3.4*). – Further develop the bibliography of the course (*for specific examples, see R3.4*). – Specify the amount of homework at the end of each day (which should be used to prepare the next course by reading it and its attached documentation). – Organise the exam during the course and not after.

	– Include more information from the lectures in the attached PDF files. – Include in the PDF files the code to be used for those who do not know the language or provide material about the language used during the course. **Pedagogical activity proposed** – Organise the practical activities on-site or use a simulation software developed for the course. **Overall presentation of the programme and organisation** – Specify the description of the programme (title and abstract, skills and knowledge, learning outcomes, targets). – Restructuring the course on more numerous but shorter timeslots could improve industrial workers' participation.
4.5 - Unit of measurement and Errors	**Technical content** – Change the course title to "Diagnostics of drone electronic devices". – Modify the abstract (*for specific examples, see R3.4*). – Specify the content of the lessons within the syllabus (*for specific examples, see R3.4*). – Focus on defence sector issues (such as the encryption of the TCP client/server communication). – Address regulatory aspects. – Specify the Job Profiles targeted by the course (*for specific examples, see R3.4*). **Pedagogical content** – Develop interactive activities with the participants in each slot of 4 hours to facilitate interactions (replace multiple-choice questionnaires at the end of all the modules by smaller, more interactive ones (*for specific examples, see R3.4*). – Require a minimum level of English for the course. – Further develop the bibliography of the course (*for specific examples, see R3.4*). – Specify the amount of homework at the end of each day (which should be used to prepare the next course by reading it and its attached documentation). – Organise the exam during the course and not after. **Pedagogical activity proposed** – Organise the practical activities on-site or use a simulation software developped for the course. **Overall presentation of the programme and organisation** – Organise communication on the programme at least 3 months before the beginning of the course. – Specify the description of the programme (title and abstract, skills and knowledge, learning outcomes, targets). – Restructuring the course on more numerous but shorter time slots could improve industrial workers' participation.
4.6 - Analytical tools	**Technical Content** – As the three-day pilot course was cramped for content, it has been replaced by a five-day course (5.8 *Cybersecurity*). **Pedagogical Content** – Only skilled workers should be participants in future courses to avoid accepting students with no practical experience. **Pedagogical Activity Proposed** – Practical exercises should be emphasized to enhance the hands-on feeling of the course. **Additional comments** – The original title "Analytical Tools" is too generic compared to the replacement course title "Cybersecurity".

4.7 - Controlling operations of processes to solve problems	**Pedagogical content** – More exercises could be proposed to better assimilate the concepts.. **Overall presentation of the programme and organisation** – Clarify the title of the course.
4.8 - Records of maintenance and equipment documentation	**Technical content** – While the course is aimed at an "Aerospace Technical Engineer", other job profiles could be considered, including: →Maintenance and repair engineer →Telecommunications Engineering Technician →Knowledge Engineer →Engineering SATCOM – These are the most relevant missing Techs & Apps, according to the Technologies and Applications Matrix: → Internet of Things (IoT) →Cloud / Cloud computing →Mobile & IoT Security →Cloud and virtualization security – These identified standards were not specifically covered during the course: →ISO 20022 Standard Maintenance Process →ECSS-Q-ST-60-02C ASIC/FPGA DEVELOPMENT →ARP4754A Guidelines for Development of Civil Aircraft and System →RTCA-DO-178B, Software Considerations in Airborne Systems and Equipment Certification (must be removed as it is substituted by the 178C) →RTCA-DO-178C, Software Considerations in Airborne Systems and Equipment Certification **Pedagogical activity proposed** – Access to a trial license of ILS systems as well as live exercises and simulations on the topics exposed in the course should be available. – Enterprise Architect trial license would allow the possibility to download and read EA diagram provided with ASD standard. – Correcting the initial and final exam at the end of the sessions would give participants relevant feedback and provide tools to apply the topics in their field of activity. **Overall presentation of the programme and organisation** – Modify the title and abstract of the course to give a better description and understanding of the main topics. **Additional comments** – Provide more specific examples for the best applications of the topics in different contexts.
4.9 - Instructions into machine control units to start operation	(No improvements listed)
5.1 - Performance calculation	**Technical content** – Expand the length of the course with at least an extra day (given the compressed nature of the programme within a two-day timeframe), which would also benefit a versatile course format (combination of online "classroom sessions", laboratory exercises and self-study materials). **Pedagogical activity proposed** – Pedagogical activity could be developed further through a more generous time frame (three days for a more generic course, more specialized issues should probably be covered in four days).

	Overall presentation of the programme and organisation – Individuals should pursue courses at an advanced EQF level as well as have the opportunity to apply the technologies within the context of their professional responsibilities. **Additional comments** – The course should probably be offered in Spanish as well as English. – A few standards are proposed to be included in the syllabus by the evaluators: →RTCA-DO-178C, Software Considerations in Airborne Systems and Equipment Certification →ARP4754A Guidelines for Development of Civil Aircraft and System →ARP4761 Guidelines and Methods for Conducting the Safety Assessment However, including these would require the course to be longer and more specialized (in which case Mercantec would not be the best suited provider, as there is no specialized space/defence industry in the immediate vicinity of the school). – The title of the course is too generic and could be changed to "Introduction to employed data science and engineering".
5.2 - Programming	**Technical content** – A standardized introductory course to Python could be added to the course (which would extend the course). **Pedagogical content** – The course should incorporate more holistic teaching approaches, where the teacher could propose series of videos explaining how each part of the course fits into the subject as a whole (a new video for each topic on the course, explaining its place in the bigger picture, presenting the exercises for the specific topic and explaining the main learning objectives for the topic). – The course should emphasize more discussion-based learning and a wider variety of activities to keep participants engaged. **Pedagogical activity proposed** – Use of webcams should be mandatory to mitigate the participants' experience of anonymity, and the resulting low feeling of commitment. – The online format might be explored further by allowing asynchronous participation through recorded lectures and a chat-function with the teacher. **Overall presentation of the programme and organisation** – The bibliography for individual studying should contain a list of the recommended literature and websites for each topic on the course. **Additional comments** – It is recommended that the title of the course is changed to "Introduction to applied machine learning".

Revision of the programmes EQF6

This section will detail the observations and suggested improvements for the two courses implemented at the EQF6 level. Namely, it will give feedback received regarding prototypes:

6.1 Seasonal School – Machine Learning for Defence

6.2 Defence Awareness - European Defence Challenge II

At the end of this section, a summary chart will be provided which sums up the improvements outlined for each course point by point.

Prototype Programme 6.1 Seasonal School - Machine Learning for Defence

1. Content of the programme

a. Technical content

The covered topics were Machine Learning fundamentals and Operations (MLOps), the "K Nearest Neighbors (K-NN)" approach, Bayes and "Support Vector Machine" (SVM) learning methods and the Neural Networks approaches, *e.g.* Artificial Neural Networks (ANN), Convolutional Neural Networks (CNN).

Industry professionals are involved in the pedagogical activities, either as invited speakers or members of a committee. The pedagogical activities make students apply state-of-the-art techniques in order to tackle complex challenges.

Knowledge acquired by the students during the course must include:

- Machine Learning overview
- Model training & evaluation
- Core Machine Learning algorithms
- Machine Learning issues & MLOps

As a result of the the technical skills developed participants should be able to:

- prepare datasets for training,
- build Machine Learning models on various data types,
- use standard Python libraries for Machine Learning,
- apply Machine Learning wisely, in accordance with ethical rules.

This set of knowledge acquired and skills developed are in accordance with the following market positions:

- Data scientist
- Data analyst
- ICT Intelligence Systems designer

Feedback from external experts corroborates the adequacy of the technical content with the targeted job profiles as well as the main educational goals and learning outcomes. Participant's feedback confirm that the programme allows them to acquire the aforementioned knowledge and skills.

b. *Pedagogical content*

Among the comments, the most recurrent consists in the availability of dataset related to the defence sector for the student's project. However, it is difficult to overcome this problem due to confidentiality issues. The development of a closer relationship between course providers and industrial partners, for example as part of a project such as a doctoral thesis, could be a solution to making less sensitive data available.

Some programming skills, particularly in Python, enable students to concentrate on the subject (machine learning) without the additional difficulties of simultaneously learning a new programming language. This disadvantage can be mitigated if the required skills are not only announced in the module description, but if links to tutorials are also made available, so that students can work on the subject before the first module.

2. Pedagogical activity proposed

A project-based pedagogy was applied in this programme. Students attended lectures and conferences in the mornings, and had supervised practical classes in the afternoons, during which they worked in pairs on their projects. Feedback on this topic reveals that project work was well perceived by the participants, and their commitment was confirmed by the instructors. Nevertheless, collaboration between faculty and industry, not only in the design of the course preparation, but also throughout the project, could be beneficial.

Some criticism has been voiced regarding the presentation of the project's main objectives and expectations of the final results. This problem could be countered by providing students with examples of successful projects from previous years.

3. Overall presentation of the programme and organisation

External experts highlighted the lack of bibliographic resources provided to students in the course description. Course providers should be able to prepare a list of important literature in the field and make it available to participants.

The organisation of the programme consisted of three phases of activities lasting two or three days, with lectures and conferences in the morning and guided practical courses in the afternoon, so that participants could work in pairs on their projects. For some participants, this organisation was too dense. Nonetheless, grouping the sessions together is necessary in view of the opening up of the whole module to international students on mobility programs, in order to avoid excessive travelling.

4. Additional comments

The level of English was highlighted in the evaluations and was sometimes considered an obstacle to a proper understanding of the subject. English as a "Lingua Franca" was one of the main topics discussed during the panel discussion of the Workshop "Training the Trainers" organized in Bordeaux (France) by Aerocampus and University of Bordeaux in November 2022. The guest panellists Mrs. Martine DERIVRY and Mr. Régis MALET (Professors at the University of Bordeaux – INSPE and responsible of the Master 2 - International education and training - IET) highlighted the fact that teaching a course in a multicultural group (different cultures, different

backgrounds, different professional profiles, different English proficiencies, etc.) is a challenge and therefore ensuring good communication is key to success. "*The challenge is to be understood by native and non-native speakers especially in the Defence sector where misunderstanding could have a huge impact"* said Mrs DERIVRY during the conference. In additional to this element, panellists pointed out the fact that within a group, it is important to create intercultural communication to enable people to talk together and help them overcome language insecurity.

The course provider should start the course by outlining the context (multicultural participants, different backgrounds, language proficiencies, etc.) in order to initiate trust within the group.

Prototype Programme 6.2 Defence Awareness - European Defence Challenge II

The prototype programme 6.2 "Defence Awareness" was a particular format compared to the other prototypes, as it is linked to the initiative European Defence Challenge, a competition for undergraduate and graduate students about relevant topics related to Defence industry and emerging technologies and skills. Therefore, this section has a different structure than the other programmes presented in this document. It is divided into two parts: the first one related to the content and overall organisation of the programme and the second one related to additional comments.

1. Content and overall organisation of the programme

The external experts highly appreciated the guidelines for this course, however, their comments and recommendations also pointed out some minor remarks for improvement, concerning:

- Clarify the title and abstract of the course (this was a recurring remark also in other programs).
- Explain how homework hours can be measured.
- Evaluate the possibility to have practical or laboratory sessions.
- Improve/add the bibliography information.
- Deepen the evaluation of the reports.

The average score for this programme is excellent, and upon closer evaluation, the programme obtained:

- High scores (from 8,1 to 9,4) for the overall comprehensibility of the program, the educational objectives, the description of access conditions, the clarity of learning outcomes, the description of hardware and software required for implementation, and the extent of information provided to support future implementation.
- Average scores (from 6,3 to 6,9) for the clarity of the target group descriptions, the overall completeness of the course descriptions and the comprehensibility of the learning methods.
- Low scores (3,8) for the completeness of the course parameters and the description of the bibliography and course materials.

The internal industry evaluators appreciated the EDC and related educational activities, pointing out that the EDC helped students become familiar with the defence sector, that the skills and professional profiles required by industry were well presented, and that the challenge offered them great prospects. They made a number of suggestions, which are summarized below:

- The topics were considered important and very relevant for the industry, both the more technological-oriented and the last one with a wider perspective (*i.e.*, on security). Similarly, the content of the proposals submitted were very interesting and good. They suggest to better frame the topics to be aligned closer with the industry and to better specify the subject to know what was expected in terms of methods and content.
- The dissemination and communication processes could be improved.
- The selection of winning teams could:
    - Be more transparent (for example, done via video) providing a better explanation on how the winner is chosen, with feedback on their proposals and scoring methods.
    - Insist on the pedagogical value of the challenge.
    - Award students in several categories (*e.g.*, most innovative, armed forces most appreciated solution, etc).

- They suggest the idea of developing a network of contacts and mentors to connect participants with professionals or insiders.
- The evaluation process was judged to be very good in terms of timing and content. They suggest "it would be useful if evaluators could see each other's evaluations in an (online) evaluation seminar, where discussions on how the different solutions/teams were evaluated could take place. This would also contribute to the transparency of the evaluation process". In addition, it could be useful to better elaborate the purpose of the theme of each challenge to the evaluators (*e.g.* focus on a moral issue, or realistic use cases, etc.) to ensure a proper evaluation of the proposals.
- The awards ceremony could be held in person and not just online, so that the winners can receive their prizes at the ceremony (including, for example, invitation letters from various companies, who volunteer for this).
- As for participation, motivation might be higher if there were more concrete prizes for the winners, for example opportunities to meet professionals, perhaps a personal meeting with a coach, and better interaction with the industry overall.

The comments received may be useful for the next edition of the European Defence Challenge, and for subsequent editions. Taking into account most of the comments received as part of the internal and external evaluation, these included in particular:

- Framing the topic better, clarifying the title and abstract and providing clear bibliographic references.
- Improving the dissemination and communication processes targeting teachers and students most likely to be interested in the proposed topic.
- Taking a closer look at the motivations behind participation (*e.g.* awards, confrontation with professionals, personal encounter with a coach, interaction with industry, etc.) to capitalize on them in the dissemination and communication processes.
- Taking on board suggestions concerning the review process, addressing both explanations for reviewers and feedback for students.
- Implementing the idea of developing a network of contacts and mentors to connect participants with professionals and/or insiders.
- Finally, assessing the feasibility of having the ceremony award in person.

2. Additional comments

Some of the proposed elements cannot be fully considered due to the specific nature of the programme. In particular, the implementation of the competition at the European level and the theoretical approach adopted (students are asked to produce a report) make it difficult to organize practical or laboratory sessions for participants. Students are free to take part in the competition, and some teachers have included it in a specific program, but it is generally difficult to monitor and measure the hours of homework devoted by students to this initiative. The only measure which can be obtained is the time spent attending the proposed webinars. Therefore, this suggestion will be taken into consideration, reflecting on the topics and modalities of webinars in the next edition of the EDC.

Improvement Summaries for EQF6 Programmes

In Table 3 below the reader can find the list of the summarized improvements suggested for the two prototype programmes implemented at the EQF6 Level.

Table 3. Improvement Summary Chart at EQF6

6.1 Seasonal School - Machine Learning for Defence	**Pedagogical content** – Developing a closer relation between course providers and industrial partners (for example, through a doctoral thesis project), could increase the availability of dataset related to the defence sector for the students' project. – Describe required skills in the description of the module with links to tutorials available to participants so that they can work on the topic prior to the first session. **Pedagogical activity proposed** – It would be beneficial to have faculty-industry collaboration not only during the design of the course preparation but also over the course of the project itself. – Providing the students some examples of successful projects from the previous years/editions would provide a better understanding of the main objectives of the project and expectations for the final results. **Overall presentation of the programme and organisation** – The course providers should be able to prepare a bibliography available to course participants. **Additional comments** – The course provider should start the course by acknowledging the different multicultural backgrounds and language proficiencies/deficiencies in order to develop a sense of trust within the group.
6.2 Defence Awareness - European Defence Challenge II	**Content and overall organisation** – The title and abstract should be clarified. – Clear bibliographic references should be provided. – Improve the dissemination and communication processes targeting the teachers and students potentially interested in the proposed topic. – Improve participation by advertising the advantages of the courses in the communication/dissemination (for example: low-cost, interactions with professionals/industry, personal meetings with experts). – For the review process: →Improve transparency in the evaluation process by allowing reviews to see other reviewers' evaluations (for example in a remote seminar) →Explain in more detail the objective/theme of each Challenge (for example, ethical issues, real world use cases). →Increase student motivation through prizes, professional meet-ups, personal coaches, and overall better interaction with industry professionals. – Develop a network of contacts and mentors to connect participants with professionals and industry insiders. – Evaluate the feasibility of having the awards ceremony on-site.

Revision of the programmes EQF7

This section will detail the observations and suggested improvements for the four courses implemented at the EQF7 level. Namely, it will give feedback received regarding prototypes:

7.1 – Artificial Intelligence Based Optimization in Aerospace Engineering

7.2 - Computer Methods in Aerospace Engineering

7.6 - Remote sensing image analysis course

7.7 - AI for defence

At the end of this section, a summary chart will be provided which sums up the improvements outlined for each course point by point.

Prototype Programme 7.1 - Artificial Intelligence Based Optimization in Aerospace Engineering

This programme is not going to be replicated within the scope of the ASSETS+ project due to the lack of candidates for the master's studies in the field of Avionics at the Faculty of Mechanical Engineering and Aeronautics of the Rzeszów University of Technology. However, the results have been taken into consideration to issue new editions of this course after the end of ASSETS+. This section describes the improvements to be implemented in subsequent editions.

1. Content of the programme

a. Technical content

The course is addressed to graduate students who have relevant skills in airspace engineering, including control theory, mathematical modelling, and the basics of artificial intelligence.

Unfortunately, neither the on-site lectures nor the practice-oriented activity of students during the workshops could be evaluated by the external experts. For this reason, the critical opinions issued by the experts on the programme are based solely on the materials made available to students in the form of a PDF file.

b. Pedagogical content

As part of the lectures, the students become acquainted with the theory of optimal decision-making and learn various AI-based optimization methods. During the workshops, the students solve practical optimization tasks by applying the methods, theories, and techniques presented during the lectures. The students propose to use them for solving selected problems that can occur in the area of airspace engineering. Student feedback also suggests to focus more on real-world applications and on implementation. The field of AI is vast and constantly evolving, which is why they indicate that they do not need to study every existing method. According to one student, application to a real project provided a deeper understanding than an entire course.

2. Pedagogical activity proposed

The presented AI-based optimization techniques, especially swarm optimization, are novel methods that are constantly being developed. In consequence, the available information on the subject could be gathered mainly from scientific publications. It is regrettable that none of the industry partners were interested in sharing their experience with us by presenting interesting examples, indicating practical problems, and showing difficulties which can arise during the realization of real-world optimization tasks in airspace engineering. It would be very helpful if industrial partners could share their experience, providing interesting examples and highlighting practical problems that may arise when carrying out optimization tasks in the real world.

3. Overall presentation of the programme and organisation

The programme is relatively short, as it includes only 15 class hours (45 minutes each) of lectures and 15 hours of workshops. According to the trainer of the course, some parts of the course should be extended.

Prototype Programme 7.2 - Computer Methods in Aerospace Engineering

1. Content of the programme

a. Technical content

The topics discussed concern modern methods and computer tools supporting the process of the conceptual and preliminary design of complex aviation and space systems. During the course, the existence of a strong interdependence between design tools and design processes was emphasized. During the classes, the role of each discussed tool at each stage of product development was presented.

In addition to classes held in the university format, industry lectures were conducted by industrial partners. In gave the students the opportunity to learn about the practical application of computer methods in industrial activities. The opportunity to ask questions and discuss with industry partners allowed to deepen content in areas of interest to students.

The knowledge acquired by students must include the use of CAE methods and tools in the engineering design of complex aerospace systems, in particular the use of the mission-based and model-based approach to systems design and engineering. The theoretical and practical knowledge should concern methods of modelling, analysis and design of aerospace systems.

As a result of developed technical skills, students should be able to:

- verify and validate a list of design requirements,
- verify and validate models used in the optimal designing process,
- recognize the advantages and disadvantages of the used models, methods and tools, and obtained solutions,
- select and apply existing computer tools to design a product and solve optimization tasks,
- identify optimization tasks, select and apply optimization methods in designs,
- select and apply existing software tools to engineering analysis, design and optimisation,
- analyse the strengths and weaknesses of the obtained solutions.

This set of knowledge gained and skills developed is consistent with the following market positions:

- Systems Engineer
- Computer-aided Design Engineer
- Data Scientist
- Data Analyst

Feedback from external experts confirms the relevance of the technical content to job profiles and the main objectives and learning outcomes. The course has a good general base and well identified knowledge and skill areas. The course should be supplemented with more defence-related topics, as it currently deals mainly with the aerospace sector. The course should also be supplemented with additional elements such as artificial intelligence, neural networks and Big Data analysis. Constant contact should also be maintained with industry partners to incorporate the most current developments and trends.

b. *Pedagogical content*

Comments focus on placing more emphasis on practical issues and the possibility for students to carry out more workshops during which simple tasks will be solved under expert supervision. Teaching materials should be improved to better adapt them to the implementation nature of the course. The availability of materials also needs to be improved.

Collaboration with industrial partners should be developed to strengthen the practical aspects of the course. Educational materials should be improved to include modern and innovative teaching methods. Interactions between course participants should also be improved through appropriate methods, such as creating online forums or other platforms for exchanging information among course participants.

2. Pedagogical Activity Proposed

The course is implemented as part of studies in the field of aviation and astronautics. For this reason, the layout of the course, divided into lectures and projects, is blocked. The greater number of lectures makes the course more theoretical than practical, which may be perceived by students as a less attractive form of learning. However, the participation of industrial partners in lectures introduces a practical element by presenting the practical use of theoretical knowledge. During the lectures, discussions with course participants should be conducted to a greater extent in order to make this form of classes more attractive. Practical-based courses are better accepted by students, who find them more interesting and useful. Study visits to industrial partners could perhaps make the courses more attractive to student participants.

3. Overall presentation of the programme and organisation

External experts have emphasized the need to modify the scope of the course in order to broaden coverage of defence fields. Also, certain skills related to the defence sector, such as social skills, the impact of computer modelling in the defence sector, encryption/model security, could be included in the course.

There is a constant need to consider the current trends and requirements of the defence sector, which makes the participation of industrial partners crucial.

The use of modern methods and educational tools will improve the level of the course and its attractiveness from the point of view of the participants.

Due to the specificity of the issues addressed and their topicality, there is a lack of educational literature. Consequently, teaching materials prepared for students must be comprehensive and easily accessible. They also need to be constantly updated and improved.

4. Additional comments

The "Computer Methods in Aerospace Engineering" course is carried out in the specialty of aviation and astronautics, so its thematic scope must correspond to the specialization of education. The possibility of extending the content to general defence issues is therefore limited.

As a result, the issues addressed mainly concern the defence sector with a focus on the aerospace industry.

Students entering the course are required to have some initial knowledge resulting from the course of study. Consequently, opportunities to take the course are limited for other participants who do not have the required basic knowledge of the aerospace sector.

Prototype Programme 7.6 - Remote sensing image analysis course

This programme is not going to be replicated within the scope of the ASSETS+ project due to problems with availability of the trainers. However, the results have been taken into consideration to issue new editions of this course after the end of ASSETS+. This section describes the improvements to be implemented in subsequent editions.

1. Content of the programme

a. Technical content

Among the comments, the most recurrent is to explain the relevance of the technologies listed below for defence and also to give a more defence-oriented examples:

- Introduction to Remote sensing
- Characteristics of RS optical and radar and images
- Introduction to multimedia analytics: content analysis and applications
- Efficient storage of massive imaging data
- Compressive sensing for images
- Lab session: Compressive sensing
- Image handling: storage, search and retrieval at big scale
- Content descriptors extraction
- Machine learning tools for multimedia analysis
- Classification and regression
- Clustering
- Lab session: Exploratory data analysis
- Lab session: Inference on the data
- Object detection/recognition in the compressed domain
- Sparse representation and dictionaries
- Dimensionality reduction via Compressed Sensing
- Lab session: Object detection/recognition in the compressed domain

In the first part: Introduction to Remote Sensing, the relevance to defence will be explained more clearly. Some of the examples are related to defence applications, but it is true that other examples are drawn from different situations. However, they were chosen to explain the concepts more clearly by using examples that were more familiar to the students.

Although the evaluators did not specifically address the issue, students gave feedback during the course to reduce the mathematical/theoretical content and use a more descriptive approach. These changes had in fact already been implemented in the first edition.

Although not specifically addressed by the reviewers, the students gave feedback during the execution of the course to reduce the mathematical/theoretical content and to use a more descriptive approach. These changes were in fact already implemented during the first edition.

A comment was made about the lack of inclusion of regulatory aspects in the course. Another difficulty with the course is that ASSETS+ industry partners have commented that it is too long. Thus, work is being undertaken to reduce it and, as a result, it is not possible to introduce new elements such as regulatory aspects. In any case, it may be easier for students to acquire this knowledge themselves from open sources.

b. Pedagogical content

Comments have been made about the incompleteness of the bibliography. This is indeed the case. The reason is that specific documentation has been developped to follow the course. However, the documentation has been updated to include a more complete bibliography for future editions.

2. Pedagogical Activity Proposed

The pedagogical approach was on-line lectures, on-line examples, and on-line laboratories. A few comments were received on this subject. A first comment on this point was to include labs and/or practical examples. This comment is probably due to the fact that the external experts did not have access to all the course documentation. In fact, the course did include laboratories and practical examples.

Other comments concerned the change of teaching language and/or the use of face-to-face teaching instead of online teaching. Both of these comments are related to the fact that it was necessary for the course to have a "European dimension" and to be available to all ASSETS+ participants. In fact, there are plans to publish additional editions of this course for a local Spanish audience, and these changes will be implemented for that audience. But they are not feasible for subsequent European-wide editions.

In terms of evaluation, as some evaluators pointed out, there was no performance evaluation. This is because the course content and approach were tailored to student feedback received during course development. Therefore, it was not feasible to provide students with an assessment report that did not truly represent the learning outcomes indicated in the documentation describing the course. This point will be corrected in future editions.

3. Overall presentation of the programme and organisation

The course has been stated as too long by the ASSETS+ industrial partners, making it difficult to be attended by their employees. It will be corrected in subsequent editions.

Comments were also made to improve the course description and target audience. This is a common comment and it must be accepted it as true. In particular, the prerequisite knowledge students need to understand the whole course was not clearly defined. Nor was the target audience clearly defined. In the new edition, the mathematical content will be reduced, so that the prerequisite knowledge requirements will be lower and more clearly explained during the dissemination phase.

Prototype Programme 7.7 - AI for defence

1. Content of the programme

a. Technical content

The AI for Defence course is divided into five main topics:

- confidential computing
- federated learning
- explainability and trustworthiness in AI
- ethical and legal aspects in AI
- cybersecurity

Learning outcomes are given below, as highly specialised theoretical and practical knowledge in the field of:

- AI and machine learning algorithms
- legal and ethical aspects of AI for the defence sector
- Explainable AI (XAI)
- AI use in cyber defence

The level of content was too low for the participating target group. This situation can be improved by detailed lessons in more problem-specific sub-headings. Before preparing the course, it is necessary to ensure that the target group's expectations and skills match the course content through better industry involvement and a clear link with defence application. The course content is high level and can be improved by making the details and methods more concrete. The course description can be improved by specifying more details on the subtopics.

b. Pedagogical content

The course type was an upskilling programme for industry employees. New and existing courses tailored for the defence sector are part of the pedagogical objectives. Participants suggest keeping a good overview of the challenges of machine learning in AI and the link between AI and defence.

To improve the practical components of the course, collaboration with industrial partners should be encouraged. Interaction between participants should also be enhanced by appropriate means, such as the development of online forums or other venues for sharing information between course participants.

One recommendation is to redesign the course to better meet the requirements of a professional target group, in particular by more clearly assessing the prerequisites for participating in this training. Although the content effectively corresponds to the original goal, it does not adequately meet the demands of the target audience. The course could perhaps be better used for postgraduate students rather than professionals.

One comment refers to an inadequate bibliography. A few references and a bibliography have been given, but it does indeed seem poor. A more complete bibliography for any new course will be provided in the future.

2. Pedagogical activity proposed

The pedagogical approach was hybrid, being mostly online, though with a few physical activities (such as labs and workshops). Resources for this prototype programme are E-Learning platforms (*e.g.*, Moodle) and open-source software and tools. Participants suggest keeping that the materials were provided on-demand.

3. Overall presentation of the programme and organisation

The target group for this course was industry professionals, so mainly people that are already familiar with the subject. Most of the participants commented: "It is an opportunity for self-assessment and for the development or the improvement of skills."

According to the participants', the overall added value of the course, in terms of comprehension of the subject, support for further development, acquiring new skills, and improvement of intellectual and critical thinking skills can be improved. Since the subjects in this prototype programme are very broad, a more detailed and focused curriculum can be created by dividing these topics into sub-topics in the future.

Considering the relevant technologies identified for this course, greater collaboration with industry, perhaps addressing current challenges, would make the course more interesting.

The course makes mention of the EASA guidelines and the EC Ethical Guidelines. It may be expanded to incorporate a reflection exercise on the consequences of using AI in defence. In addition, participants felt that the training could be improved by incorporating more real-life case studies. In view of this comment, more real-life case studies will be considered in the future. In addition, it is stated that the course should have focused on AI applied to cybersecurity rather than general cybersecurity knowledge. More emphasis can be placed on AI elements by creating more detailed courses.

Industry experts could help improve the courses. It might be possible to add some specific challenges/cases from industrial participants. For closer interaction, teachers need to be more active and agile.

Improvement Summaries for EQF7 Programmes

In Table 4 below the reader can find the list of the summarized improvements suggested for the four prototype programmes implemented at the EQF7 Level

Table 4. Improvement Summary Chart at EQF7

7.1 -Artificial Intelligence Based Optimization in Aerospace Engineering	**Pedagogical activity proposed** – The course should focus more on implementation and on real-world applications. →Industry partners should share their experience by providing interesting examples and pointing out practical problems that may arise during the realization of real-world optimization tasks where students can apply the methods, theories, and techniques addressed during the lectures. **Overall presentation of the programme and organisation** – The course should be made longer as it includes only 15 class hours (45 minutes each) of lectures and 15 hours of workshops.
7.2 - Computer Methods in Aerospace Engineering	**Technical content** – Supplement with more defence-related issues, as it is currently mainly related to the aerospace sector. – The course should also be supplemented with additional elements, such as AI, Neural Networks, and Big Data analysis. – Maintain continuous contact with industrial partners to take into account the most current developments and trends. **Pedagogical content** – Place more emphasis on practical issues and the possibility for students to carry out more workshops during which simple tasks. – Improve teaching materials by: →Better adapting them to the implementation style of the course. →Making them more available. – Collaboration with industrial partners should be developed to strengthen the practical aspects of the course. – Educational materials should be improved to include modern and innovative teaching methods. – Interactions between course participants should also be improved through appropriate methods, (for example, creating online forums or other platforms for the exchange of information between course participants). **Pedagogical activity proposed** – Increase attractiveness of course through: →emphasizing discussions with course participants. →using practical-based lessons. →exploring the possibility of course-related visits to industrial partners. **Overall presentation of the programme and organisation** – Modify the scope area of the course towards broader coverage of defence areas. – Include defence-related skillsets such as social competencies: the impact of computer modelling in the defence sector; encryption/model security could be included in the course.

	– Participation of industrial partners crucial because of the constant need to take into account the current trends and requirements of the defence sector. – The level of the course and its attractiveness for participants can be improved by the use of modern methods and educational tools. – Due to the specificity of the discussed issues, and their topicality, there is a lack of sufficient educational literature. Therefore, educational materials prepared for students should be extensive and easily accessible, given the specificity of the discussion topics and issues. – Educational materials should also be continuously updated and improved.
7.6 - Remote sensing image analysis course	**Technical content** – Reduce the theoretical content and use a more descriptive approach. – Limiting topics like regulatory aspects, which students can research independently from open sources, will help reduce the length of the course. **Pedagogical content** – Include a more extensive bibliography in subsequent editions. **Pedagogical activity proposed** – Spanish will be used in an on-site implementation of the programme in order to address issues with participants' level of English. – Evaluation/assessment of performance should be carried out in subsequent courses. – The course is too long and should be shortened in the future. – Improve the description and the target audience by: →reducing the mathematical content in order to scale down the background requirements. →more clearly explain the background requirements during the dissemination phase.
7.7 - AI for defence	**Technical content** – Improve the content level, which is considered too low for the target group participating, by providing detailed lessons in more problem-specific subtitles. – Ensure consistency between the course level and the target group's expectations and skill level through: → better industry involvement. →a clear connection to defence application. – Course content is high-level and can be further improved by providing concrete details and methods. – Course description can be improved by specifying more details about the sub-topics. **Pedagogical content** – To improve the practical components of the course, collaboration with industrial partners should be encouraged, (for example through the development of online forums or other venues for the sharing of information amongst course participants). – Interactions between participants should also be improved. – The course did not adequately address the demands of the intended audience and thus should be altered to better suit the demands of the professional target group, though: → For example, evaluating the prerequisites for enrolling. →Gearing the course towards graduate students rather than towards professionals. →Including a more extensive bibliography in future courses.

	Overall presentation of the programme and organisation – Given the broad nature of the subjects in this programme, dividing these topics into sub-titles will create a more detailed and focused curriculum in the future. – The course could be rendered more interesting though more collaboration with the industry and by addressing current challenges. – EASA guidelines and the EC Ethical Guidelines are mentioned during the course. It should perhaps be expanded to incorporate a reflection exercise on the consequences of using AI in defence. – The course should include more real-life study cases in the future. – As it has been stated that the course should have emphasized AI applied for cybersecurity rather than general knowledge about cybersecurity, emphasis should be put on AI by creating more detailed courses. – Industrial experts could help to improve the courses (perhaps through providing some specific challenges/cases). – To improve interaction with industrial experts, teachers need to be more active and adaptable.

Conclusion

R3.4 "Guidelines for Education & Training Programme Prototype" had for objective to reflect upon the lessons learned coming out of the first pilot of the three Education & Training Programmes Prototypes collected in R3.2, for EQF 4/5, EQF6, and EQF7. For the 15 courses implemented, various forms of feedback and commentary from internal and external evaluations provided concrete suggestions for improvement in the replication of these courses. Because of this, one of the most useful components of this report was the observation of commonalities across those suggested improvements.

Some of common suggestions for improvements in EQF 4/5 included: providing a more detailed bibliography, modifying both the title and the abstract of the course to more accurately reflect the main topics covered, increasing course duration, considering other targeted job profiles, and covering more industry standards during the course. For the two prototypes at the EQF6 level, the most common suggestions included providing more bibliographic references and more interaction between industry partners, course providers, and participants. Lastly, for the four EQF7 level courses, common suggestions included longer courses, more emphasis on real world and/or practical applications in the lessons, more participation from industrial partners in the courses, and a clearer connection between the courses and defence-application.

From the improvements observed in this report, subsequent reports such as R.3.7 "Technical Report of the Education and Training Programmes Implementation" and R3.8 "Recommendations for final review of Education and Training Programmes" will provide an overview of the second phase of course implementation, including replicated courses. These will provide substantial data regarding the development and evolution of the programmes designed and implemented over the course of the ASSETs+ project.

APPENDIX 1 – List of prototyped programmes implemented during the prototyping phase

EQF Level	Course provider	Prototype Programs
EQF4/5	AEROCAMPUS	4.3 - Types of technical reports
	AEROCAMPUS	4.4 - Circuit boards Processors Chips Electronic equipment
	AEROCAMPUS	4.5 - Unit of measurement and Errors
	MERCANTEC	4.6 - Analytical tools
	LTT	4.7 - Controlling operations of processes to solve problems
	LTT	4.8 - Records of maintenance and equipment documentation
	LTT	4.9 - Instructions into machine control units to start operation
	MERCANTEC	5.1 - Performance calculation
	MERCANTEC	5.2 - Programming
EQF6	UBX	6.1 Seasonal School - Machine Learning for Defence
	UPM/UNIPI/ LEONARDO	6.2 Defence Awareness - European Defence Challenge – Second Edition
EQF7	PRZ	7.1 -Artificial Intelligence Based Optimization in Aerospace Engineering
	PRZ	7.2 - Computer Methods in Aerospace Engineering
	UPM	7.6 - Data science for defence - remote sensing image analysis course
	AAU/UC3M	7.7 - AI for defence