EGHD Expert Group on the Human Dimension of the Single European Sky

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The long-term human dimension implications of integrating UAS/U-space into controlled airspace

This paper is the first paper to form part of the Human Dimension Roadmap, with a future looking perspective intending to highlight long-term human dimension concerns and subsequently provide inputs into the European ATM Master Plan. The roadmap intends to advise the European Commission on the future human dimension issues that will likely need to be tackled in order for the vision set out in the European ATM Master Plan to become a reality.

This roadmap paper seeks to envisage the potential interactions between ATM and U-space and the implications of integrating UAS in controlled airspace in the long term. Based upon this long-term vision, the EGHD develops a series of actions for different EU bodies to consider, to ensure the consequential human factor implications are appropriately considered and addressed as U-space and UAS operations develop. This list of actions is included in section 3.

1 INTRODUCTION

1.1 Context

The future of global aviation promises to deliver new concepts, that have the potential to propel the aviation sector towards significant change. New types of airborne vehicles are expected to emerge, which will operate in new ways and perform missions that are not currently performed. These new vehicles may include fully autonomous vehicles, lighter-than-existing aircraft, constellations of aircraft, commercial space missions, Uncrewed Aerial Systems (UAS) and eVTOLs. These concepts have the potential to drastically change Europe's skies and lead to developments in new technology that creates opportunities to improve the capacity, safety and sustainability of aviation at large.

The emergence of UAS, manned eVTOLs[1], and their supporting infrastructure in particular is significant as they have the potential to be a key contributor to the aviation sector fulfilling the European Union's ambition to lead the transition of the transport sector to be greener and more digital. With UAS having the potential to become an increasingly important part of mobility strategies, in November 2022 the European Commission published the European Drone Strategy 2.0[2], to provide political direction on the next steps to promote UAS development within the European market.

Given that they utilise new technologies and digital systems, UAS hold enormous promise for the evolution of the efficient use of airspace and aviation at large. However, the introduction of this technological change and digital transformation requires a step-change in the way airspace is managed, with direct implications on the human in ATM.

According to the U-space CONOPS[3], the integration of U-space airspace and UAS within controlled airspace will happen in stages. In the short-term, U-space airspace in controlled airspace will begin. In the medium and long-term, UAS operations in controlled airspace outside U-space airspace are also expected to be further introduced and then become widespread, however their integration with manned aircraft will require improved technical and operational procedures and appropriate training for all involved. Similarly, in the medium to long-term manned aircraft will be able to access U-space where required to ensure there is seamless, flexible and efficient access to all airspace according to operational needs.

Within U-space airspace UAS operations will remain separated and will rely on increasing levels of automation[4] as its phased implementation evolves (see Figure 1). Inside U-space airspace USSPs[5] will provide U-space services to UAS traffic to ensure their safe and efficient operation.

Whenever UAS traffic interfaces with operations in controlled airspace (such as U-space in or near controlled airspace), there will be the need for an interface between USSPs and ANSPs, which will need to be carefully managed from the perspective of the human dimension. This will need

FIGURE 1: EVOLUTION OF U-SPACE SERVICES

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[1] *The term 'electric Vertical Take Off and Landing' aircraft (eVTOL) is used for the transport of people and cargo initially with a pilot on board controlling the flight, in the future, they will have the ability to fly autonomously using the latest technologies when regulations allow.*

[2] https://transport.ec.europa.eu/system/files/2022-11/COM_2022_652_drone_strategy_2.0.pdf

[3] *In controlled airspace, crewed aviation is not allowed to enter U-space airspace hence ensuring separation from all UAS operations. Using the concept of Dynamic Airspace Reconfiguration (DAR), Air Traffic Control can temporarily change the boundaries of U-space by deactivating parts of the U-space airspace to allow for exceptional passage of crewed aircraft - Source: U-space concepts of operation (CONOPS), 4th edition.*

[4] *Separation standards of UAS-UAS and UAS-conspicuous crewed aircraft within U-space will evolve and become more automated as U-space services become more mature.*

[5] *U-space Service Provider.*

to consider nominal and non-nominal operations from both manned aviation and UAS. This interface may be handled by the CISP[6], when this entity is in place, otherwise, other mechanisms must be used.

The requirements that this interface will place on ATM staff in terms of the shared situation awareness, information sharing, communication, emergency and contingency procedures will need to be considered.

During the course of 2023 both EGHD and ASPRET have produced papers focussing on the short-term impacts of UAS/U-space integration with ATM from a human and social dimension respectively. As described in the following section, the scope of this paper is on the longer-term impacts of UAS/U-space integration, beyond 2035, considering the scenarios proposed in the '*U-space Concept of Operations (CONOPS), 4th Edition*'[7] [2], and by CANSO[8] (following the discussion within the ICAO Working Group)..

1.2 Scope

This proposed roadmap paper seeks to:

1 Envisage **how the ATM human dimension aspects will look like** in the long term, **beyond 2035**, in order to **support the interaction between ATM and U-space airspaces environments and full integration of UAS in controlled airspace**;

2 Propose a **strategic set of actions**[9] to be put in place by the different EU bodies, to ensure human factors implications are appropriately considered and addressed in **making the defined human vision a reality**.

This roadmap paper only assesses the human dimension aspects necessary to ensure a safe and effective interaction between ATM and U-space airspace environments and integration of UAS in controlled airspace.

This paper focus on the following **front line human actors in the ATM system** likely to be affected by the integration of UAS and U-space in controlled airspace:

- ATCOs
- manned aircraft pilots
- ATSEP
- AIS/AIM staff (e.g., AIS -PUB, NOF- NOTAM-Office, ARO, AIS AD, CHART staff)
- Other ATS personnel such as: FDA, FDS, FDP, FMP, Flow Coordinator, Data Assistant, FISO and AFISO, Clearance Delivery, Apron Control, COM -AFTN, Aeronautical Radio Station – HF/VHF Freq. staff)
- Frontline managers e.g., Supervisors (ATCO, ATSEP).

Other staff, such as staff of Common Information Services Providers (CISPs), U-space Service Provider (USSPs) and UAS operators and pilots whilst not part of the main scope of this roadmap paper, will be addressed as necessary.

1.3 Structure of the paper

This paper is structured into the following sections:

- Section 1: Introduction
- Section 2: ATM Human dimension implications related to the UAS and U-space integration with ATMATM Human dimension implications related to the UAS and U-space integration with ATM

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[6] Common Information Service Provider, where applicable, provides the services mentioned in the U-space regulation IR EU) 2021/664 article 5. The CISP is concerned with the provision of the necessary information for the well-functioning of the ecosystem. Its objective is to ensure that the information comes from trusted sources and that it is of sufficient quality, integrity and accuracy as well as security so that the USSPs and other users such as ASNPs can use this information with full reliability when providing their services. (Source: U-space ConOps and architecture, ed. 3.1, CORUS-XUAM, https://corus-xuam.eu/wp-content/uploads/2022/11/CORUS-XUAM-D4.1-delivered_3.10.pdf).

[7] See section C.1 for further details.

[8] See section C.2 for further details.

[9] The roadmap paper does not aim at the production of recommendations, instead it aims to identify human dimension related actions to deliver the vision beyond 2035.

- Section 3: Human dimension actions to deliver the vision beyond 2035

The paper is supported by the following annexes:

- Annex A - Acronyms
- Annex B - Existing regulatory context
- Annex C - Inputs for the future vision of UAS and U-space
- Annex D - References

1.4 Regulatory framework

As this roadmap paper seeks to envisage the future human impacts from U-space and UAS/drone integration in 2035 and beyond, a detailed exposition of the current regulatory framework is not included. This is because the regulatory context relevant for the future scenarios in 2035 has yet to be developed. The existing regulatory context is extensively covered in another EGHD position paper *'Human impacts of increasing interactions between drones and the ATM system'*, and it is included in annex B of this paper for the reader's reference.

2 ATM HUMAN DIMENSION IMPLICATIONS RELATED TO THE UAS AND U-SPACE INTEGRATION WITH ATM

2.1 Introduction

Nowadays, UAS are already being used as daily tools in some economic sectors, such as agriculture, construction, surveillance, public safety and security, filmmaking and photography, among others. In the future these and new UAS activities are expected to expand and spread to other economic sectors, encouraged by the Commission's Drone Strategy 2.0 [1].

At an initial stage the interactions of UAS with ATM are forecasted to be non-existent or very limited, but with the rapid forecasted ramp-up of UAS operations, the implementation of U-space airspace and the introduction of advanced air mobility (AAM), including urban air mobility (UAM), across Europe, this situation will likely change.

There is still great uncertainty around how UAS operations will evolve and grow, and on which will be the implications to ATM, and consequently to the ATM human dimension, but some scenarios are already set which give some hints on how the future will look like and which are the challenges ahead, and more importantly to the EGHD, which are changes in terms of the ATM human dimension.

To be able to identify the expected long-term changes and challenges, beyond 2035, the EGHD sets the scene in the following section, considering the scenarios proposed the '*U-space Concept of Operations (CONOPS), 4th Edition*'[10] [2], and by CANSO[11] (following the discussion within the ICAO Working Group).

2.2 The vision: imagining UAS and U-space integration with ATM from 2035 onwards

> This section is <u>freely inspired</u> by the 'U-space Concept of Operations (CONOPS), 4th Edition' [1] and by inputs provided by the EGHD members. It imagines an ambitious scenario on how UAS and U-space integration with ATM may look like by 2035.
>
> The purpose of this section is not to portray the most likely or accurate view of the future. EGHD members have diverse views regarding the future development of UAS and U Space from 2035. For some EGHD members this ambitious scenario is not regarded as the most realistic, nonetheless the

[10] *See section C.1 for further details.*

[11] *See section C.2 for further details.*

EGHD have chosen to consider this deliberately ambitious scenario in the development of this paper in order to better pinpoint proposed CONOPS evolutions with important implications on the future ATM human dimension, which are identified in section 3.

In this ambitious scenario, from 2035, it is expected that UAS commercial operations, including BVLOS, for aerial work, and goods deliveries will become common place.

Initially, singular UAS operations in controlled or uncontrolled airspace will still have to follow an authorisation process similar to what happens today with the application of IR (EU) 2019/947, and in the longer term this process should become automated.

High density UAS operations will operate within U-space airspaces, within controlled or uncontrolled airspaces, and Dynamic Airspace Reconfiguration (DAR) is a common procedure. By then it is still expected that:

- For U-space airspace in **controlled** airspace:
  - **Crewed aviation is not allowed to enter U-space airspace**.
  - ATC use **Dynamic Airspace Reconfiguration (DAR), to temporarily change U-space boundaries**[12].
  - **U-space Service Providers (USSPs) are informed by ATC when DAR is being used**.
- For U-space airspace in **uncontrolled** airspace:
  - Crewed aviation is allowed to freely enter U-space airspace provided that it is electronically conspicuous.

U-space services (available within U-space airspace) and U-space CNS performance are already more mature enabling U-space tactical services within U-space airspace.

In this ambitious scenario, **many U-space airspace volumes have been defined, in what was previously controlled or uncontrolled airspace**.

In uncontrolled airspace, as most drone operations are performed in the VLL, U-space airspace is declared below 500 feet AGL. For some UAS operations **which require to fly higher, such as inter-cities passengers or cargo transportation, corridors are in place and published in the AIP.**

In more densely occupied U-space airspaces tactical conflict resolution is routinely offered through U-space services. **UAS traffic in ATC controlled areas** is **routinely controlled by ATC through U-space** that is using U-space means of CNS.

Some U-space airspaces with **tactical services** will **accommodate** remotely piloted flight according to a **new flight rule**, **UFR** (see Section 4 of [2]).

In this ambitious scenario, commercial **manned VTOL operations will become common** under a range of environmental conditions, **both VMC** and **IMC,** in urban and regional areas. A **first proof of concept** of **unmanned VTOL operations** will start to emerge.

This scenario goes together with the **first networks of innovative** solutions for **ground infrastructures** (vertiports/vertispots/helipads and adapted heliports or small airports), at some major cities and airports.

Research and innovation activities will progress, and regulatory decisions will be made to take forward ATC automation, detect-and-avoid capabilities, advanced communication, and urban infrastructure extension.

[12] *"(...) Using the concept of Dynamic Airspace Reconfiguration (DAR), Air Traffic Control can temporarily change the boundaries of U-space by deactivating parts of the U-space airspace to allow for exceptional passage of crewed aircraft. The U-space Service Providers (USSPs) are informed by ATC if and when DAR is being used so they can adapt their flight authorisations in order for the drone operators to no longer use these temporarily deactivated parts of the U-space airspace (...)", [2].*

2.2.1 *Once full U-space integration is achieved*

When this ambitious scenario will become a reality, when U4 U-space services are fully deployed[13], most professional aerial operations could be uncrewed [2]. **Uncrewed and crewed operations use U-space services and fly UFR**.

U-space airspace is defined widely. Uncrewed aircraft are capable to autonomously detect and avoid collisions with any other aircraft.

2.3 How will the human dimension aspects look like from 2035 onwards?

Hereafter are summarised how some human dimension aspects will be affected in the scenario portrayed above, beyond 2035. **This is deliberately an ambitious scenario to support the discussions in section 3 in which the HF/HP challenges are analysed that need to be overcome before this scenario can be delivered.**

2.3.1 Roles and responsibilities

Despite the increasing use of automation, ATM/ANS systems will remain human centred[14] by 2035. Nonetheless, with the increasing complexity of systems and more interactions between ATM and U-space, there may be a shift towards more specialized roles, such as data analysts, system administrators, and remote operators. This will be reinforced by the decoupling of the service provision from the data management.

But overall, while automation brings efficiency, human cognition's decision-making and adaptability remains irreplaceable for safety. A dynamic balance between technology and human expertise will be in place. Human roles will begin to shift in focus towards managing and monitoring automated systems, exception handling, and decision-making.

In this ambitious scenario, to avoid exceeding the capabilities of the tactical conflict resolution service, when UAS traffic in ATC controlled areas is routinely controlled by ATC, a dynamic capacity management service (an U3 service) will be created to match the capacity and traffic demand and this will need to be coordinated by ATC, following defined priority rules.

2.3.1.1 Staff for new service providers, USSPs and CISP

Certification of USSPs and the CISPs will follow regulations that are similar to the regulations applicable to the ANSPs.

For these new service providers, the human operators working within them will have to meet well defined skillsets and training requirements, similarly to what is required for the ATM staff. This means for example, that engineers working on operational U-space and CIS equipment will need to meet similarly high proficiency standards to those that ATSEPs have to meet today.

2.3.2 ATM working methods, based on new concept of operations, procedures or technological changes

In this ambitious scenario, ATM and U-space operations will start to be based on a more automated and data-driven concept. Predictive analytics and AI systems will be used during life operations to optimise routes,

[13] The timing of full U-space integration is hard to gauge. Full integration requires that most aircraft used for professional purposes are uncrewed. If that requires new aircraft then the time taken may be a function of the useful life of the final generation of crewed aircraft. Currently aircraft are expected to have a working life of 25 to 30 years on average.

[14] As the level of automation increases, it becomes increasingly difficult for a human to resume control in the event of a failure/issue, especially in complex environments, nonetheless, the human will have a supervisor role over the automated systems.

weather avoidance, and traffic management and for future analysis of ATM and U-space interaction. Human air traffic controllers will monitor and validate the new working methods developed[15].

Procedures will be adapted to the new technological and operational landscape, such as the proliferation of U-space airspaces and the use of Dynamic Airspace Reconfiguration (DAR), introduction of VTOL operations, control of UAS operations in controlled airspace (likely using U-space services and CNS) and the redesign of the airspace and its reclassification.

Effective communication and collaboration will remain critical in this new environment. For instance, air traffic controllers, pilots, and other stakeholders will work closely together to ensure safe and efficient operations. This will involve real-time data sharing and improved situational awareness tools. *AIM and UAS' information are merged, for UAS operations in controlled airspace, and alerts information are automated and displayed for UAS, U-space and ATCOs*.

2.3.3 Training and licensing

The training of human actors within ATM, USSP and CISPs will start to have a relevant level of harmonisation EU level beyond 2035. Recurrent regular training programmes will be adapted to reflect the changes in roles and responsibilities and ATM working methods and will have a strong focus on system failure events and how to react.

2.3.4 Fatigue Management

With the expected complexity increase in air traffic management, stress management and professional well-being programmes will be in place to promote the mental health and general well-being of front-line operators.

3 HUMAN DIMENSION ACTIONS TO DELIVER THE VISION BEYOND 2035

The scenario presented in section 2 underpins the main adaptations likely to be required in ATM, beyond 2035, to deliver the vision set by the Commission for the integration of drones whilst maintaining the existing levels of safety and security, and while assuring the professional well-being of human operators.

The changes foreseen have consequences on the ATM human dimension that will need to be considered in the ongoing revision of the European ATM Master Plan.

The safe, efficient, and sustainable operation of the future Air Traffic Management (ATM) system demands a critical focus on the challenges and uncertainties associated with human factors and human performance. To achieve this, extensive research, collaboration, and continuous adaptation will be necessary. A comprehensive and coordinated effort is required to deliver the vision for the human dimension aspects in ATM.

In this section the EGHD describes challenges that need to be resolved by 2035 to ensure that human factors are appropriately considered in the integration of drones and U-space within ATM and in the delivery of the vision set above. For each challenge preparatory or mitigating actions are outlined to be considered by the different ATM stakeholders.

3.1 Adapting roles and responsibilities

The future of ATM is expected to merge the advantages of human capabilities and automation, incorporated using AI and machine learning algorithms. Although technology will have a more prominent role, people will still be at the core of decision-making, safety, and supervision. So, the appropriate tools to assist the human, will play a crucial role. The integration of UAS/U-space may contribute significantly to the changes in roles and

[15] *The human Air Traffic Control Officer (ATCO) would not have the capability to fully monitor and validate the results of AI-based tools that, for example, will provide optimized routes, but the ATCOs will be able to verify whether or not the results provided by the tools adhere to simplified criteria.*

responsibilities within ATM, which are likely to evolve and become more specialised and focussed on monitoring and decision making.

New service providers such as USSPs and CISPs, will also impact the roles of personnel within ATM, who's responsibilities may have to evolve to incorporate interaction with these new service providers, which may additionally include additional real-time data sharing.

In light of these new interactions, a significant challenge will be ensuring the effective collaboration between ATM staff and staff working in the UAS/U-Space domain, such as within USSPs and CISPs. The roles and responsibilities across the human operators in these two domains will need to be clearly defined and the methods of communication and data exchange established. This is particularly pertinent in non-nominal or emergency situations, where the requirements on the communication and data exchange between the various actors become extremely time sensitive and demand every human operator to have a clear understanding of who is responsible for which tasks.

An additional dimension to the challenge of appropriately defining roles and responsibilities is the introduction of automation and AI systems that is expected to start to be integrated into ATM and UAS/U-space from 2035. The impact of this on the roles in ATM will need to be appropriately considered and implemented to enable a seamless transition to more automated systems.

As roles evolve to incorporate more automated systems the responsibilities of human operators will change. The impact on the responsibilities of each human operator will need to be clearly communicated and integrated to ensure each individual understands the changing demands of their role as UAS/U-space integration progresses.

One particular aspect of UAS and U-space integration which will lead to changes in roles and responsibilities in ATM is the introduction of Dynamic Airspace Reconfiguration (DAR). This is a procedure that has been tested in SESAR U-space projects, but so far has not been tested under real operational conditions. Consequently, the true impact remains to be evaluated, specifically the impact on ATM staff, from integrating such a U-space procedure is unknown. This procedure could have significant impacts on ATM as it will mean that airspace that is controlled by an ATCO could change much more frequently than it does under existing procedures (e.g. FUAs). The degree of automation built into DAR and the roles needed within ANSPs, USSPs and CISPs to ensure its safe and efficient operation will need to be established, with the impact on the human operators appropriately considered.

The increased complexity in the routine activities can also lead to the creation of new roles such as a dynamic capacity management service to balance the capacity and traffic demand. These potential additional roles need to be identified and planned for.

ACTION 1: SESAR should continue their efforts to understand the real impact of automation, increased complexity and new procedures (such as DAR) on the roles and responsibilities of ATM staff[16].

3.2 Defining liabilities

As described in section 3.1, the integration of U-space/UAS could lead to changes in responsibilities for human operators in ATM. Consequently, as the integration between U-space/UAS and ATM progresses, a key challenge will be defining who is legally responsible if an incident occurs. It is essential that human operators have a clear understanding of the liabilities associated with their job, and that this is clearly communicated and agreed upon prior to changes taking place.

Changes in liabilities will come as a result of many of the changes in roles and responsibilities described in section 3.1. A shift to more specialised roles, with an increased focus on monitoring and decision-making tasks

[16] The SESAR 3 JU should continue the development of related solutions under the U-space and urban air mobility flagship, as it is already doing today with digital sky demonstrators projects (e.g. U-ELCOME, Burdi) and industrial research and innovation projects (e.g. ENSURE).

will naturally alter the allocation of liability in case of an incident. This is complicated further by the integration of USSPs and CISPs, since there will be increased interactions with external systems, data and players. Increased automation and the introduction of data-driven concepts and data providers (such as ADSPs) will add to the challenge.

Clearly defining and communicating liabilities will support collaboration between the different stakeholders, which is an essential component to ensuring the long-term vision for integrating UAS/U-space comes to fruition.

ACTION 2: The European Commission should work together with EASA to understand how the liabilities associated with the integration of UAS/U-space may evolve. As UAS/U-space progresses the European Commission should ensure that any changes to the liabilities of ATM staff are clearly disseminated to the relevant human operators.

ACTION 3: The European Commission should update the legal framework for responsibilities and liabilities, to take into consideration the new environment with numerous automated systems, and promote with the Member States the implementation of the appropriate legislative tools at the national level. In the definition of this framework of responsibilities and liabilities, the legal experts should also consider practical operational aspects.

3.3 Ensuring appropriate staffing

Staffing is a key concern within ATM, and a lack of staff impacts the safety and capacity of the ATM system. There is still a lack of understanding of the real impact of UAS/U-space integration on ATM operations. As capacity is one of the main challenges facing the European ATM system (mainly because of a shortage of staff), the impact on workload from any new changes in roles and responsibilities resulting from the integration of changes in ATM to support UAS/U-space integration will need to be appropriately considered. These changes should not impact the day-to-day business or the adoption of technological upgrades.

The interaction between ANSPs and USSPs or CISPs is likely to increase the workload of ATM staff, without appropriate staffing measures being put in place to handle such a change.

Additionally, to accommodate for the introduction of UAS/U-space, the existing airspace may have to be reclassified or redesigned. Airspace change can be a lengthy process and may also impact ANSP staffing.

A key challenge will be addressing where the financial resources will be derived from to protect the workload of ATM staff and ensure the capacity of the ATM system is maintained, whilst new procedures that facilitate the integration of UAS with the ATM system are put in place. It will need to be decided how within the financial model of European aviation (including The European Performance and Charging Scheme), ANSPs can be provided the platform to protect the workload of ATM staff. Ultimately, this involves identifying who will pay to ensure the introduction of procedures to facilitate U-space integration can be supported by appropriate staffing levels.

ACTION 4: In their research related to UAS/U-space, SESAR should consider the impact of technological advances on staffing requirements for ANSPs, across the various roles.

ACTION 5: The European Commission should ensure that any potential impacts on ANSP staffing requirements from implementing the long-term UAS/U-space integration vision is accounted for in a revised financial model for European aviation. This new model should continue respecting user-paying and equity principles.

3.4 Re-thinking the ATM working methods (based on new concept of operations, procedures or technological changes)

The integration of UAS/U-space with ATM is likely to require a number of changes in the working methods of ATM staff. By 2035, it is likely that human roles will be evolving to become more specialised to address the increasing complexity of systems and increased degree of automation. To integrate UAS/U-space effectively, the move towards more specialised roles will need to be reflected by changes in the working methods and training of human operators.

U-spaces in controlled airspace with the use of dynamic airspace reconfiguration (DAR) will have a direct impact on the ways of work of ATCOs and on the airspace capacity balancing. Additionally, the control by ATM of UAS operating in controlled airspace (outside U-space airspace) will create a new challenge for ATCOs, and the move to a scenario with a more diversified traffic mix, which will include aircraft with different performance and requirements, will increase the complexity of their work. Procedures and training will have to be adapted accordingly.

To support U-space/UAS integration, the two separate domains will require a sufficient understanding of each other's operations, and the associated terminology to be able to communicate effectively. A key challenge will be establishing protocols for communication between ATM personnel and U-space/UAS personnel which give clear guidance on when and how to communicate with each other. These protocols will be critically important in non-nominal/emergency scenarios.

In an ambitious scenario considering the wider use, by 2035, of new technologies such as machine learning, and real-time data exchange among the different players (e.g., ANSP, CISP, USSP and AUs including the UAS operator), working methods will need to be adapted to effectively use and manage these tools. In addition, appropriate contingency procedures will be required to manage manned air traffic and UAS in the event that automated systems fail or in the event of data corruption or failure. In such cases, provisions should be made to override automation and adjust the operational conditions (e.g. clear the sky procedures), with the necessary procedures included in the training programmes for staff. Operators will need clear guidelines for dealing with situations where automation is unavailable or malfunctioning, with the requirement for human operators overriding automated systems in the event of failures clearly outlined.

Human error contributions to ATM incidents and accidents, could be aggravated by the increased level of complexity. A key challenge will be to integrate U-space/UAS in a way that puts error management at the forefront, particularly in relation to automated procedures. This requires a foundation of well thought out procedures, enhanced training programmes and appropriate fatigue management processes.

To mitigate human-error and contribute to situation awareness the integration of UAS/U-space will need to be supplemented by the introduction of improved situational awareness tools and new safety nets.

Another aspect which could have a direct impact on the ways of work of front-line operators is the potential need to redesign the airspace and its classification to integrate U-space and potentially other types of flight rules (e.g. UFR).

The successful collaboration between ATM and UAS/U-space depends on the interoperability, smooth integration of technology, clear communication, and compliance with standardised protocols and regulations. It is essential to identify timely gaps in these areas to ensure the safe and efficient operation of both manned and unmanned aircraft in shared airspace.

ACTION 6: The European Commission together with SESAR must continue to promote the input from ATM operational staff throughout the UAS/U-space solutions maturity cycle (in particular for solutions which may interfere with ATM)**. The involvement of ATM operational staff in validating SESAR solution contributes to the development of appropriated working methods throughout the maturity cycle, not only during the deployment phase.**

ACTION 7: SESAR and EASA should assess the implications of changes, such as the introduction of U-space DAR, evolution of the traffic mix, increased automation, communication and data exchange (sometimes in real-time) with external stakeholders, on human-error risks and the ways of working of ATM front-line operators and supervisors. This evaluation should inform adjustments in work procedures and training requirements aimed at reducing human error risks and, consequently, the overall level of risk.

ACTION 8: The Network Manager should investigate if EU wide programmes for airspace redesign will be required to facilitate the introduction of U-space and UAS operations and together with EASA should assess if new/adapted flight rules are required.

ACTION 9: SESAR should investigate how ATM situation awareness tools and safety nets should evolve to support the safe integration of UAS/U-space and ATM.

ACTION 10: SESAR should continue to consider the role of automation and data exchange in UAS/U-space integration with ATM and include within this angle of research an understanding of the impact this may have on the working methods of ATM staff, and in particular during non-nominal situations.

3.5 Adjusting training and licensing requirements

The rapid evolution of technology and changing roles in ATM will require human operators to undergo continuous training and skill development. However, determining the most effective training methods, adapting licensing and certification processes, and ensuring a well-prepared workforce remain ongoing challenges. The introduction of UAS will provide a further challenge in terms of training and licensing.

Organisations will need to prioritise the development of ongoing training programs to prepare the workforce for evolving roles and responsibilities associated with UAS/U-Space integration. To reflect these changes, modifications to the licensing and certification processes will be necessary. Essential collaboration between EU and national regulatory authorities (EASA – NSAs), training organisations and ATM service providers is required to develop these training programs and adjust licensing requirements.

ATCO training (including the training of the ATCO OPS supervisor) will need to be adapted to consider changes in the role and the ways of work from the integration of UAS/U-space. Training and licensing will need to be adapted to reflect the introduction of new procedures such as Dynamic Airspace Reconfiguration (DAR), increased automation, data exchange, communication, evolution of the traffic mix, new tools etc.

In addition, the integration of U-space related data into ATM systems will likely lead to changes to system functionalities. ATSEP training on these new systems and their interfaces will need to be provided. Alongside this, general awareness of U-space operation and its technical implementation must become part of training requirements. Considering this, a dedicated U-space orientated training stream should be created, which will support ATSEPs who are also employed by CISPs and USSPs. To ensure the implementation of such training is practical and timely, USSPs and CISPs will need to be mature enough for the operational environment to be stable in terms of technical systems and procedures.

Furthermore, it is important to define a set of proficiency and authorisation requirements for the technical operators and engineers handling the management, operation and maintenance of USSPs and CISPs operational equipment. For example, this would mean that engineers working on operational U-space and CIS equipment could be considered an ATSEP in terms of equivalency of knowledge and proficiency. Ensuring that staff working for USSPs and CISPs have a similar level of knowledge and training as their ATM counterparts is an essential enabler to support collaboration between ATM and U-space/UAS. Another important step would be to understand if the USSP and CIS operational equipment should be considered as a part of the ATM functional system.

ACTION 11: EASA should continue to evolve the regulatory requirements for the training of human operators and supervisors to ensure the content of training programmes accurately reflects changes in the real operational environment resulting from the integration of UAS/U-space.

ACTION 12: EASA should ensure that as the future vision for UAS is implemented, the proficiency requirements for staff of USSPs and CISPs are defined and at a commensurate level of knowledge and expertise to those for staff in the ATM domain.

ACTION 13: EASA should consider expanding the definition of the ATM 'functional system' (which currently means 'a combination of procedures, human resources and equipment, including hardware

and software, organised to perform a function within the context of ATM/ANS and other ATM network functions') to incorporate UAS/U-space systems and procedures.

3.6 Reinforcing the Just Culture

Not only is it expected that UAS/U-space will be integrated with the ATM system, but a completely new industry to support the manufacture and commercial operation of UAS will be developed. A key component of the current aviation system is the Just Culture framework accounted for in regulation **(EU) 376/2014** to support a non-punitive culture when it comes to incident reporting and safety concerns. It is critical that the Just Culture incorporates new forms of aviation and that this culture becomes engrained within the UAS/U-space industry as it grows.

For this to be a success, it requires the collaboration of all industry stakeholders including new service providers such as USSPs and CISPs, UAS operators and manufacturers, new infrastructure providers (e.g., vertiports/vertispots/helipads, etc), regulators and all existing actors within ATM. It will be necessary for lessons to be learned and shared across these key stakeholders, and this will require the evolution and reinforcement of the just culture framework in aviation.

ACTION 14: The European Commission, EASA, EUROCONTROL and Member States should continue their efforts to establish a Just Culture environment for all ATM-related stakeholders, as established in Regulation (EU) No 376/2014[17]. All involved actors should be familiar with the Just Culture framework and be encouraged to report issues, incidents or risks. The European Commission should oversee the implementation of the Just Culture by each Member State and encourage Member States to continue adjusting their national safety prosecution and criminal investigation policy to be in line with the Just Culture principles, confirming that only gross negligence and wilful misconduct should be prosecuted, moreover ensuring that penal responsibilities take into account the increasing automated environment associated with the emergence of UAS in the ATM system.

3.7 Evolving the regulatory framework

As UAS/U-space integration progresses, it will be critical that regulatory frameworks evolve to keep pace with the changes in the industry. As an example, regulatory frameworks will need to be updated to reflect the changing nature of ATM human roles and changes in working methods.

The introduction of USSPs and CISPs will require evolutions in the scope and nature of regulation to ensure staff working for these new service providers are captured by regulation in a similar way to that currently existing for ATM.

The regulatory framework will also need to evolve to harmonize training and licensing, when possible, at EU level for ATM, USSP and CISPs.

To support the effective integration of UAS/U-space, it will be important that regulation sufficiently protects the professional well-being of ATM front-line operators.

The process of updating regulation should begin as soon as new technologies and operational concepts are introduced.

ACTION 15: The European Commission should initiate the creation of EU-wide training and licensing programmes for ATM, CISP and USSP staff. The training programmes should be harmonised as far as possible to reduce disparities among member states and to guarantee consistent coverage of relevant contents across the programmes for the different staff.

[17] *https://www.easa.europa.eu/en/document-library/regulations/regulation-eu-no-3762014*

ACTION 16: EASA should initiate the specification of the skills and authorisation requirements for technical personnel working in CISPs and USSPs.

3.8 Considering fatigue management

ATCOs frequently encounter high cognitive workloads, which can result in stress and fatigue. To better manage and reduce ATCO workload, especially in complex and high-traffic scenarios, more research is required. This entails developing user-friendly interfaces and decision-support tools, which will become increasingly important when it comes to dealing with an evolving mix of air traffic (with differing performances and separation requirements), alongside new techniques for controlling the traffic through increased automation.

Another key impact on cognitive workload will be the introduction of Dynamic Airspace Reconfiguration (DAR) of U-space, which has the potential to put additional strain on the cognitive workload of ATCOs through more frequent changes to the nature of the airspace they are controlling. Ensuring that automation and new support tools sufficiently mitigate the impact of DAR on ATCO fatigue will be a key challenge to support the integration of UAS/U-space beyond 2035.

The high-stress nature of ATM can have a significant impact on mental health and well-being. With increasing complexity and criticality of tasks, it is essential to provide mental health and stress management support for operators to ensure their overall well-being. Developing support systems, addressing stress factors, and promoting mental health awareness are areas where more research and strategies are needed. A careful analysis of stress and fatigue in relation to the integration of UAS/U-space with the ATM system, followed by the implementation of stress and fatigue management approaches could contribute to a successful integration and would facilitate the adoption of new ATM procedures by the affected ATM operators.

ACTION 17: SESAR and EASA should seek to thoroughly examine and understand, how expected increased complexity in the ways of working as a result of UAS and U-space integration may affect the levels of stress and fatigue of ATM front-line operators and supervisors. These bodies should investigate which stress and fatigue management programmes will be required to ensure staff professional well-being.

ANNEX A. ACRONYMS

Acronyms	Full Term
AAM	Advanced Air Mobility
AD	Aerodrome
ADSP	ATM Data Service Provider
(A) FISO	(Aerodrome) Flight Information Service Officer
AFTN	Aeronautical Fixed Telecommunication Network
AGL	Above Ground Level
AI	Artificial Intelligence
AIM	Aeronautical Information Management
AIP	Aeronautical Information Publication
AIS	Aeronautical Information Service
AMC	Acceptable Means of Compliance
ANS	Air Navigation Services
ANSP	Air Navigation Service Provider
ARC	Air Risk Classification
ARO	Air Traffic Service Reporting Office
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATM	Air Traffic Management
ATS	Air Traffic Services
ATSEP	Air Traffic Safety Electronics Personnel
AUs	Airspace Users
BVLOS	Beyond Visual Line of Sight
CAA	Civil Aviation Authority
CIS	Common Information Services
CISP	Common Information Services Provider
CNS	Communications, Navigation and Surveillance
COM	Communications
DAR	Dynamic Airspace Reconfiguration
EASA	European Union Aviation Safety Agency
EC	European Commission
EGHD	Expert Group on Human Dimension
EU	European Union
FDA	Flight Data Analysis
FDP	Flight Data Processing
FDS	Flight Data Services

Acronyms	Full Term
FMP	Flow Management Position
FUA	Flexible Use of Airspace
GM	Guidance Material
GRC	Ground Risk Classification
HAO	Higher Airspace Operations
HF	Human Factors
HP	Human Performance
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
MET	Meteorological (information)
NAA	National Aviation Authorities
UAM	Urban Air Mobility
UAS	Unmanned Aircraft System
UFR	Unmanned Flight Rules
USSP	U-space Service Provider
VFR	Visual Flight Rules
VHF	Very High Frequency
VLL	Very Low-Level Airspace
VLOS	Visual Line of Sight
VMC	Visual Meteorological Conditions
VTOL	Vertical Take-Off and Landing
WG	Working Group

ANNEX B. EXISTING REGULATORY CONTEXT

This annex provides an overview of the existing regulatory framework for drones and U-space.

B.1 Summary of Drone Regulations as per 2023

B.1.1 (EU) 2018/1139

European regulation **(EU) 2018/1139** establishes essential requirements relating to the design, production, maintenance and operation of unmanned aircraft. The regulation also stipulates the certification requirements in each of these areas, as well as the certification necessary to operate an unmanned aircraft. The certification of the organisations involved in design, production, maintenance and operational activities is also covered.

This regulation stipulates that member states ensure that information about the registration of unmanned aircraft and of operators of unmanned aircraft that are subject to a registration requirement, is stored in digital, harmonised, interoperable national registration systems.

B.1.2 (EU) 2019/947

Regulation **(EU) 2019/947** establishes three broad categories of unmanned aircraft systems operations:

- **"Open":** safety is ensured through operations limitations, compliance with industry standards, and the requirement to have certain functionalities and a minimum set of operational rules. Enforcement mainly by the police.
- **"Specific":** operations of medium risk and complexity. Authorisation by a Civil Aviation Authority (CAA) possibly assisted by a Qualified Entity (QE) following a risk assessment on safety [and security] performed by the operator.
- **"Certified**": operations of high risk and complexity. Requirements are comparable to those for manned aviation. Oversight by CAA (issue of licences and approval of maintenance, operations, training, ATM/ANS and aerodromes organisations) and by EASA (design and approval of foreign organisations).

This regulation not only covers the type of operations that can be performed in each category but also the competency and age requirements for the pilots that are performing the drone operations. The regulation also covers the rules and procedures for the airworthiness of unmanned aircraft systems, the rules that apply when conducting an operational risk assessment and the rules governing model aircraft clubs.

B.1.3 (EU) 2019/945 and (EU) 2019/947

Delegated Regulation **(EU) 2019/945** sets out requirements for the design and manufacture of unmanned aircraft systems intended for use under the conditions defined in Regulation **(EU) 2019/947** . It lays down rules concerning the placing on the market of UAS intended for use in the open category. It covers the obligations of importers, distributors and also requirements relating to conformity assessment bodies. In addition, it lays down rules for third-country operators when conducting operations under Implementing Regulation **(EU) 2019/947.**

B.1.4 (EU) 2020/1058

Regulation **(EU) 2019/945** was amended by delegated regulation **(EU) 2020/1058** to include two new classes of unmanned aircraft systems, C5 and C6. The regulation details the system requirements for drones to be included in these categories. The regulation refines requirements related to the labelling of drones as well as the remote identification of drones necessary to support the future implementation of U-space.

B.1.5 (EU) 2020/639

Regulation **(EU) 2019/947** was amended by regulation **(EU) 2020/639,** which sets out two standardised scenarios for operations under the 'Specific' category of unmanned aircraft systems in or beyond the visual line of sight:

i) **Standard scenario 1** ('STS-01') covers operations executed in visual line of sight ('VLOS'), at a maximum height of 120 m over a controlled ground area in a populated environment using a CE class C5 unmanned aircraft system (this classification system was introduced under **(EU) 2019/945** and refers to the operational requirements of the drone, a C5 drone has a Maximum Take-Off Mass of below 25kg, amongst other requirements).

ii) **Standard scenario 2** ('STS-02') covers operations that could be conducted beyond visual line of sight ('BVLOS'), with the unmanned aircraft at a distance of not more than 2 km from the remote pilot with the presence of airspace observers, at a maximum height of 120 m over a controlled ground area in a sparsely populated environment and using a CE class C6 UAS (this classification system was introduced under **(EU) 2019/945** and refers to the operational requirements of the drone, a C6 drone has a Maximum Take-Off Mass of below 25kg, amongst other requirements).

This regulation outlines the responsibilities of the UAS operator and remote pilot under these two standard scenarios and provides the training and examination requirements necessary for remote pilots to be able to conduct operations under these scenarios.

B.2 Summary of U-space Regulations as per 2023

To ensure the recommendations provided by members in this paper maintain relevance with the implementation of U-space, it is necessary to gain a better understanding of the regulations that have been introduced related to U-space. A summary of regulations **(EU) 2021/664**, **(EU) 2021/665** and **(EU) 2021/666** is provided below. EASA published its first set of Acceptable Means of Compliance (AMC) and Guidance Material (GM)[18] to the U-space regulatory framework (regulations **(EU) 2021/664** , **(EU) 2021/665** and **(EU) 2021/666** on the 19th of December 2022.

B.2.1 (EU) 2021/664

The European Commission released on 22 April 2021 the regulation **(EU) 2021/664** , publishing proposals for the implementation of a regulatory framework for U-space in Europe. The regulation, applicable from 26th January 2023, introduces the application of rules and procedures for the safety of UAS operations in certain airspace designated by the state, U-space, ensuring the integration of them into the aviation system. The regulation establishes the services to be provided in this airspace, which will be based on digital services and automation of functions. The regulation also provides the provisions and general requirements for UAS operators and U-space service providers. It defines the conditions for obtaining certification for U-space service providers and single common information service providers. EASA AMC/GM to (EU) 2021/664 issue 1 from 16 December 2022 provides guidance and detailed acceptable means of compliance to apply U-space regulation**Error! Reference source not found.**.

B.2.2 (EU) 2021/665

(EU) 2021/665 amends implementing regulation **(EU) 2017/373** which stipulates common requirements for providers of air traffic management/air navigation services and other air traffic management network functions and their oversight. The amendment describes the requirements for providers of air traffic management/air navigation services and other air traffic management network functions in U-space airspace designated in controlled airspace.

[18] https://www.easa.europa.eu/en/document-library/acceptable-means-of-compliance-and-guidance-materials/amc-and-gm-implementing

B.2.3 (EU) 2021/666

Commission implementing regulation **(EU) 2021/666** of 22 April 2021 amends regulation **(EU) 923/2012** which lays down the common rules of the air and operational provisions regarding services and procedures in air navigation. Implementing regulation **(EU) 2021/666** makes amendments to the requirements for manned aviation operating in U-space airspace. Section 6 (SERA.6005) of the annex of **(EU) 923/2012** is amended to include the new requirement for electronic conspicuity in uncontrolled U-space airspace.

ANNEX C. INPUTS FOR THE FUTURE VISION OF UAS AND U-SPACE

This annex summarises the scenarios proposed the 'U-space Concept of Operations (CONOPS), 4th Edition' [2], and by CANSO (following the discussion within the ICAO Working Group) for the U-space and UAS introduction and consolidation.

C.1 U-SPACE CONCEPT OF OPERATIONS (CONOPS), 4th Edition [2]

C.1.1 Before 2023: the foundations of U-space

States are setting up registries and defining geographic areas in accordance with the UAS regulatory framework, EU IR 2019/947 [4] & EU DR 2019/945 and subsequent amendments such as 2020/639, 2020/746, 2020/1058, 2021/1166, 2022/425, etc, together with the corresponding AMC-GM. Drones fly without U-space services. Manual coordination with and authorizations from the involved authorities are usually required. ATC procedures make Visual Line of Sight (VLOS) flights possible, though sometimes requiring some effort. Beyond Visual Line of Sight (BVLOS) flights are limited, time consuming and expensive to set up.

C.1.2 Initial U-space implementation (2023-2030)

Initial U-space implementation (2023-2030)

The U-space regulatory framework and corresponding AMC-GM came into force on the 26th of January 2023. In line with these, a limited number of services are available, providing a digital assistance to the authorities in charge of authorising the operations, and a digital assistance to the operators to plan and declare their operations. When required, airspace structures are defined, temporarily or permanently, to allow drone operations (e.g., corridors for point-to-point goods or passenger carriage).

- U-space airspaces are defined:
  - **In controlled airspace**, crewed aviation is not allowed to enter U-space airspace hence ensuring separation from all UAS operations. Using the concept of Dynamic Airspace Reconfiguration (DAR), Air Traffic Control can temporarily change the boundaries of U-space by deactivating parts of the U-space airspace to allow for exceptional passage of crewed aircraft. The U-space Service Providers (USSPs) are informed by ATC if and when DAR is being used so they can adapt their flight authorisations in order for the drone operators to no longer use these temporarily deactivated parts of the U-space airspace.
  - In uncontrolled airspace, crewed aviation is allowed to freely enter U-space airspace provided that it is electronically conspicuous.
- In U-space airspace conflict resolution is strategic, that is, the plans are free of conflicts.
- Within U-space airspace, BVLOS operations are significantly easier to organise than has been possible before.
- Traffic densities are expected to be relatively low. In the initial period flights are expected to be widely spaced.

U-space is made aware of the current position and motion of the aircraft (surveillance) mostly by the UAS reporting the position of the aircraft through the Network Identification Service. Initial operations are expected to occur before the performance of U-space surveillance is well understood. Plans will initially be subject to wide separations in time and/or distance to allow for this uncertainty about the performance of this surveillance.

The U-space regulatory framework resolves strategic conflicts by prioritising "first to file."

The authors of this ConOps expect when the U-space regulatory framework is revised, another resolution scheme will be adopted in the interest of fairness to flights that cannot be planned long in advance. This topic is explored in the paper Market Design for Drone Traffic Management, but at the time of writing no mature proposal for a fairer resolution scheme exists.

- As experience grows, U-space and UAS evolve rapidly. Standards and best practice will emerge in a number of fields. It is expected that during this period the level of performance achievable in communications, navigation and surveillance will improve. Confidence in the Communication, Navigation and Surveillance (CNS) performance will lead to the safe provision of U-space tactical services.

C.1.3 General U-space (2030-…)

In view of rising UAS traffic and as experience grows, many U-space airspace volumes have been defined, in what was previously controlled or uncontrolled airspace. In uncontrolled airspace, as most drone operations are performed in the VLL, U-space airspace is declared below 500 feet AGL. For some UAS operations which require to fly higher, such as inter-cities passengers or cargo transportation, corridors are in place and published in the AIP.

In more densely occupied U-space airspaces tactical conflict resolution is routinely offered. UAS traffic in ATC controlled areas is routinely controlled by ATC through U-space; that is using U-space means of CNS. In order to avoid exceeding the capabilities of the tactical conflict resolution service, a dynamic capacity management service will be needed to match the capacity and traffic demand.

Some U-space airspaces with tactical services will accommodate remotely piloted flight according to a new flight rule, UFR (see Section 4 of the CONOPS).

C.1.4 Full U-space Integration

U4 is deployed. Most professional aerial operations are uncrewed. Uncrewed and crewed operations use U-space services and fly UFR. U-space airspace is defined widely. Uncrewed aircraft are capable to autonomously detect and avoid collision with any other aircraft.

The timing of Full U-space Integration is hard to gauge. While U-space may have followed the trajectory mentioned above, full integration requires that most aircraft used for professional purposes are uncrewed. If that requires new aircraft, then the time taken may be a function of the useful life of the final generation of crewed aircraft. Currently aircraft are expected to have a working life of 25 to 30 years on average.

C.2 Summary of CANSO input based on ICAO WG outputs

C.2.1 Evolutionary Step 1 – Initial Operations, Demonstrations & Concept Development (from 2024 – first movers)

- Small UAS BVLOS trials/operations. First manned VTOL operations in VFR within dedicated routes/corridors resembling helicopter operations.
- Basic UTM services for managing high-density traffic of small UAS and explore which services are useful for VTOL operations in the future.
- Early innovative solutions for ground infrastructures (vertiports/vertispots/helipads and adapted heliports or small airports), including first vertiport networks at some major cities and airports.
- Institutional action to bring together the key stakeholders, both public and private, for the creation of harmonised regulatory frameworks and safe and secure technology, and infrastructure development.

C.2.2 Evolutionary Step 2 – Scaling Up (from 2030 – first movers)

- Proliferation of UAS commercial services in medium-high complexity scenarios for aerial work and goods deliveries.
- Advanced UTM services for integrating air traffic.
- UAS traffic management zones, dynamic airspace volumes, and improved digital communication expand alongside growing understanding of UTM systems.
- Commercial manned VTOL operations with a range of environmental conditions under both VMC and IMC in urban and regional areas, and first proof of concept of unmanned VTOL operation will emerge.

- Regulatory decisions, ATC automation, detect-and-avoid capabilities, advanced communication, and urban infrastructure extension to play pivotal roles.
- More tests are needed to establish robust and safe regulation frameworks.

C.2.3 Evolutionary Step 3 – Sustainable and Gradual Integration (from 2035 – first movers)

- Large scale AAM commercial services with manned, unmanned, and autonomous AAM vehicles supported by new UTM/ATM services.
- The most important element will be a safe and secure intermodal and innovative transportation network of services.
- Innovative ground infrastructure will be dynamically introduced and incorporated into a growing and flexible AAM operating environment.

ANNEX D. REFERENCES

[1] *https://transport.ec.europa.eu/system/files/2022-11/COM_2022_652_drone_strategy_2.0.pdf*

[2] *SESAR Joint Undertaking | U-space CONOPS 4th Edition (sesarju.eu)*

[3] *https://corus-xuam.eu/wp-content/uploads/2022/11/CORUS-XUAM-D4.1-delivered_3.10.pdf*