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MILITARY AND U-SPACE: GUIDELINES

D2 – COST-BENEFIT ANALYSIS

31 May 2023

EUROPEAN DEFENCE AGENCY

Document information

GENERAL INFORMATION

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Version	V1.3
Reference	TLS/C4064/N21021

HISTORY OF CHANGES

Version	Date	Drafted by	Checked by	Changes
V0.1	01-Jun-2021	J. SCHOMANN S. BERNARD H. DREVILLON A. HOURCLATS	H. DREVILLON S. BERNARD A. GUILLAUME	Initial version
V0.2	02-Jun-2021	J. SCHOMANN H. DREVILLON	H. DREVILLON A. GUILLAUME	Version submitted for review by EDA and SCG
V1.0	24-Aug-2021	J. SCHOMANN S. BERNARD H. DREVILLON	H. DREVILLON S. BERNARD	Updates in response to comments received from the stakeholders on 01-Jul-2021.
V1.1	31-Aug-2021	J. SCHOMANN H. DREVILLON	H. DREVILLON	Correction
V1.1a	10-Sep-2021	H. DREVILLON	H. DREVILLON	Correction in Executive Summary
V1.2	12-Sep-2022	H. DREVILLON	H. DREVILLON	First update under SC2 – No change
V1.3	31-May-2023	T. FRANCOIS	H. DREVILLON	2nd update under SC2 – Costs and scenarios update (sections 1, 2, 3, 5, Annex A)

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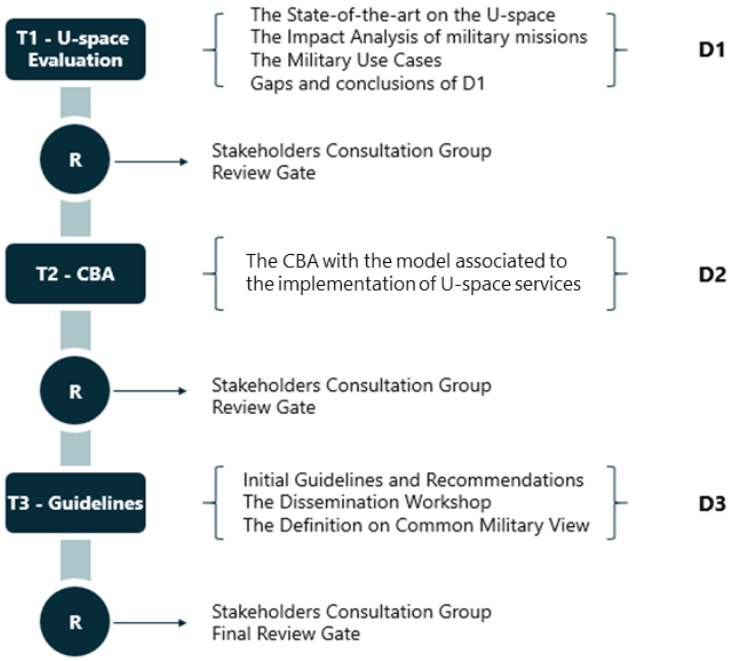
1.1 - Overview of the "Military and U-space: guidelines" study

The Military and U-space guidelines study consists of 3 tasks (T1, T2, T3) with their respective deliverables (D1, D2, D3) as depicted in the figure below:



THE TASK 1 (T1) – U-SPACE EVALUATION - The State-of-the-art section reviews the input material and provides necessary knowledge on current stage of U-space implementation including Military involvement. The Impact Analysis assesses the impact of typically military missions and operations by the U-space services and sets the basis for the D2. The Use Cases in section 4 show how the mandatory and most beneficial U-space services will affect Military missions and operations. Task 1 results in the identification of the U-space services with the highest potential for affecting Military missions and operations by the development of the U-space, and the description of this impact and a formal description of how the services are operated through Use Cases. The final Use Cases will be distributed to the SESAR projects – and national initiatives – testing the U-space implementation for validation.

THE TASK 2 (T2) – COST AND BENEFIT ANALYSIS (CBA) – T2 results in the identification of the costs and benefits mechanisms associated with the implementation of the U-space services retained in Task 1. Three implementation scenarios are being proposed and compared against the status quo, i.e. the baseline scenario. Despite the conceptual nature of U-space and limited understanding of the precise implementation requirements in each member state, the CBA considers the implementation-related capital and operating expenditure, including upgrades to military ATS systems and air assets, process reviews, staff related costs and other. As the U-space concept and requirements become clearer throughout the course of this study, and with further input from the individual project stakeholders, this CBA can be developed in greater detail.

THE TASK 3 (T3) – GUIDELINES concludes on the study by consolidating a Common Military View, representing the position of the EDA and its member states on the development of U-space services. The initial guidelines and recommendations developed for Military Stakeholders were based on the results of T1 and T2. A Dissemination Workshop was organised on 9 November 2021 to communicate the initial conclusions of D3 to EDA's Member States and to gather the Stakeholder's feedbacks for the final D3 version. The Definition of a Common Military View on the impact of the U-space development was the final D3 deliverable that includes the outcomes from this Dissemination Workshop.

1.2 - Establishing a framework for costing the impact of U-space on the military

In order to gain an initial understanding of the costs implied for the military, this CBA distinguishes between investment in ATM systems and data exchanges, aircraft equipment, process reviews, staff related costs and studies. While the precise implementation requirements for U-space are yet to be defined and the investment needs per member states are not fully understood, this CBA establishes a framework for costing the deployment and proposes a number of assumptions that enable the calculation of monetary values.

The outcome of the CBA is negative, yielding a net present value ranging from € -400k to € -850k for standard euros and from € -355k to € -743k in estimated 2023 euros for implementation scenario 1 (minimal military collaboration), from € -1.95 million to € -4.82 million in standard euros for U-space implementation scenario 2 (full military collaboration), and from € -2.25 million to € -6.02 million for U-space implementation scenario 3 (full military collaboration with conspicuity). It was assumed that the implementation of U-space will be concluded by 2028, leading to an annual capital expenditure between 2024 and 2028, followed by annual operating expenditure.

The resulting costs for individual member state can vary significantly and are not shown in detail in this analysis. However, based on the feedback from the project stakeholders it will be possible to gain a better understanding of the expected implementation efforts and costs, as well as the benefits of U-space.

This report provides a high-level overview of funding mechanisms at the European level, aimed at the development of technological and defence capabilities, civil-military collaboration, and the implementation of ATM capabilities.

2 - INTRODUCTION

This Cost-Benefit Analysis (CBA) considers the military costs and benefits associated with three different U-space deployment scenarios, namely a scenario in which (1) the military does not collaborate in the realisation of U-space (and only performs the bare minimum investment and adaptation of processes), (2) where the military actively collaborates to improve the benefits of civilian users mostly, (3) where the military collaborates to a wide extend with civilian stakeholders in U-space in order to maximise the benefits of U-space for civilian and military users alike.

The scenarios are referred to as U-space implementation scenarios 1, 2 and 3, respectively.

Each case is compared against a baseline scenario, consistent with the status quo and where no mandatory or voluntary measures have been taken by the military to adapt to the implementation of U-space.

It should be noted that the development of U-space in Europe is only at an early stage of implementation and there is only a limited agreement on the exact solutions that need to be implemented by the various stakeholders. As for the military stakeholders, it is understood that a combination of technical capabilities and modified processes for the exchange of U-space related information need to be established, should they plan to collaborate with civilian U-space stakeholders. As foreseen in regulations IR 2019/947 and IR 2021/664, at the very least, military stakeholders are expected to contribute to the definition of UAS geographical zones and U-space airspace with the competent authority of their member state. While the specific requirements may vary between member states or the respective ATS units and U-space service providers involved, this CBA initially outlines a set of measures that need to be undertaken to support the implementation of scenario 1, 2 or 3.

It should be noted that the U-space implementation generates costs for the military authorities involved; however, no significant monetary benefits could be identified in the course of this CBA. As a result, this CBA at the current stage of analysis assesses mostly the implementation costs, discussing the net present value of the required capital expenditure and potential depreciation patterns. Consequently, the outcome of the CBA is negative.

By engaging with the project stakeholders at European level and with the member states, it is hoped to gain a better understanding of the costs involved and potential monetary benefits that may affect individual military organisations.

2.1 - Definition of the framework and scenarios

The following paragraphs describe the functional requirements for the military which derive from each U-space implementation scenario. Costs and benefits are based on generalised assumptions and may vary between member states or between military units. Further detail in relation to the implementation costs can be found in Annex A.

2.1.1 - Framework definition of the CBA

This CBA relies on a number of assumptions about the timeline over which costs and benefits are incurred, the depreciation period for different types of assets, funding mechanisms, costs of capital and other. Given that the parameters of the design and implementation of U-space are yet to be defined, this CBA takes a simplified approach by proposing assumptions that are consistent with comparable cost assessments in the context of military and civilian projects related to the Single European Sky and other ATM investments. Based on the progress made in U-space implementation, these assumptions will be revisited at different times in the study (i.e., in the regular updates planned over the 2022-2024 timeframe). This will allow confirming the present assumptions or defining new ones.

Also, the complexity of implementations and costs of the required investments are likely to vary substantially between member states. This conceptual CBA therefore applies simplified assumptions which only distinguish

between small, medium and large member states[1], making a set of assumptions for each category. Following discussions with the stakeholders, these assumptions can be replaced with specific input for each member state, if available.

Bearing in mind the complexity of the current military landscape in Europe, generalised assumptions were also made in relation to the mission requirements (consistent with the use cases presented in report D1). It is understood that these requirements may in reality differ between member states

2.1.1.1 - Project timeline

Based on the deployment sequence associated to regulation 2021/664 on the implementation of U-space, the Acceptable Means of Compliance (AMC) and Guidance Material (GM) on the five basic U-space services – Common Information Service, Network identification service, Geo-awareness service, UAS flight authorisation service and Traffic information service – have been published in December 2022. The latest Terms of Reference of EASA's Rulemaking Task in charge of developing the regulatory framework for drone operations foresees to complete its work by the end of 2025 (with the AMC and GM for drone operations in the 'certified' category). Tentatively, a timeline for the completion of all military investments by 2028 was chosen. This CBA works on the assumption that the related military investments under scenarios 1, 2 and 3, respectively, need to be completed by the end of 2028; however, later investments by the military that are not foreseen in the scope of this study may be required. Further, the earliest date for any investment, studies or new processes that command financial costs is January 2024.

It is therefore assumed that U-space related investment takes place over a five-year period from January 2024 until December 2028.

2.1.1.2 - Investment funding, cost of capital and discount rate

At the time that this CBA is prepared, different funding options for U-space related investments are being considered, including funding through government budgets, as well as grants from governments and European programs. Given that militaries are part of (central) government, it is therefore proposed that the same cost of capital and discount rates as for other government projects is considered in the CBA. In the context of the member states of the EDA, these parameters are expected to resemble those of the euro currency area.

Pending validation and refinement with the project stakeholders, the cost of capital for the militaries is assumed to be 4%, i.e. 2.5% for Time Value of Money (TVM) plus a 1.5% Premium Risk. The inflation rate is estimated at 5% for 2023 and 2% for the following years. The resulting discount rate would be 9% (TVM plus Premium Risk plus inflation) for 2023 and then 6% for the next years.

2.1.1.3 - Depreciation periods

The depreciation period for military ATM and CIT assets and on-board equipment related to the implementation of U-space relies on general assumptions, consistent with comparable investments in ATM and other projects across Europe.

The depreciation period for ATM assets is therefore proposed to be 10 years; 7 years for CIT equipment; 10 years for on-board equipment; and 5 years for all other related studies and efforts.

It is understood that these values may differ significantly depending on the common practice of each member state, as well as the condition and stage in the life cycle of the existing assets involved.

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[1] The distinction between member states should ideally be based on the complexity of the future, still-to-be-defined, U-space structure that partly will drive the cost of U-space related investment for military and civilian stakeholders. As an approximation of the military complexity involved, it is suggested to consider the number of ATS units that need to be linked to CISP/USSPs.

2.1.1.4 - Incremental operating expenditure and replacement expenditure

In terms of operating expenditure, it is assumed that no additional staff are required as the additional tasks and workload for military actors to interact with U-space will remain limited in the timeframe considered within this CBA as it was estimated that these new activities will be a complement for current military ATM activities. However, initial and recurrent training costs will be applicable for current staff to address the new systems and potential workload. The impact on staff workload will differ by member state, depending on current staffing level and workload organisation. There are no additional maintenance costs from the implementation of U-space; also no replacement expenditure (REPEX) is assumed. The reason for this assumption is that the modifications/additions in equipment, ATM hardware and software are relatively small and will not substantially increase OPEX/maintenance compared to the baseline case. There is however a cost for drawing up the new processes.

2.1.1.5 - Cost-benefit by state

The CBA is based on the estimated deployment costs and economic benefits (where applicable) for each state. For this purpose, specific assumptions were made either for individual states (regarding the number of aircraft in operation) or by the size of each state (distinguishing between large, medium and small member states[2]).

In this release of the CBA, no results are presented at member state level given that most cost figures are based on assumptions (e.g. number of ATS units, workstations and military controllers affected, as well as very high-level cost estimates for implementations). It is suggested that these assumptions be validated and replaced with more detailed input from each member state in order to obtain more granular CBA output in a later version of this CBA.

2.1.2 - Costs

To facilitate the costing of the implementation, the measures were broken down into the categories equipment, procedures/processes and studies and risks assessments. Particularly those items which are reliant on human labour may be affected by differences in the average wage cost for military staff in each member state. While at this stage of the study all staff costs are treated as an average among member states, at a later stage of the CBA study local costs (or correction factors) should be taken into account. Likewise, it will be necessary to differentiate between the implementation costs for member states of different sizes, different volumes of envisaged U-space and the size of military fleets of helicopters and drones.

2.1.2.1 - Equipment

I. Ground-based data exchange capabilities (between military stakeholders and civilian Air Traffic Service (ATS) units and/or Common Information Services (CISP)/U-Space Service Providers (USSP));
II. Visualisation of U-space related information at Air Traffic Controller workstations, Tactical Controller workstations, Air Surveillance Operators workstations or for military operators of unmanned aircraft;
III. Conspicuity and data exchange capabilities on-board manned and unmanned military aircraft;
IV. Cyber security risk mitigation (update of security management framework, implementation of additional security controls, IT upgrades to enhance cyber security).

2.1.2.2 - Procedures/processes

I. Strategic and Pre-Tactical Airspace Management processes[3];
II. Coordination involving military ATS, military airspace users and CISP/USSP;
III. Initial and recurrent training.

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[2] *See footnote 1*

[3] *It is assumed that it will be in the scope of the national implementation to build up a civil-military coordination process, e.g. similar to Flexible Use of Airspace (FUA). However, this would be on the basis of a fast time data exchange rather than a traditional day by day FUA process.*

2.1.2.3 - Studies and risk assessments

Cyber security risks that were identified in the Impact Assessment Study (Deliverable D1) are not monetised in this CBA. The loss of life and aircraft resulting from accidents between military helicopters and drones resulting from a lack of collaboration between military and civilian U-space users are being monetised, though[4].

However, the corresponding mitigation measures are reflected as part of the costs for equipment and data exchange, as well as in their impact in terms of operational benefits.

2.1.3 - Benefits

The military benefits from U-space implementation can be broken down into:

I. Safety benefits
   a. Avoidance of conflict with civilian airspace users, either conflict between:
      - manned military aircraft/helicopters and civilian drones, or
      - military drones and civilian drones.
   b. Reduced loss of life and of military assets, e.g. loss or damage to military aircraft and other assets.

II. Operational benefits
   a. More efficient use of the physical U-space (i.e. a portion of the airspace where drone operators are mandated to use services provided by USSPs), e.g. where prior to the implementation of U-space a strict separation of military and civilian usage would be required, U-space implementation would lead to an enhanced awareness and expedited dynamic reconfiguration of airspace;
   b. Improved availability of the U-space system (the whole ecosystem consisting of systems, procedures, actors, etc.);

III. Financial benefits
   a. The potential for the military to benefit from the civilian use of U-space, for example by outsourcing civilian drone-based services like maintenance, surveillance or surveys.

The operational benefits for the military which were identified in the Impact Assessment Study are considered marginal and are not monetised in this CBA. The approach described under financial benefits may be novel to most militaries and have not been quantified at present.

2.2 - Baseline scenario

The baseline scenario corresponds to the current arrangements related to drone operations and U-space, meaning that no implementations and investments are required from the military whatsoever. There are no costs and benefits for the military that derive from the baseline scenario.

Under this scenario, the responsibility of segregating drone traffic from military air traffic and preventing drone/military aircraft collisions would fall on the drone operators and USSPs.

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[4] While in this study, the loss of life was quantified in the context of civilian programmes such as SESAR, it is common practice not to monetise the costs from safety and security related accidents and incidences (e.g., loss of hull, damage to ground infrastructure, etc.) due to their very low rate of occurrence. Insurance costs ought to be considered for commercial organisations, but are likely to be not applicable in a military context.

2.3 - Implementation scenarios

The implementation scenarios correspond to the requirements of regulation 2021/664, which mandates the deployment of 5 services in U-space airspaces:

- Common Information Service, an enabler for the provision of other U-space services;
- Network identification service;
- Geo-awareness service;
- UAS flight authorisation service;
- Traffic information service.

This CBA distinguishes between implementation scenarios 1, 2 and 3, whereby:

- scenario 1 assumes that the military offers only a minimum degree of collaboration in the implementation of U-space,
- scenario 2 assumes that the military does collaborate in the same way as civilian ANSPs, through the exchange of data and the implementation of the Dynamic Airspace Reconfiguration process for airspace management, and
- scenario 3 assumes that, in addition to providing data to U-space, the military makes their unmanned aircraft and helicopters conspicuous to USSPs when operating in U-space airspace. Below, all 3 scenarios are explained in greater detail.

2.3.1 - Implementation scenario 1 ("minimal military collaboration")

Under implementation scenario 1, it is assumed that the military offers only an absolute minimum degree of collaboration with the implementation of U-space. This collaboration is limited to the strategic and pre-tactical management of airspace (including the issuance of AIP or NOTAM for very low level (VLL) airspace), meaning that the military has otherwise limited involvement in the day-to-day (tactical) operation of U-space.[5]

In this implementation scenario, reflecting a minimal degree of military collaboration, no costs for the implementation of means of conspicuity are accounted for. The military will not experience any operational benefits.

The only capital expenditure that the military incurs under implementation scenario 1 corresponds to the review and implementation of internal strategic and pre-tactical airspace management processes for the very low-level airspace. It is expected that a study will be conducted, followed by the implementation of revised processes by means of staff training and an update of training materials and manuals. Furthermore, there will be an operating expenditure corresponding to strategic/pre-tactical airspace management staff.

In this scenario no costs for the implementation of means of conspicuity are included.

2.3.2 - Implementation scenario 2 ("military does collaborate")

In this scenario it is assumed that the militaries of the member states do actively collaborate in the implementation of U-space, therefore requiring investment into ATM hardware and software to facilitate the exchange and visualisation of U-space related information, as well as modified communications and operational process within the organisation and towards CISP/USSP.

Furthermore, the military contribute to the implementation of the Dynamic Airspace Reconfiguration (DAR) process in controlled airspace and provide USSP's traffic data.

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[5] *This is subject to the actual structure that member states will put in place to manage their airspace once U-space airspaces are implemented and noting this process is currently starting.*

2.3.3 - Implementation scenario 3 ("military does collaborate, with conspicuity")

This scenario is similar to scenario 2 except that unmanned aircraft must make themselves conspicuous to the USSP (if their mission allows it), therefore possibly requiring new equipment or other means of conspicuity while manned aircraft are not equipped with additional avionics.

2.3.4 - Breakdown of implementation requirements and costing

The required capabilities referred to above were identified on the basis of use cases and their related communication processes, and information exchanges that involved the military and were affected by a U-space implementation. These were then broken down by the type of impact and cost driver:

- **Financial costs** to upgrade systems, or to develop new ones, in order to connect with the USSP, process the information received through the service and share their information with the USSP;
- Review and update of **processes**;
- **Studies** (strategic, technical, economic, safety, cyber security) to identify the required investments and process adjustments within the military organisation;
- **Training** of ATCOs, Tactical Controllers, ASO and Drone operators to use the U-space services and **adaptation of the Safety Management System**.

The following paragraphs describe the implementation requirements for each use case[6].

2.3.4.1 - Strategic/pre-tactical airspace management

For the coordination of strategic/pre-tactical airspace management, the military needs the ability and processes to receive and take into consideration airspace constraints prior to drone flights.

I. The regulator, National Air Operation Centre (Command and Control) and Squadron Planning Operation Cell feed information into the National Airspace Management Cell.

   This requires the modification of communication and processes, plus the adaptation of initial and recurrent training for staff involved.

   In the CBA, the definition and implementation of the processes, training materials, manuals and initial training can be costed.

II. The information is propagated to military ATS units (incl. APP and TWR) and to the CISP/USSP.

   The information flow is unidirectional, with no requirement for the military to implement modifications at the workstation. Since no integration of IT infrastructures is implied, there is no additional cyber-security risk.

   This requires the adaptation of communication and processes, plus the adaptation of initial and recurrent training for staff involved.

   In the CBA, the definition and implementation of the processes, training materials, manuals and initial training can be monetised.

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[6] The implementation requirements correspond to the use cases described in report D1 where assumptions are described in a more detailed manner, i.e. UC1.1, UC1.2, UC1.3 and UC2.

2.3.4.2 - Tactical airspace management

For the coordination of tactical airspace management, the military requires the following capabilities:

I. The military ATS unit needs to communicate directly with CISPs/USSPs.

No modifications are required to ATS workstations; however, the specifications of the data exchange need to be defined and implemented. In the civilian context, the data exchange would be characterised as follows:

a. The establishment of a service level agreement (SLA) defining the quality of information and the exchange model used.

b. According to regulation IR 2021/664, the data exchange model shall:
   i. be in digital format;
   ii. describe the data features, properties, attributes, data types, and associations;
   iii. include data constraints and validation rules;
   iv. apply a standard data encoding format;
   v. provide an extension mechanism to extend the properties of existing features or to add new features.

c. Use of a recognised encryption method, and

d. Use of a common secure interoperable open communication protocol.

Cyber security risks need to be assessed and potentially mitigated.

The adaptation of communication and processes is required, plus the adaptation of initial and recurrent training for staff involved.

In the CBA, the establishment of the data exchange capabilities, processes, related assessments, initial training can be costed.

2.3.4.3 - Dynamic airspace reconfiguration

The capability to provide dynamic airspace reconfiguration generates the following requirement:

I. The military ATS communicates directly with the CISP/USSP. The implementation requirements are identical with those presented under 0(I).

2.3.4.4 - Production of recognised air picture function

The provision of this function generates the following requirements:

I. The CISP/USSP communicates with military ATS and Control and Reporting Centres (CRC).

The information from CISPs/USSPs needs to be received and presented to military Air Surveillance Operators (data exchange and integration with workstation).

This requires the adaptation of communication and procedures, plus the adaptation of initial and recurrent training for staff involved.

Cyber-security risks need to be assessed and mitigated.

All the above can be costed for the purpose of the CBA.

II. In non-segregated airspace (i.e. airspace that is not exclusive to the military), military users (manned and unmanned) need to make their position visible to CISP/USSP to improve their own flight safety. No decision has been taken and no requirement has been defined regarding what information the USSPs will require and how it shall be transmitted. For the purpose of this CBA, it is assumed that a mix of different means of conspicuity will be used, including on-board equipment as well as more cost-efficient ground-based technologies. This assumption can be refined in the future, when the equipment required to communicate with the CISPs/USSPs is defined in acceptable means of compliance supporting regulation IR 2021/664.

On-board equipment is costed in the CBA, comparing to the cost of ADS-B on-board civilian aircraft, including the cost for the purchase, installation and certification of the equipment. In order to reflect the potential savings that can be achieved with alternative and more cost-efficient technologies, a cost reduction of -50% was applied to this estimate.

In a later iteration of this CBA, a refined assumption could be made about the roll-out of on-board equipment, considering aircraft that are about to be phased out may not need to be fitted with U-space compatible equipment. The number of aircraft within the scope of this study (i.e., military helicopters and drones) has been estimated using information from EDA and extracted from the CODABA database[7].

2.3.4.5 - Traffic Information of unmanned activities

The provision of traffic information to inform about unmanned activities, for the benefit of manned military and civilian airspace users generates the following requirements:

I. The CISP/USSP communicates to military ATS Units (incl. APP and TWR) and Military Controlling Units.

   The requirements and costs are identical with those presented under 2.3.4.4 - (I).

II. Military ATS Units/Military Controlling Units, incl. APP and TWR, and civilian ANSP propagates information of unmanned military airspace users within the U-space to manned military and civilian airspace users, respectively.

   No additional process or implementation is required.

2.3.4.6 - Traffic Information of manned activities

The provision of traffic information to inform about any manned activities, for the benefit of military and civilian drone operators generates the following requirements:

I. The CISP/USSP communicates to military ATS, incl. APP and TWR.

   The requirements and costs are identical with those presented under 2.3.4.4 - (I).

II. The CISP/USSP propagates information of manned military airspace users within the U-space to military and civilian drone operators.

   Should the military wish to operate under the control of the CISP/USSP, military drone operators would need to be capable of receiving and visualising the relevant information.

   The adaptation of communication and processes is required, plus the adaptation of initial and recurrent training for staff involved.

   In the CBA, the establishment of the data exchange capabilities, processes, related assessments, initial training can be costed.

[7] *https://eda.europa.eu/publications-and-data/latest-publications/factsheet-collaborative-database-(codaba)*

2.3.4.7 - Summary of implementation requirements

In summary, the following implementation requirements can be costed in the CBA:

SCENARIO 1

Category	Description	Stakeholders
Processes	Strategic/pre-tactical airspace management coordination	Regulator, National Air Operation Centre (Command and Control), Squadron Planning Operation Cell, National Airspace Management Cell
Studies	U-space study by member states' military organisations (strategic, technical, economic, cyber security)	Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators

TABLE 1: OVERVIEW OF IMPLEMENTATION REQUIREMENTS FOR SCENARIO 1

SCENARIO 2

Category	Description	Stakeholders
IT implementations	Data exchange ATS to CISP/USSP	IT department, ATS units
IT implementations	Data exchange CISP/USSP to ATS	IT department, ATS units
IT implementations	Visualisation of data CISP/USSP to ATS	IT department, ATS units
IT implementations	Mitigation of cyber security risks	IT department, ATS units
Processes	Strategic/pre-tactical airspace management coordination	Regulator, National Air Operation Centre (Command and Control), Squadron Planning Operation Cell, National Airspace Management Cell
Processes	Propagation of strategic/pre-tactical information to military ATS	Strategic/pre-tactical planning, Tactical planning, ATS units
Processes	Military ATS unit communicates to CISP/USSP (data exchange)	Military ATS
Processes	Military ATS receive information from CISP/USSP	Military ATS
Processes	Strategic/pre-tactical airspace management	Regulator, National Air Operation Centre (Command and Control), Squadron Planning Operation Cell, National Airspace Management Cell
Processes	Tactical coordination staff	Military ATS
Studies	U-space study by member states' military organisations (strategic, technical, economic, cyber security)	Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators

Category	Description	Stakeholders
Training	Update of training syllabus	Training department, Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators
Training	Initial training	Training department, Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators
Documentation	Update of training materials and manuals	Training department, Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators

TABLE 2: OVERVIEW OF IMPLEMENTATION REQUIREMENTS FOR SCENARIO 2

SCENARIO 3

Category	Description	Stakeholders
IT implementations	Data exchange ATS to CISP/USSP	IT department, ATS units
IT implementations	Data exchange CISP/USSP to ATS	IT department, ATS units
IT implementations	Visualisation of data CISP/USSP to ATS	IT department, ATS units
IT implementations	Mitigation of cyber security risks	IT department, ATS units
Aircraft implementations	On-board transmitters for helicopters, incl. related airworthiness process	Rotorcraft engineering and maintenance
Aircraft implementations	On-board transmitters for drones, incl. related airworthiness process	Drone engineering and maintenance
Aircraft implementations	Visualisation of data CISP/USSP to drone operators, incl. related airworthiness process	Drone engineering and maintenance
Processes	Strategic/pre-tactical airspace management coordination	Regulator, National Air Operation Centre (Command and Control), Squadron Planning Operation Cell, National Airspace Management Cell
Processes	Propagation of strategic/pre-tactical information to military ATS	Strategic/pre-tactical planning, Tactical planning, ATS units
Processes	Military ATS unit communicates to CISP/USSP (data exchange)	Military ATS
Processes	Military ATS receive information from CISP/USSP	Military ATS

Category	Description	Stakeholders
Processes	Strategic/pre-tactical airspace management	Regulator, National Air Operation Centre (Command and Control), Squadron Planning Operation Cell, National Airspace Management Cell
Processes	Tactical coordination staff	Military ATS
Studies	U-space study by member states' military organisations (strategic, technical, economic, cyber security)	Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators
Training	Update of training syllabus	Training department, Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators
Training	Initial training	Training department, Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators
Documentation	Update of training materials and manuals	Training department, Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators

TABLE 3: OVERVIEW OF IMPLEMENTATION REQUIREMENTS FOR SCENARIO 3

3 - CBA RESULTS

Considering the implementation requirements identified above, all items have been costed for each scenario. All costs are expressed both in standard euros (i.e. not taking into account inflation, time value of money and premium risks) and 2023 euros and based on the assumptions described in Annex A, reflecting the total expenditure for all EDA member states segregated by the size of their ATS.

It needs to be noted, that at this stage of the study only safety benefits have been monetised, but no operational benefits could be identified and quantified, meaning that the CBA is mostly limited to the analysis of the proposed capital expenditure schedule and depreciation costs. Other potential benefits that were not measured include potential non-military missions in U-space, such as maintenance and surveillance of infrastructures. By conducting such missions in accordance with the rules of civilian U-space operations and potentially outsourcing activities or sub-tasks (e.g., provision of civilian drones, operation, maintenance, pilot training, etc.), militaries could benefit from cost-efficiencies similar to the ones achieved from outsourcing civilian assets and services (e.g., car fleets, real estate, troop charter flights and other).

The outcome of the CBA is negative, yielding a net present value ranging from € -400k to € -850k in standard euros for implementation scenario 1 (minimal military collaboration), from € -2.52 million to € -5.84 million in standard euros for U-space implementation scenario 2 (full military collaboration), and from € -4.10 million to € -50.69 million for U-space implementation scenario 3 (full military collaboration with conspicuity).

In estimated 2023 euros, the CBA outcome ranges from € -354k to € -741k for implementation scenario 1, from € -2.07 million to € -4.73 million for implementation scenario 2 and from € -3.32 million to € -40.24 million for implementation scenario 3.

By considering the depreciation period and extending the investment period to 10 years (from 2025 to 2034), the CBA outcome range from € -1.86 million to € -4.21 million for implementation scenario 2 and from € -2.86 million to € -32.60 million for implementation scenario 3 (estimated 2023 euros).

MS size	CAPEX	CAPEX (2023 €)	CAPEX (depreciated and 2023 €)
Small	€ 400k	€ 353k	-
Medium	€ 500k	€ 433k	-
Large	€ 850k	€ 741k	-

TABLE 4: CAPEX FOR SCENARIO 1

MS size	CAPEX	CAPEX (2023 €)	CAPEX (depreciated and 2023 €)
Small	€ 2.52 million	€ 2.07 million	€ 1.86 million
Medium	€ 3.85 million	€ 3.12 million	€ 2.96 million
Large	€ 5.84 million	€ 4.73 million	€ 4.21 million

TABLE 5: CAPEX FOR SCENARIO 2

MS size	CAPEX	CAPEX (2023 €)	CAPEX (depreciated and 2023 €)
Small	€ 4.10 million	€ 3.32 million	€ 2.86 million
Medium	€ 11.51 million	€ 9.19 million	€ 8.10 million
Large	€ 50.69 million	€ 40.24 million	€ 32.60 million

TABLE 6: CAPEX FOR SCENARIO 3

3.1 - Overview

The capital expenditure phase for military investments related to U-space is assumed to extend from 2024 to 2028, whereby the costs in the first year correspond to studies and process re-design, followed in the subsequent years by training and documentation, as well as substantial investment in IT (for scenarios 2 and 3) and on-board equipment (for scenario 3 only).

For a small-sized member state, the capital expenditure in 2024 is € 300k (scenario 1), € 600k (scenarios 2 and 3), respectively, followed by € 25k (scenario 1), € 480k (scenario 2) and € 875k (scenario 3) annually from 2025 to 2028.

For a medium-sized member state, the capital expenditure in 2024 are € 300k (scenario 1) and € 600k (scenarios 2 and 3), respectively, followed by € 50k (scenario 1), € 812.5k (scenario 2) and € 2.73 million (scenario 3) annually from 2025 to 2028.

For a large-sized member state, the capital expenditure in 2024 are € 550k (scenario 1) and € 850k (scenarios 2 and 3), respectively, followed by € 75k (scenario 1), € 1.25 million (scenario 2) and € 12.46 million (scenario 3) annually from 2025 to 2028.

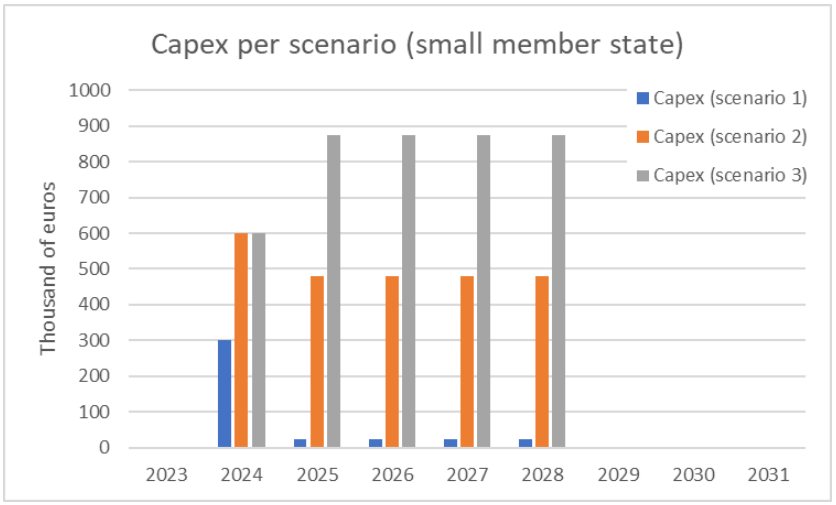

FIGURE 1: CAPEX PER SCENARIO FOR SMALL-SIZED MEMBER STATE

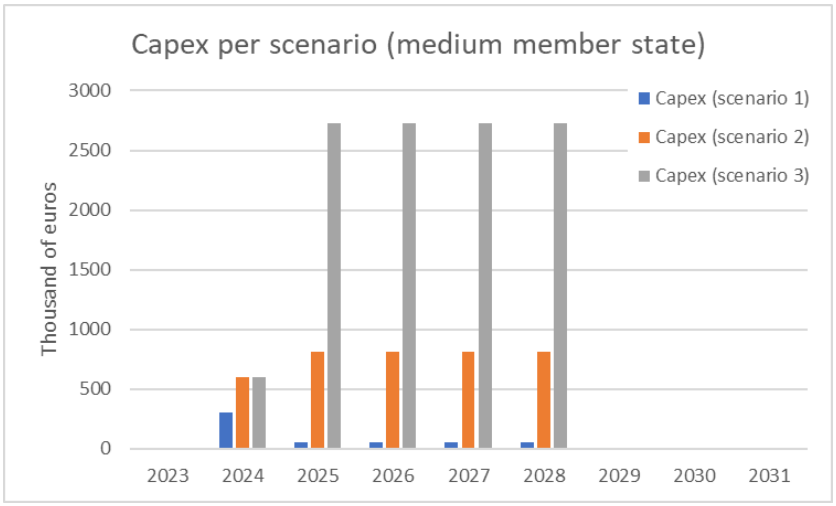

FIGURE 2: CAPEX PER SCENARIO FOR MEDIUM-SIZED MEMBER STATE

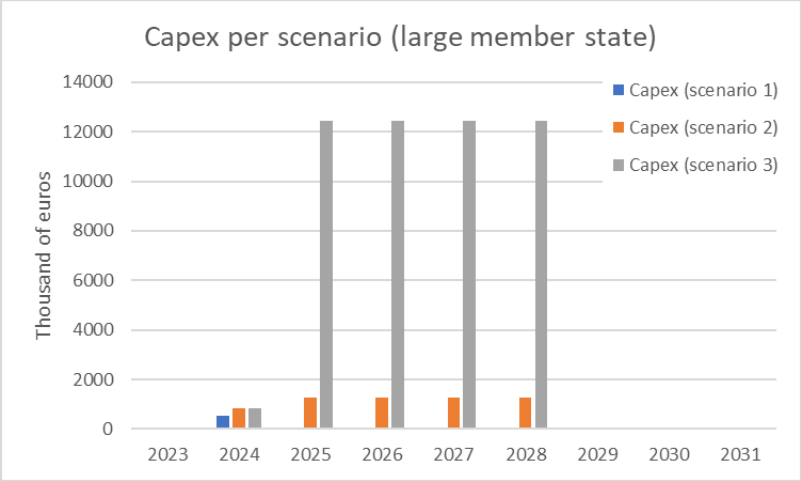

FIGURE 3: CAPEX PER SCENARIO FOR LARGE-SIZED MEMBER STATE

3.1.1 - Capital expenditure breakdown for scenario 1

A more detailed breakdown of the expenditure categories for scenario 1 shows that in the case where the militaries only commit to a minimal level of collaboration, the biggest single cost item would be to conduct initial studies to fully understand the ramifications of U-space implementation at national level (€ 250k for a small- or medium-sized member state, € 500k for a large-sized member state). This is necessary to ensure all safety critical and security related risks can be identified and mitigated. Furthermore, the processes involving the strategic and pre-tactical airspace management need to be revised and adjusted (€ 50k), followed by minor updates in the training syllabus and manuals for affected staff (€ 100k for a small-sized member state, € 200k for medium-sized, € 300k for large-sized).

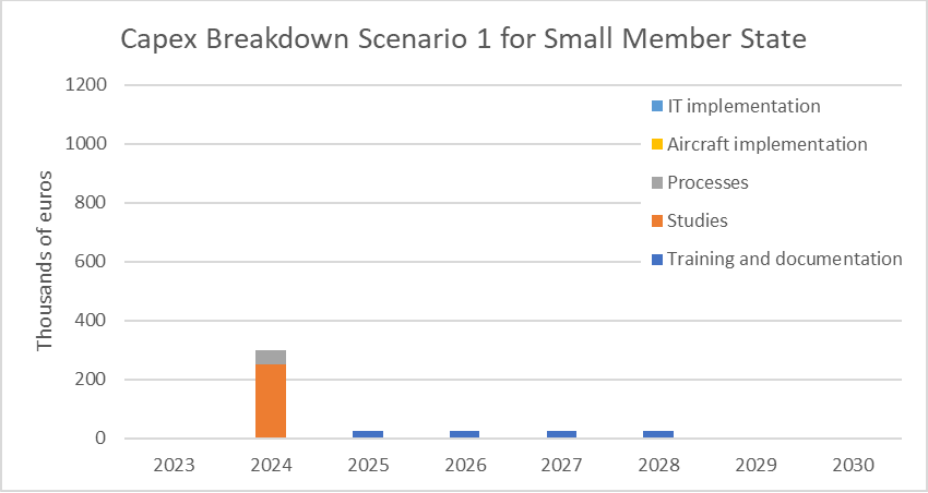

FIGURE 4: CAPEX BREAKDOWN IN SCENARIO 1 FOR SMALL-SIZED MEMBER STATE

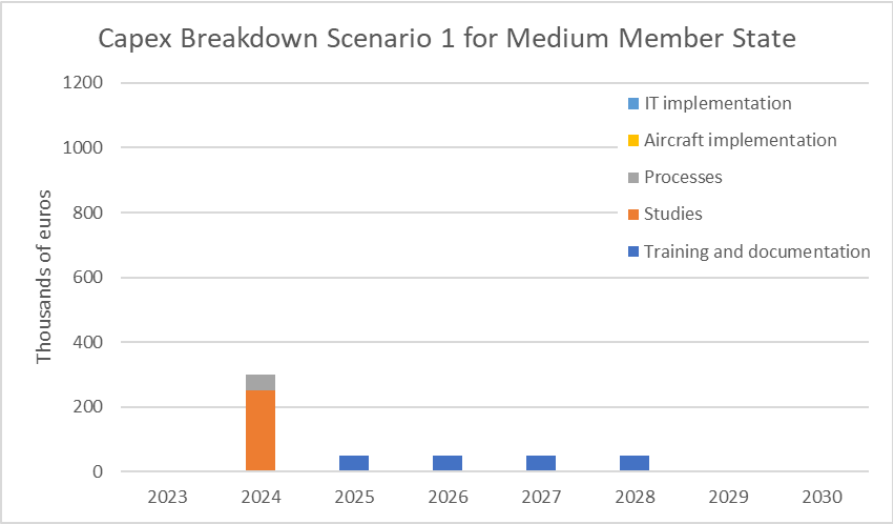

FIGURE 5: CAPEX BREAKDOWN IN SCENARIO 1 FOR MEDIUM-SIZED MEMBER STATE

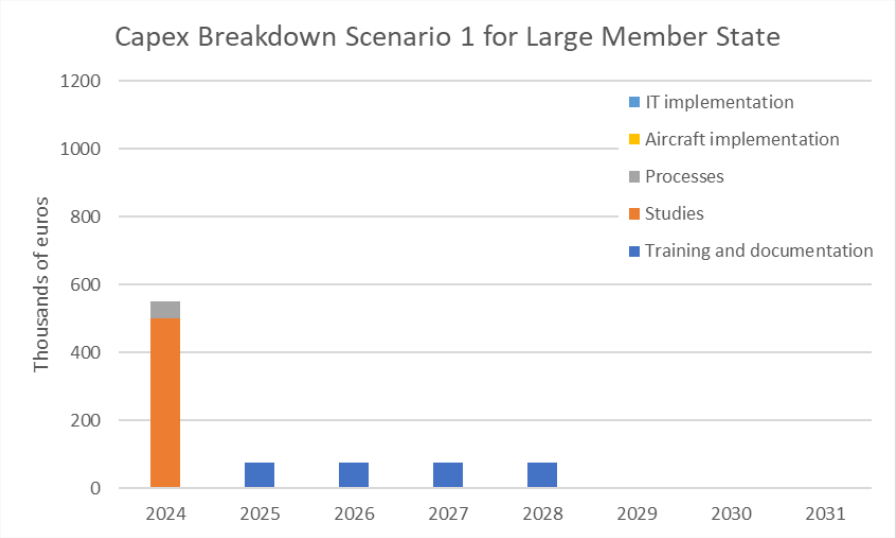

FIGURE 6: CAPEX BREAKDOWN IN SCENARIO 1 FOR LARGE-SIZED MEMBER STATE

The discounted capital expenditure for this scenario is € -354k for a small-sized member state, € -433k for a medium-sized and € -741k for a large-sized.

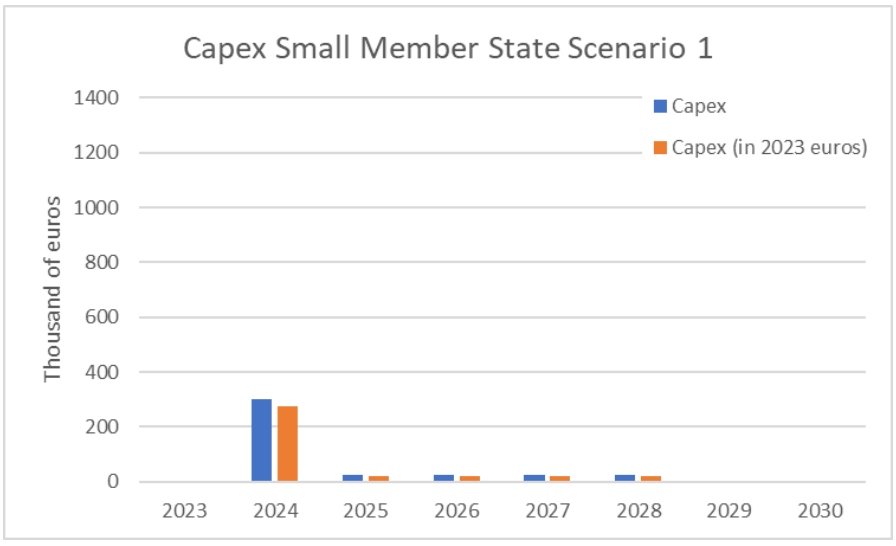

FIGURE 7: CAPEX IN 2023 EUROS FOR SMALL-SIZED MEMBER STATE SCENARIO 1

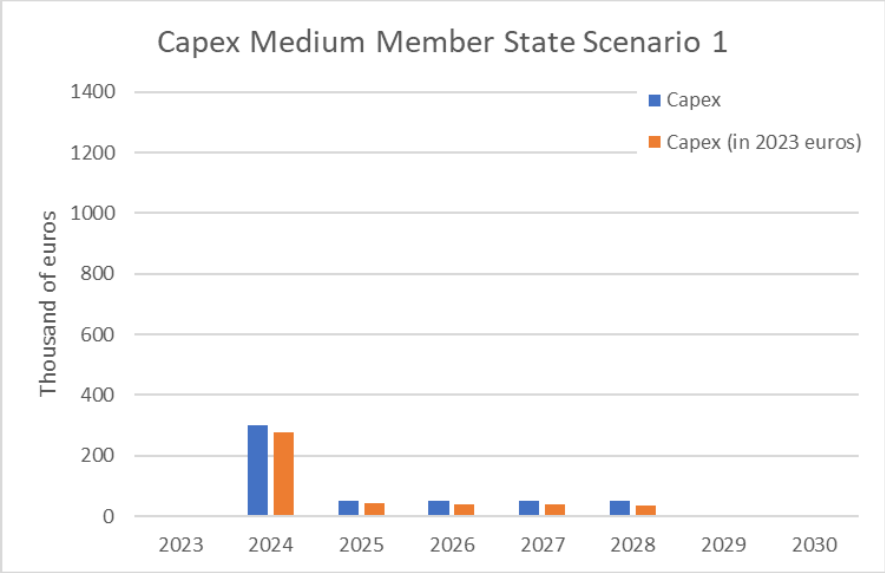

FIGURE 8: CAPEX IN 2023 EUROS FOR MEDIUM-SIZED MEMBER STATE SCENARIO 1

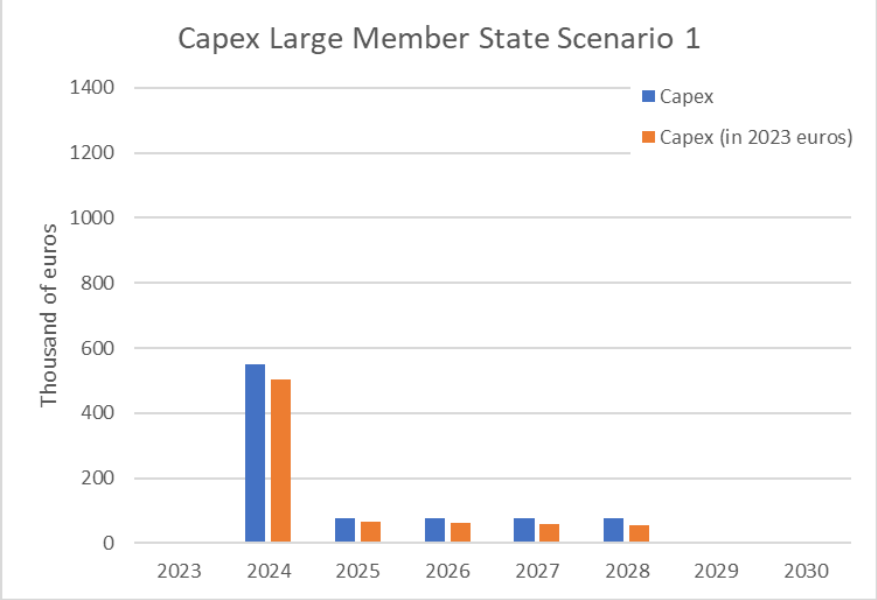

FIGURE 9: CAPEX IN 2023 EUROS FOR LARGE-SIZED MEMBER STATE SCENARIO 1

3.1.2 - Capital expenditure breakdown for scenario 2

For scenario 2, the costs for initial studies are assumed to be identical as in scenario 1 (€ 250k for a small- or medium-sized member state, € 500k for a large-sized member state); however, the efforts and costs related to the re-design of processes is bigger (€ 350k), given that the scope of U-space implementation in the collaborative scenario includes tactical activities.

Still, the main part of the implementation costs is incurred in the context of implementing data exchange (€ 1.72 million for a small-sized member state, € 2.95 million for medium-sized, € 4.59 million for large-sized). Training and documentation related activities are expected to continue throughout, generating a relatively small cost of € 200k for a small-sized member state, € 300k for medium-sized and € 400k for large-sized .

The non-discounted capital expenditure for this scenario is € -2.52 million for a small-sized member state, € -3.85 million for medium-sized and € -5.84 million for large-sized.

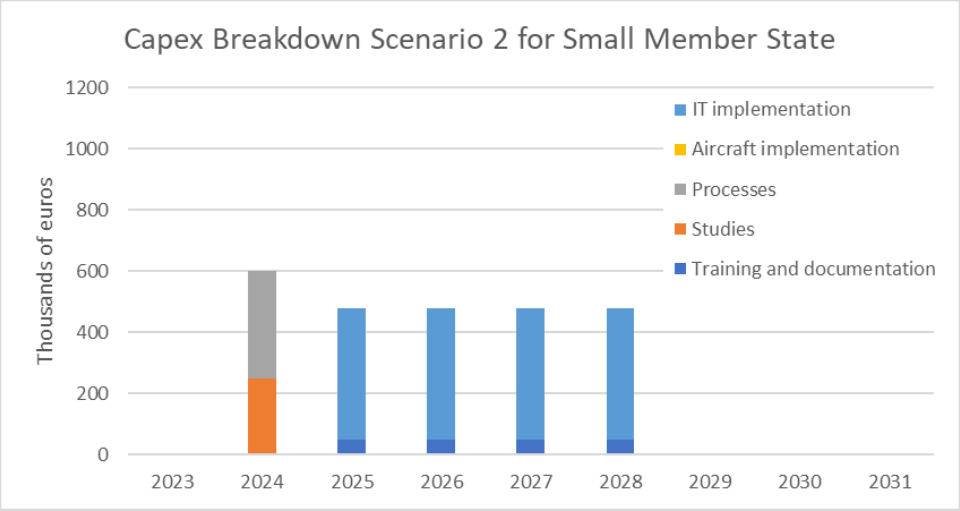

FIGURE 10: CAPEX BREAKDOWN IN SCENARIO 2 FOR SMALL-SIZED MEMBER STATE

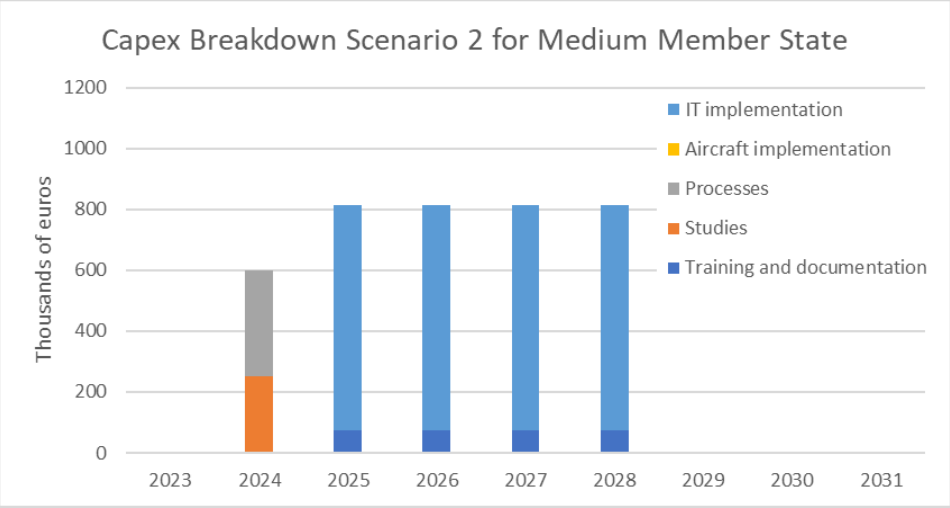

FIGURE 11: CAPEX BREAKDOWN IN SCENARIO 2 FOR MEDIUM-SIZED MEMBER STATE

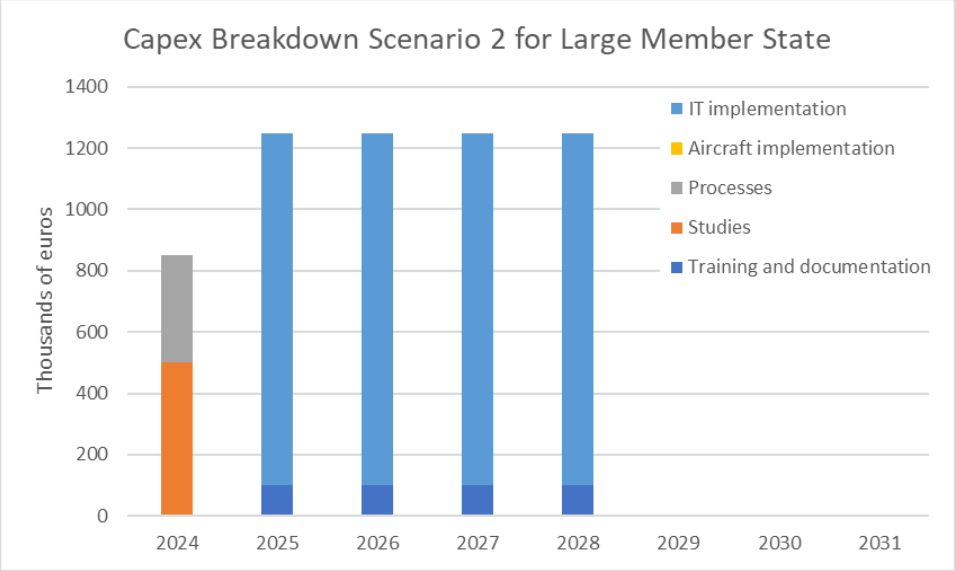

FIGURE 12: CAPEX BREAKDOWN IN SCENARIO 2 FOR LARGE-SIZED MEMBER STATE

The discounted capital expenditure for this scenario is € -2.07 million for a small-sized member state, € -3.12 million for medium-sized and € -4.73 million for large-sized.

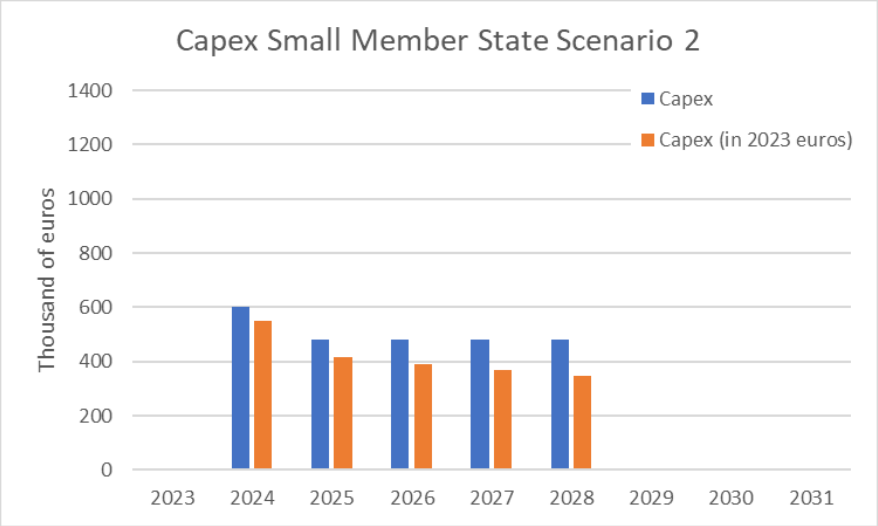

FIGURE 13: CAPEX IN 2023 EUROS FOR SMALL-SIZED MEMBER STATE SCENARIO 2

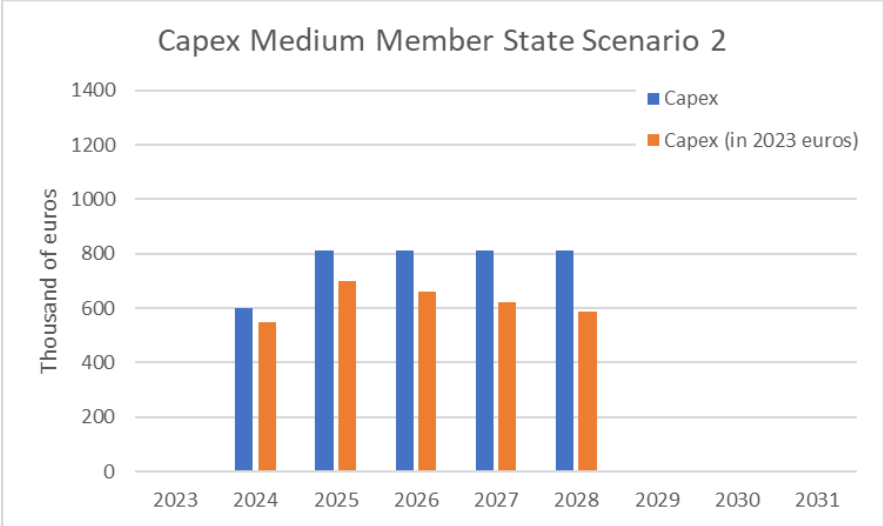

FIGURE 14: CAPEX IN 2023 EUROS FOR MEDIUM-SIZED MEMBER STATE SCENARIO 2

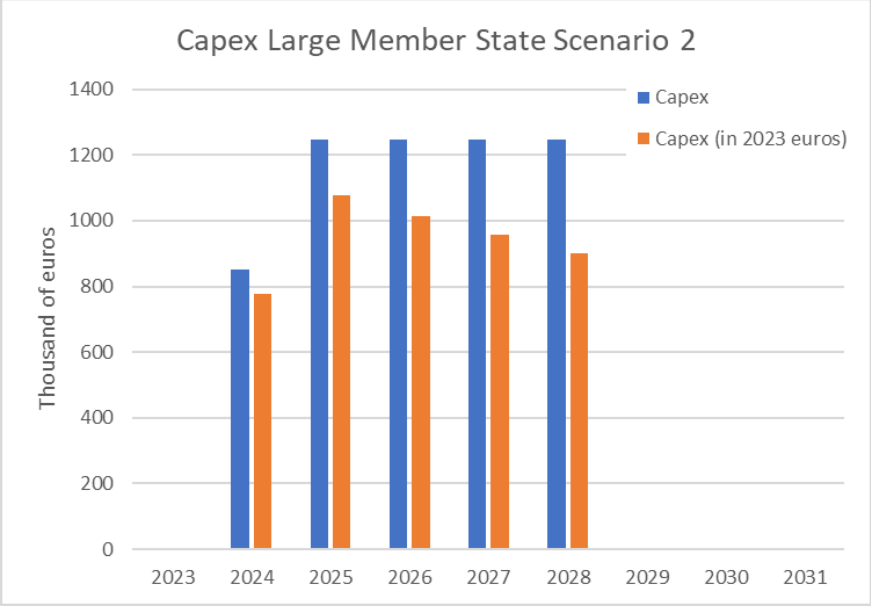

FIGURE 15: CAPEX IN 2023 EUROS FOR LARGE-SIZED MEMBER STATE SCENARIO 2

3.1.3 - Capital expenditure breakdown for scenario 3

For scenario 3, the costs for initial studies are assumed to be identical as in scenario 1 and 2 (€ 250k for a small- or medium-sized member state, € 500k for a large-sized member state) while the efforts and costs related to the re-design of processes is similar to scenario 2 (€ 350k), given that the scope of U-space implementation in the collaborative scenario includes tactical activities.

Still, the main part of the implementation costs is incurred in the context of Drone and Helicopters transmitters implementation (€ 1.58 million for a small-sized member state, € 7.66 million for medium-sized, € 44.85 million for large-sized) followed by data exchange systems implementation (€ 1.72 million for a small-sized member state, € 2.95 million for medium-sized, € 4.59 million for large-sized). Training and documentation related activities are expected to continue throughout, generating a relatively small cost of € 200k for a small-sized member state, € 300k for medium-sized and € 400k for large-sized.

The discounted capital expenditure for this scenario is € -3.32 million for a small-sized member state, € -9.19 million for medium-sized and € -40.24 million for large-sized.

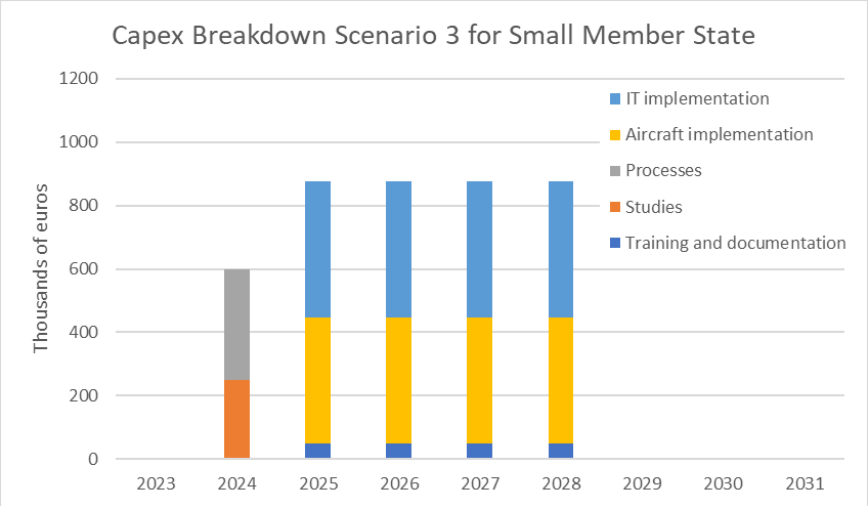

FIGURE 16: CAPEX BREAKDOWN IN SCENARIO 3 FOR SMALL-SIZED MEMBER STATE

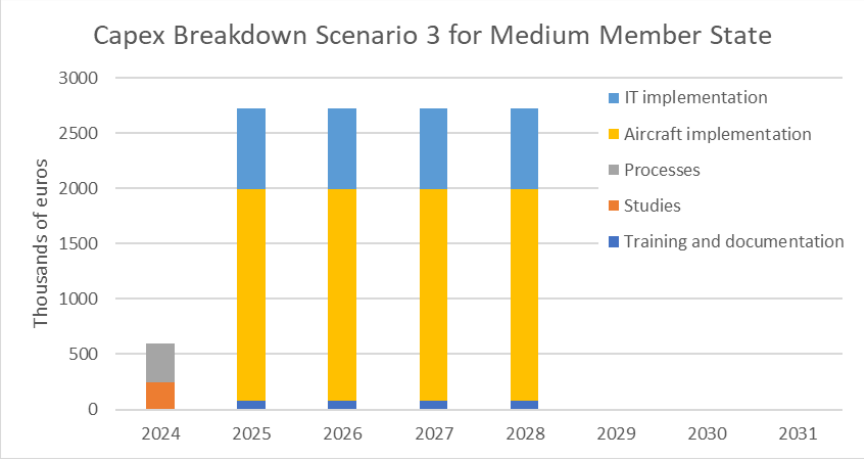

FIGURE 17: CAPEX BREAKDOWN IN SCENARIO 3 FOR MEDIUM-SIZED MEMBER STATE

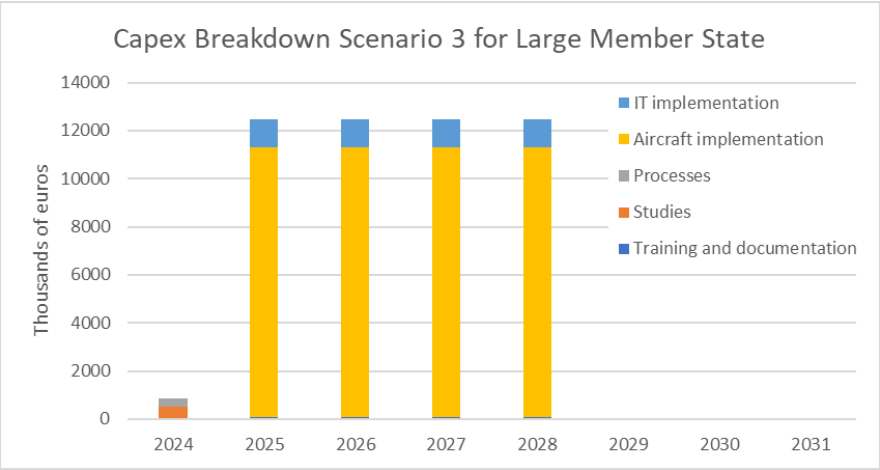

FIGURE 18: CAPEX BREAKDOWN IN SCENARIO 3 FOR LARGE-SIZED MEMBER STATE

The discounted capital expenditure for this scenario is € -2.86 million for a small-sized member state, € -8.10 million for medium-sized and € -32.60 million for large-sized.

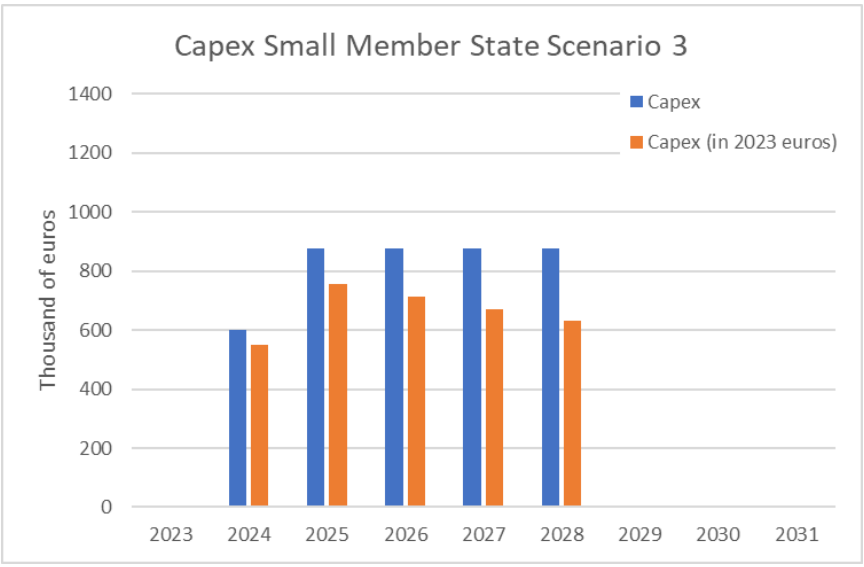

FIGURE 19: CAPEX IN 2023 EUROS FOR SMALL-SIZED MEMBER STATE SCENARIO 3

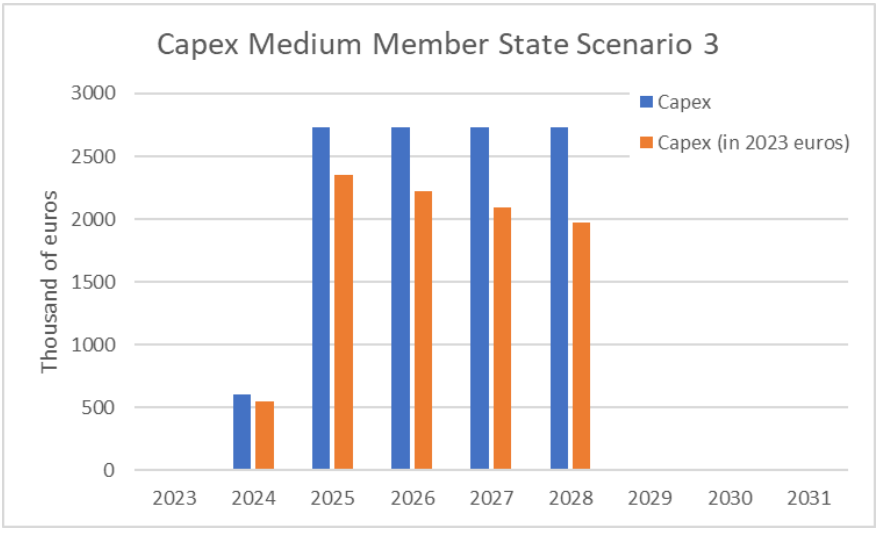

FIGURE 20: CAPEX IN 2023 EUROS FOR MEDIUM-SIZED MEMBER STATE SCENARIO 3

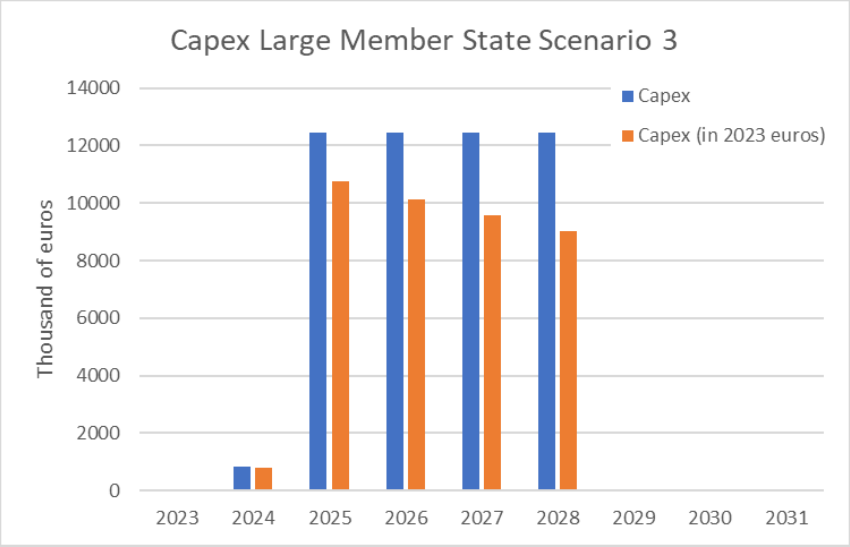

FIGURE 21: CAPEX IN 2023 EUROS FOR LARGE-SIZED MEMBER STATE SCENARIO 3

3.1.4 - Operating expenditure and ongoing costs

No operating expenditure costs are expected since no scenario includes additional staffs, offices space, data subscriptions or licenses purchases.

3.1.5 - Depreciation

In order to better understand the economic costs of the investment over time, a simplified depreciation schedule has been developed, assuming that the depreciation period is:

- IT and ATS unit related assets: 7 years
- Aircraft on-board equipment: 10 years
- Training and documentation: 1 year
- Studies, processes: not applicable (costs are not capitalised)

These assumptions may of course vary between individual investment items and between member states. In discussion with the project stakeholders, the applicable capitalisation and depreciation policies and assumptions should be clarified and refined.

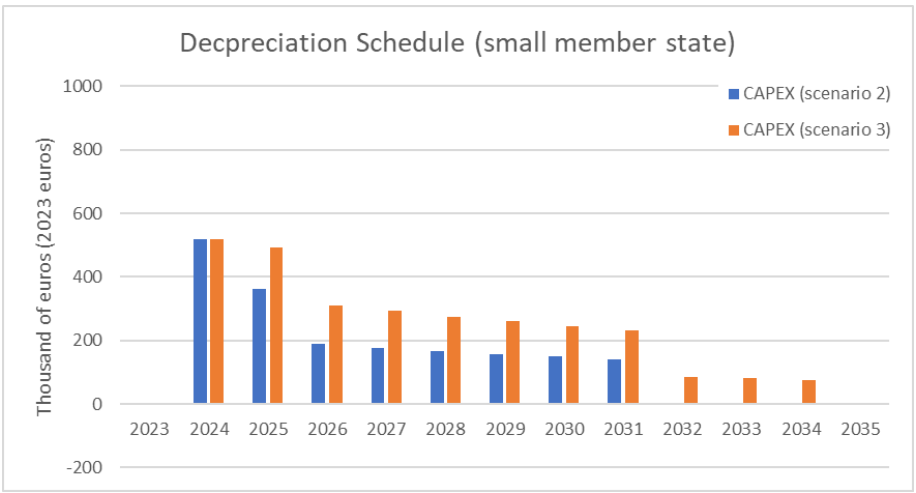

FIGURE 22: DEPRECIATION SCHEDULE FOR SMALL-SIZED MEMBER STATE

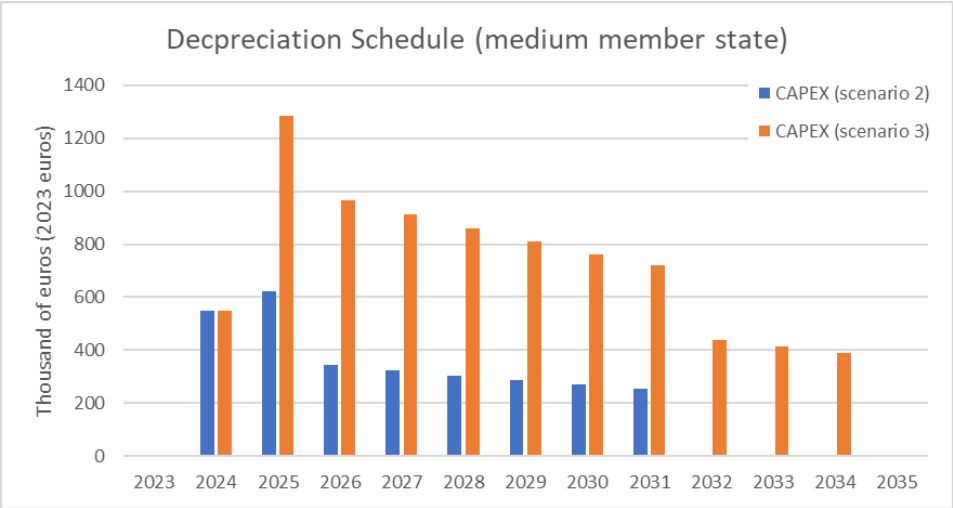

FIGURE 23: DEPRECIATION SCHEDULE FOR MEDIUM-SIZED MEMBER STATE

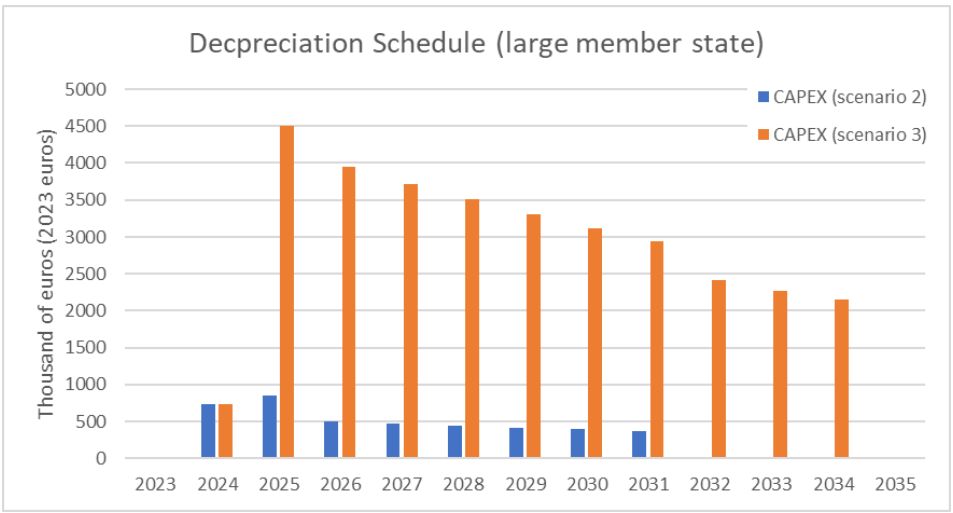

FIGURE 24: DEPRECIATION SCHEDULE FOR LARGE-SIZED MEMBER STATE

3.2 - Sensitivity analysis

Given the conceptual nature of this CBA and significant uncertainties about the required capital expenditure and available funding mechanisms, no sensitivity analysis was conducted at this stage of the study.

4 - FUNDING OF U-SPACE INVESTMENT

As shown in this report, the implementation of U-space will require capital expenditure from the military of the member states, deriving from investment into data exchanges, ATS units and aircraft as well as modifications to processes, training and documentation. Benefits are mainly limited to safety improvements and small operational benefits. As a result, the military CBA for U-space implementation is negative and there is limited financial incentive for the military to invest.

Still, in order to maximise the benefits of U-space to all users, including civilian and commercial applications, it is critical that the military is supportive and undertakes a number of investments and procedural adjustments. It is therefore essential that funding mechanisms should be identified that minimise the financial impact on the military, ideally preventing the military from having to shoulder the entirety of the costs from their regular budget.

4.1 - Funding options

A number of funding options from European institutions and related to research and technology deployment were identified. Other funding options that may exist at the member states level, NATO and other organisations could not be identified or are considered outside of the scope of the present report.

4.1.1 - EDA portal 'IdentiFunding'

Under the name 'IdentiFunding', EDA launched in 2019 an online tool that allows defence stakeholders to quickly identify existing EU funding schemes available for their defence-related projects[8]. IdentiFunding covers more than 20 funding opportunities currently open for defence-related projects, including the Preparatory Action on Defence Research (PADR), the European Defence Industrial Development Programme (EDIDP), Structural Funds, COSME, LIFE, Erasmus+. Since July 2019, the European Investment Bank (EIB) has joined EDA's IdentiFunding by adding its "Project loans". Available opportunities for funding encompass grants, loans and equity.

The aim of the IdentiFunding tool is to save budget, time and human resources usually required for defence stakeholders in order to identify whether their project and entities qualify for potential EU support.

Different EU funding opportunities are available for Ministries of Defence and Armed Forces; European defence industry including Small and Medium-sized Enterprises (SMEs - up to 250 employees) and Mid-Caps (250-3000 employees), large companies and EU PRIMEs; and Defence-related Research & Technology organisations, universities and other institutes.

It needs to be noted that at the time of preparation of this report the portal was unavailable and under review. A revised version of the portal is expected to become available in the near future.

Below, several funding options that can be relevant in the context of U-space related investment are presented. More detailed and up-to-date information is expected to be included in the revised IdentiFunding tool.

4.1.2 - European Defence Fund (EDF)

This funding mechanism has been available since 2018 through DG MOVE under the funding window of the European Defence Industrial Development Program (EDIDP). It was intended to facilitate the cooperative development of product technologies for agreed defence capabilities and priorities. Funding is available to consortia of public and private entities in the form of grants and public procurement opportunities.

In the context of the implementation of U-space, this program could be used by militaries to study, design and test U-space related solutions together with the industry and develop these towards maturity.

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[8] *Information from European Defence Agency, IdentiFunding Fact Sheet (www.eda.europa.eu)*

4.1.3 - Structural Reform Support Program (CEF)

This funding mechanism has been available since 2014 through INEA under the CEF Transport Single European Sky ATM Research window (SESAR). It is intended to fund ATM related studies and (cooperative) works as well as pilot activities conducted by the Single European Sky member states.

If calls were to be launched under this mechanism, applications would need to be submitted by member states or entities in agreement with a member state.

4.1.4 - European Structural and Investment Funds (ESIF) – Cohesion Funds

ESIF funds (European Regional Development Fund (ERDF), European Territorial Cooperation Goal (ETC), European Social Fund (ESF), Cohesion Fund) have been available to public-private bodies, ministries of defence, universities, private enterprise and other since 2014, with the funds aimed at facilitating objectives such as technical innovation, cross-border cooperation, employment, creation of skills and sustainability. The intended scope of the programs under ESIF specifically refers to dual-use applications and seems therefore relevant in the content of U-space related military investment.

Funding is provided in forms of grants, loans and equity up to €50 Million (for the ERDF and ETC).

4.1.5 - European Defence Agency ad-hoc funding

EDA funding is available on a continuous basis under the Category A and B funding windows[9]. With the aim to support cooperative defence research and technology and capabilities, finance can be requested by enterprises, research and technology (R&T) bodies, universities and consortia.

Yearly calls for this instrument have taken place since 2017, with funding being provided by the national Ministries of Defence.

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[9] Technology development in the EDA environment is implemented through variable project geometries. The most common format is the "Category B" project, prepared by a small number of contributing Members (cM) and open to others under an "opt in" scheme. More comprehensive and complex activities are established as "Category A" project or "Joint Investment Programmes" by all pMS, with the possibility to "opt out". Recently, a hybrid format of Cat B-like projects under a Cat A umbrella has proven very successful.

5 - CONCLUSION

This report sets out to evaluate the costs and benefits for the military authorities of the EDA member states which can derive from the deployment of U-space. As already identified in Task 1 (T1) – U-space evaluation, the military will primarily incur costs, but only limited or no benefits at all in return for its support to the implementation. The Task 1 report (D1) acknowledges that the military will only be able to draw significant benefit from U-space if they chose to collaborate with other stakeholders in this new environment and contribute to U-space services.

In order to gain an initial understanding of the costs implied for the military, this CBA distinguishes between investment in ATM systems and data exchanges, aircraft equipment, process reviews, staff-related costs and studies. While the precise implementation requirements for U-space are yet to be defined and the investment needs per member states are not fully understood, this CBA establishes a framework for costing the deployment and proposes a number of assumptions that enable the calculation of monetary values.

The outcome of this initial CBA is negative, yielding a net present value from € -400k to € -850k for implementation scenario 1 (minimal military collaboration) depending on the size of the Member State, from € -2.52 million to € -5.84 million for U-space implementation scenario 2 (full military collaboration), and from € -4.10 million to € -50.69 million for U-space implementation scenario 3 (full military collaboration with conspicuity).

The outcome of the CBA with discounted rate is negative, yielding a net present value from € -354k to € -741k for implementation scenario 1 (minimal military collaboration) depending on the size of the Member State, from € -2.07 million to € -4.73 million for U-space implementation scenario 2 (full military collaboration), and from € -3.32 million to € -40.24 million for U-space implementation scenario 3 (full military collaboration with conspicuity).

The resulting costs for individual member states can vary significantly and are not shown in detail in this analysis. However, based on the feedback from the project stakeholders it will be possible to gain a better understanding of the expected implementation efforts and costs, as well as the benefits of U-space.

This report provides a high-level overview of funding mechanisms at the European level, aimed at the development of technological and defence capabilities, civil-military collaboration, and the implementation of ATM capabilities.

Annex A **Project costing**

The complexity of implementations and costs of the required investments are likely to vary substantially between member states. This conceptual CBA therefore applies simplified assumptions which only distinguish between small, medium and large member states, making a set of assumptions for each category. Following discussions with the stakeholders, these assumptions can be replaced with specific input for each member state, if available.

Small-sized member state	Number of ATS units: 6 Number of workstations: 60 Number of military drones: 8 Number of Helicopters: 8
Medium-sized member state	Number of ATS units: 12 Number of workstations: 120 Number of military drones: 16 Number of Helicopters: 46
Large-sized member state	Number of ATS units: 20 Number of workstations: 200 Number of military drones: 50 Number of Helicopters: 289

A.1 Costing of IT implementations

	Scenario	Category	Description	Stakeholders
IT-1.1	Scenario 2	IT implementations	Data exchange ATS to CISP/USSP	IT department, ATS units
IT-2.1	Scenario 2	IT implementations	Data exchange CISP/USSP to ATS	IT department, ATS units
IT-3.1	Scenario 2	IT implementations	Visualisation of data CISP/USSP to ATS	IT department, ATS units
IT-4.1	Scenario 2	IT implementations	Mitigation of cyber security risks	IT department, ATS units

FIGURE 25: OVERVIEW OF IT IMPLEMENTATION ITEMS

A.1.1 Scope

The cost for IT implementations related to U-space (i.e. data exchange, visualisation of data, cyber security risk mitigation) is dependent on the specifics of the ATM and IT systems in place in each member state and at each ATS unit.

The costs include detailed technical assessments, IT hardware, software, implementation and testing.

A.1.2 Timeline

IT implementations are assumed to take place from 2025 (after the conclusion of studies referred to in A.4) until full U-space implementation in 2028. For the purpose of this CBA, the costs will be evenly spread and depreciated over period of 7 years (the depreciation period is consistent with assumptions made in other ATM related IT implementations, for example in the context of SESAR).

A.1.3 Costing

The proposed cost figures are based on benchmarks from military and civilian ATM implementations[10]. The actual implementation costs in the context of U-space may vary significantly for individual member states and should be reviewed by the project stakeholders. Costs for development, studies and implementation are assumed to come from countries with the industrial capabilities to develop and implement all new systems (France, Germany, Italy, Belgium, etc). An FTE (Full-Time Employment) corresponds here to a year-long work from a senior software developer from these countries and is estimated at € 70k.

Cost of IT implementations	Data exchange ATS to CISP/USSP	1 FTE for development (€ 70k) + 1 FTE for test/studies (€ 70k) + 0.5 FTE on implementation per ATS unit (€ 35k)
	Data exchange CISP/USSP to ATS	1 FTE for development (€ 70k) + 1 FTE for test/studies (€ 70k) + 0.5 FTE on implementation per ATS unit (€35k)
	Visualisation of data CISP/USSP to ATS	1 FTE for development (€ 70k) + 1 FTE for test/studies (€ 70k) + 0.5 FTE on implementation per ATS unit (€ 35k) € 10 000 per ATS operator workstation
	Mitigation of cyber security risks	€ 1 FTE (€ 70k)

TABLE 7: COSTS FOR IT IMPLEMENTATIONS

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[10] *Cost estimates for data exchange capabilities from the SESAR Deployment Manager AF5 (SWIM implementation) were considered to inform this CBA. The respective Pilot Common Projects (PCP) CBA estimates the cost of data exchange capabilities (e.g. for aeronautical information exchange, meteorological information exchange, flight information exchange, cooperative network information) for civilian ANSPs with € 1-1.5 Million each per member state. The overall cost for the military implementation of AF5 on the other hand is estimated in the range of € 20 Million per member state.*

A.2 Costing of aircraft implementations

	Scenario	Category	Description	Stakeholders
AC-1.1	Scenario 3	Aircraft implementations	On-board transmitters for helicopters and air worthiness	Rotorcraft engineering and maintenance
AC-2.1	Scenario 3	Aircraft implementations	On-board transmitters or ground-based conspicuity for drones and airworthiness	Drone engineering and maintenance
AC3.1	Scenario 3	Aircraft implementations	Visualisation of data CISP/USSP to drone operators	Drone engineering and maintenance

FIGURE 26: OVERVIEW OF AIRCRAFT IMPLEMENTATION ITEMS

A.2.1 Scope

This CBA accounts for the cost of equipping and drones with on-board transmitters or ground-based means of conspicuity which would allow them to be visible to CISPs and USSPs (when their mission allows).

((Given the variety of different aircraft types that need to be equipped, the unknown cost for the on-board equipment, and alternative ground-based means of conspicuity, the cost estimate in this CBA is purely based on the number of aircraft in scope and differentiating between helicopters and drones. The assumptions need to be validated with the project stakeholders and be refined as U-space moves from conceptual towards more specific implementation requirements. Furthermore, member states may wish to prioritise which aircraft to equip first, potentially excluding aircraft which find themselves at the end of their lives.))

Costs include detailed technical assessments, hardware, initial maintenance works (installation), testing and certification (airworthiness).

A.2.2 Timeline

The implementation of conspicuity means is assumed to take place from 2025 (after the conclusion of studies referred to in A.4) until full U-space implementation in 2028. For the purpose of this CBA, the costs will be evenly spread and depreciated over period of 10 years (the depreciation period is consistent with assumptions made in other ATM related implementations but needs to be reviewed with the project stakeholders).

A.2.3 Costing

The proposed cost figures are guided by benchmarks from civilian on-board implementations, yet take into account that older aircraft might not be equipped prior to their retirement. For reference, the deployment of ADS-B on-board transmitters may cost up to €300,000; however, in reality older aircraft might rather be redeployed, instead of incurring the cost of an upgrade. The resulting average cost per aircraft could therefore be significantly lower. In any case, the actual implementation costs in the context of U-space may vary significantly for individual member states and should be reviewed by the project stakeholders.

Cost of aircraft implementations	On-board transmitters for helicopters and airworthiness	€ 0.15 million per helicopter
	On-board transmitters or ground-based conspicuity for drones and airworthiness	€ 10k per drone (average)
	Visualisation of data CISP/USSP to drone operators	€ 5k per ATS operator workstation

TABLE 8: COSTS FOR AIRCRAFT IMPLEMENTATIONS

A.3 Costing of process implementations

	Scenario	Category	Description	Stakeholders
PR-1.1	Scenario 1, 2 and 3	Processes	Strategic/pre-tactical airspace management coordination	Regulator, National Air Operation Centre (Command and Control), Squadron Planning Operation Cell, National Airspace Management Cell
PR-2.1	Scenario 2 and 3	Processes	Propagation of strategic/pre-tactical information to military ATS	Strategic/pre-tactical planning, Tactical planning, ATS units
PR-3.1	Scenario 2 and 3	Processes	Military ATS unit communicates to CISP/USSP (data exchange)	Military ATS
PR-4.1	Scenario 2 and 3	Processes	Military ATS receives information from CISP/USSP	Military ATS
PR-5.1	Scenario 1, 2 and 3	Processes	Strategic/pre-tactical airspace management	Regulator, National Air Operation Centre (Command and Control), Squadron Planning Operation Cell, National Airspace Management Cell
PR-5.2	Scenario 2 and 3	Processes	Tactical coordination staff	Military ATS

FIGURE 27: OVERVIEW OF PROCESS IMPLEMENTATION ITEMS

A.3.1 Scope

The review and update of U-space related processes may involve various operational and non-operational stakeholders of the member states' military organisations and their interaction with external stakeholders. Depending on the organisational structure and existing processes in place, the implementation of changes can vary significantly between member states and the scope of the processes in question. For the purpose of this CBA, it is assumed that the costs are similar between different member states, but may vary between processes. It is assumed that additional staff is required to support the operation of U-space in each member state.

Also, the costs in this CBA will largely depend on how much military will be affected by U-space, which at present is not clear. As the militaries are affected by IR 2019/945 and IR 2019/947, it is possible that some staff costs currently projected in this study for coordination tasks might already be in place as a consequence.

A.3.2 Timeline

Studies are assumed to be conducted in the first year of the time horizon of this CBA, in 2024. Costs would not be capitalised.

A.3.3 Costing

While the costs of reviewing and re-engineering processes are expected to vary between member states, this CBA takes a simplified approach by proposing a single proxy cost for each process. Based on comparable projects among the project stakeholders, this proxy figure can be revised with benchmark figures for each member state.

It is assumed that member states require no additional staff to support the deployment of U-space at the strategic/pre-tactical and tactical level.

Cost of process review and update	Strategic/pre-tactical airspace management coordination	€ 50k per member state
	Propagation of strategic/pre-tactical information to military ATS	€ 0.1 million per member state
	Military ATS unit communicates to CISP/USSP (data exchange)	€ 0.1 million per member state
	Military ATS receive information from CISP/USSP	€0.1 million per member state
Cost of staff to support U-space processes	Strategic/pre-tactical airspace management	€ 60k per staff
	Tactical coordination staff	€ 60k per staff

TABLE 9: COSTS FOR PROCESS REVIEW AND UPDATE

A.4 Costing of studies

	Scenario	Category	Description	Stakeholders
ST-1.1	Scenario 1, 2 and 3	Studies	U-space study by member states' military organisations (strategic, technical, economic, cyber security)	Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators

FIGURE 28: OVERVIEW OF STUDIES FOR U-SPACE IMPLEMENTATION ITEMS

A.4.1 Scope

Regardless of the choice to implement scenario 1 or 2, each member state is assumed to undertake a detailed study about the implications for the military of supporting the implementation of U-space. The study would reiterate the scope of the study currently conducted by the EDA, applying specific and detailed inputs applicable to the member state. The scope of the study would encompass strategic, economic, operational as well as detailed technical questions concerning the required system upgrades, including ATM, aircraft and IT related issues.

A.4.2 Timeline

Studies are assumed to be conducted in the first year of the time horizon of this CBA, in 2024. Costs associated to this activity is incurred in 2024 and will not be capitalised.

A.4.3 Costing

While the costs of conducting a study are expected to vary widely depending on the complexity of the military in each member state and technical questions, this CBA takes a simplified approach by proposing a single proxy cost figure for small, medium and large member states, each. Based on comparable projects among the project stakeholders (e.g. ATM related implementations involving military and civilian stakeholders), this proxy figure can be revised with benchmark figures for each member states.

Cost of studies	Small-sized member state	€ 0.25 million per member state
	Medium-sized member state	€ 0.25 million per member state
	Large-sized member state	€ 0.5 million per member state

TABLE 10: COSTS FOR U-SPACE STUDIES AT MEMBER STATE LEVEL

A.5 Costing of training and documentation

	Scenario	Category	Description	Stakeholders
TR-1.1	Scenario 1	Training	Update of training syllabus	Training department, Strategic/pre-tactical planning
TR-2.1	Scenario 1	Training	Initial training	Training department, Strategic/pre-tactical planning
TR-3.1	Scenario 2 and 3	Training	Update of training syllabus	Training department, Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators
TR-4.1	Scenario 2 and 3	Training	Initial training	Training department, Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators
DO-1.1	Scenario 2 and 3	Documentation	Update of training materials and manuals	Training department, Strategic/pre-tactical planning, Tactical planning, ATS units, military drone operators

FIGURE 29: OVERVIEW OF TRAINING AND DOCUMENTATION IMPLEMENTATION ITEMS

A.5.1 Scope

Each member state is expected to identify the need to update its training syllabus, training materials and other manuals, and to conduct an initial training corresponding to the requirements of the respective implementation of scenario 1 or 2.

No additional effort or cost is assumed for recurrent training which will not be affected in terms of frequency or duration.

A.5.2 Timeline

The update of training syllabus, training materials, manuals and documentation would take place from 2023 and throughout the remainder of the U-space implementation period until 2026.

A.5.3 Costing

While the costs of updating training material and other documentation are expected to vary depending on the member state, this CBA takes a simplified approach by proposing a single proxy cost figure for all member states. Based on comparable projects among the project stakeholders (e.g. ATM related activities involving civilian stakeholders), this proxy figure can be revised with benchmark figures for each member states. Costs will not be capitalised.

Costs related to training materials and documentation	Small-sized member state	€ 0.1 million per member state
	Medium-sized member state	€ 0.1 million per member state
	Large-sized member state	€ 0.1 million per member state

TABLE 11: COSTS FOR U-SPACE DOCUMENTATION

The cost of holding initial training sessions about the implementation of U-space is dependent on the size of the affected military organisations, including the number of ATS units, ATS operators, military drone operators and other staff. This CBA takes a simplified approach by proposing a single proxy cost figure for small, medium and large member states, each. Based on comparable projects among the project stakeholders (e.g. training activities), this proxy figure can be revised with benchmark figures for each member states.

Costs related to initial training activities	Small-sized member state	€ 0.1 million per member state
	Medium-sized member state	€ 0.2 million per member state
	Large-sized member state	€ 0.3 million per member state

TABLE 12: COSTS FOR TRAINING ACTIVITIES

A.6 Monetisation of safety benefits

	Scenario	Category	Description	Stakeholders
PR-4.1	Scenario 2 and 3	Process (safety benefits)	Avoidance of loss of life	Military helicopter operators
PR-4.2	Scenario 2 and 3	Process (safety benefits)	Avoidance of hull loss and damage to aircraft	Military helicopter operators

A.6.1 Scope

A reduction in safety risks has now been quantified in the CBA, resulting from an improvement in the safe, orderly and flexible operation of military helicopters in U-space under scenario 2. The savings account for prevented hull loss and loss of human life and are based on (limited) data available for France and the US about accidents involving helicopters and drones.

A.6.2 Timeline

Based on historic data of accidents involving military helicopters and drone in France and in the US, both fatal or non-fatal, an average expected incidence per year was derived. The corresponding annual cost is included under scenario 2 as a cost savings, starting from the year of deployment of U-space in 2025.

A.6.3 **Quantification**

Due to the limited availability of historic data involving accidents between military helicopters and drones, data for both civilian and military aircraft were considered. Due to the very small sample, figures cannot be considered as statistically relevant. Despite this, the figures and the derived estimates can provide a very rough order of magnitude and approximation of the number of accidents to be expected over time. Data were obtained from as study titled *Quantification of aircraft accident risk parameters for EDF* (2020-2021, prepared by Egis) and from the US Federal Aviation Authority (*https://www.faa.gov/news/updates/?newsId=87406*).

The approach chosen for the estimation is as follows:

1. Based on military helicopter accidents that occurred in France, none were caused by a drone. Over a 10-year period (2010-2020), only one case of mid-air collision between military helicopters has been identified over continental France.
   No data could be obtained for the amount of military helicopter traffic, not making it possible to compute a probability of an accident. However, overall military traffic has been estimated to 120 000 flight hours per year over continental France. This is a low estimate, so it is assumed that the amount of military helicopter traffic is 100 000 flight hours per year.
2. In the US, three mid-air collisions over the 2017-2020 period between a drone and a helicopter have been recorded, none fatal. A military helicopter was involved in one of these instances. An estimate of helicopter traffic (probably only civilian) was obtained, indicating about 3.5 million of flight hours per year.
   Hence, the helicopter/drone collision rate can be estimated to 2/(4 years * 3.5 mil fh) or 0.14 per million of flight hours. The rate of fatal helicopter/drone collision is thus less than this figure. In the absence of further information, it is assumed that there is 1 fatal occurrence in 10 accidents; this rate is then applied to military traffic too.
3. Combining the two above result, an estimate of fatal military helicopter/drone collision rate is 0.002 per year over continental France.
4. Assuming U-space airspace covers 5% of the overall territory, we have an estimate of 0.0001 fatal military helicopter/drone collision per year in U-space airspace in France. France total area is about 1/8th of EDA member states total area so we can estimate the rate of fatal military helicopter/drone collision per year in U-space airspace in EDA MS territory to about 0.001.
5. In the absence of any other reference values, a "cost" of €10 Million was assigned to a hull loss of a military helicopter involving the loss of life, and €1 Million for accidents involving hull loss or damage to the helicopter without a loss of life. The average annual costs for all EDA member states for these events are €10,000 and €9,000, respectively. The avoided costs are the corresponding negative values.

Monetisation of safety benefits (avoided costs)	Hull loss and loss of life	€ 10k per year, for all member states
	Hull loss or damage	€ 9k per year, for all member states